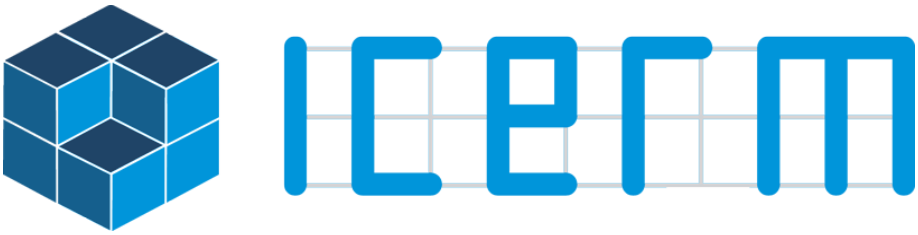

Institute for Computational and Experimental Research in Mathematics

Annual Report
May 11, 2019 – May 1, 2020

Brendan Hassett, Director
Mathew Borton, IT Director
Ruth Crane, Assistant Director
Sigal Gottlieb, Deputy Director
Elisenda Grigsby, Deputy Director (through Dec. 31, 2019)
Jeffrey Hoffstein, Consulting Associate Director
Caroline Klivans, Associate Director
Jill Pipher, Consulting Director Emerita
Kavita Ramanan, Deputy Director (as of Jan. 1, 2020)
Bjorn Sandstede, Associate Director
Homer Walker, Consulting Associate Director (through Dec. 31, 2019)
Ulrica Wilson, Associate Director for Diversity and Outreach

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Mission

The mission of the Institute for Computational and Experimental Research in Mathematics (ICERM) is to support and broaden the relationship between mathematics and computation: specifically, to expand the use of computational and experimental methods in mathematics, support theoretical advances related to computation, and address problems posed by the existence and use of the computer through mathematical tools, research and innovation.

Core Programs and Events

Note: To ensure we report the most accurate data and to better reflect ICERM's programmatic starting and end dates, the 2019-2020 report will include all program details between May 11, 2019 (the day after our last report ended) and May 1, 2020 (the last day of our Spring 2020 semester program).

The following grid lists ICERM's scheduled programs and events from May 11, 2019 through May 1, 2020 supported by the core NSF award and other grants. The grand total of "Unique Visits" during this timeframe was: **1946**. The "Unique Visits" total for just ICERM's core programs (not including TRIPODS, REUF, Hot Topics, or GirlsGetMath – see note below the grid) was **1125**. "Total #" column includes individuals who attended multiple events within a set period of time. For example, long-term visitors who attended several workshops during a semester program.

TYPE	TITLE	START	END	Unique Visit #	Total #
TRIPODS Workshop	Data Science in Low-dimensional Spaces	13-May-19	17-May-19	41	41
Collaborate@ICERM	Widening the scope of Accuracy Enhancing Filters	13-May-19	17-May-19	5	5
Simons Collaboration	Arithmetic of Low-Dimensional Abelian Varieties	3-Jun-19	7-Jun-19	79	79
Topical Workshop	Encrypted Search	10-Jun-19	14-Jun-19	56	56
Summer@ICERM	Summer@ICERM 2019: Computational Arithmetic Dynamics	10-Jun-19	2-Aug-19	29	29
Collaborate@ICERM	Geometry of Data and Networks	17-Jun-19	21-Jun-19	4	4
REUF	ICERM Research Experiences for Undergraduate Faculty (REUF)	17-Jun-19	21-Jun-19	27	27
Topical Workshop	Mathematical Optimization of Systems Impacted by Rare, High-Impact Random Events	24-Jun-19	28-Jun-19	58	58
REUF	REUF Continuation Group	24-Jun-19	28-Jun-19	7	7
Collaborate@ICERM	Higher Dimensional Post-Critically Finite Maps on Projective Space	8-Jul-19	12-Jul-19	3	3

Collaborate@ICERM	The Geometry of Nash Blowups of Schubert Varieties, Fiber Products of Resolutions, and Peterson Translation	8-Jul-19	12-Jul-19	4	4
Topical Workshop	Perspectives on Dehn Surgery	15-Jul-19	19-Jul-19	94	94
Collaborate@ICERM	The Tropical Convex Hull of Convex Sets	15-Jul-19	19-Jul-19	3	3
Topical Workshop	Women in Symplectic and Contact Geometry and Topology workshop (WiSCon)	22-Jul-19	26-Jul-19	67	67
Topical Workshop	Women in Data Science and Mathematics (WiSDM) 2019	29-Jul-19	2-Aug-19	55	55
Topical Workshop	Applied Mathematical Modeling with Topological Techniques	5-Aug-19	9-Aug-19	56	56
Collaborate@ICERM	Fault Tolerant Power Domination and Zero Forcing	12-Aug-19	16-Aug-19	5	5
GirlsGetMath	GirlsGetMath: Summer Math Camp for High Schoolers	12-Aug-19	16-Aug-19	37	37
GirlsGetMath	GirlsGetMath Train the Trainer	13-Aug-19	15-Aug-19	9	9
Semester Program	Illustrating Mathematics	4-Sep-19	6-Dec-19	86	86
Semester Workshop	Program Opener: Meet, Make and Design	5-Sep-19	6-Sep-19	12	50
Semester Panel	Math + Art Panel 1	6-Sep-19	6-Sep-19	80	80
Semester Workshop	Illustrating Geometry and Topology	16-Sep-19	20-Sep-19	86	130
Semester Panel	Math + Art Panel 2	16-Sep-19	16-Sep-19	100	100
Semester Workshop	Computational Textiles Working Group	23-Sep-19	27-Sep-19	15	34
Semester Panel	Math + Art Panel 3	7-Oct-19	7-Oct-19	125	125
Semester Panel	Math + Art Panel 4	21-Oct-19	21-Sep-19	125	125
Semester Workshop	Illustrating Number Theory and Algebra	21-Oct-19	25-Oct-19	53	94
Hot Topics Workshop	Algorithms in Complex Dynamics and Mapping Class Groups	2-Nov-19	3-Nov-19	46	46
Semester Panel	Math + Art Panel 5	11-Nov-19	11-Nov-19	125	125
Semester Workshop	Illustrating Dynamics and Probability	11-Nov-19	15-Nov-19	51	91
Topical Workshop	Numerical Methods and New Perspectives for Extended Liquid Crystalline Systems	9-Dec-19	13-Dec-19	46	46
Collaborate@ICERM	Improved Results for Root Discriminant Bounds in Towers of Number Fields and Tame Tate-Shafarevich Groups	6-Jan-20	10-Jan-20	3	3
Collaborate@ICERM	Fast and Accurate Simulation of Waves in Layered Media	13-Jan-20	17-Jan-20	7	7

Semester Program	Model and dimension reduction in uncertain and dynamic systems	27-Jan-20	1-May-20	49	49
Semester Workshop	Mathematics of Reduced Order Models	17-Feb-20	21-Feb-20	101	121
Hot Topics Workshop**	Soergel Bimodules and Categorification of the Braid Group	28-Feb-20	1-Mar-20	24	24
Semester Workshop*	Algorithms for Dimension and Complexity Reduction	23-Mar-20	27-Mar-20	77	95
Semester Workshop*	Computational Statistics and Data-Driven Models	20-Apr-20	24-Apr-20	96	111

Note: The Simons Collaboration and GirlsGetMath@ICERM programs are not funded through ICERM's core grant. REUF is supported by the National Science Foundation through a DMS grant to ICERM. Brown University's Data Science Initiative partners with ICERM on public events, included workshops supported by the TRIPODS grant from the National Science Foundation.

*Program pivoted from an in-person program at ICERM to a virtual platform to accommodate the COVID-19 pandemic restrictions. You can see in the "Total #" column that the virtual semester workshops attracted several additional participants who did not originally apply or register to attend the in-person program.

Participant Summaries by Program Type

The tables below display breakdowns of ICERM's confirmed participants by category during the reporting period for all funded programs. Each participant is represented once per unique visit regardless of the number of programs they attended during a visit. Note: Fall '19 hosted 5 panels, but only one required registration, so only one is reported here.

ICERM Funded Participants

	Program Type	Summer@ICERM 2019	7 Collaboration Groups	Fall Semester '19								Spring Semester '20					Topical '19 - '20							
				Semester Program	Opening	Panel	Workshop 1	Workshop 2	Workshop 3	Workshop 4	% of # Reporting	Semester Program	Workshop 1	Workshop 2	Workshop 3	% of # Reporting	Workshop A	Workshop B	Workshop C	Workshop D	Workshop E	Workshop F	Workshop G	% of # Reporting
Gender and Ethnicity	Total Participants	29	30	80	12	3	73	11	46	42		44	88	70	86		41	50	75	66	49	50	40	
	Female	9	11	19	4	1	16	3	14	14	35%	12	15	18	27	27%	7	11	20	55	47	16	9	56%
	Other	1	0	1	0	0	0	0	0	0	0.5%	1	1	1	1	2%	0	0	0	0	0	0	0	0%
	# Reporting Gender	25	21	61	11	1	60	7	30	35		43	81	62	76		24	33	69	55	47	40	28	
	African American	0	1	0	0	0	0	0	1	1	1%	0	0	2	5	3%	0	2	2	0	1	1	0	2%
	American Indian	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	1	1	0	1	0	1%
	Asian	6	5	7	1	1	6	1	4	5	13%	17	28	20	26	38%	8	11	16	16	16	9	11	30%
	Hispanic	3	2	2	0	0	0	0	0	2	2%	1	4	2	2	4%	1	1	5	6	3	2	2	7%
	# Reporting Ethnicity	28	21	58	11	1	56	7	31	27		41	76	57	67		23	32	70	56	42	40	25	
Geographical Point of Origin	US - Midwest	6	4	6	0	0	6	0	5	8	9%	2	8	7	11	10%	5	15	12	6	6	16	7	18%
	US - Northeast	13	7	23	1	2	18	5	14	9	27%	19	24	19	22	29%	16	14	22	18	17	9	7	28%
	US - South	2	7	11	1	0	9	2	5	5	12%	6	20	13	18	20%	9	9	15	11	7	7	4	17%
	US - West	8	7	18	6	1	14	1	11	10	23%	4	12	13	29	20%	5	7	7	19	15	13	3	19%
	Africa	0	0	0	0	0	0	0	0	0	0%	0	1	2	1	1%	0	0	0	0	0	0	0	0%
	Asia	0	1	1	0	0	1	0	0	0	1%	3	1	0	4	3%	1	1	2	2	2	1	4	4%
	Canada	0	1	2	0	0	2	0	3	1	3%	0	0	1	1	1%	1	0	1	1	2	0	1	2%
	Europe	0	1	19	4	0	22	3	7	7	23%	10	23	14	9	19%	4	3	15	17	0	4	12	15%
	Latin & South America	0	1	0	0	0	1	0	0	1	1%	0	0	1	0	0.3%	0	1	0	0	0	0	2	1%
	Oceania	0	1	0	0	0	0	0	1	0	0.4%	0	0	0	0	0%	0	0	1	1	0	0	0	1%

All Participants (ICERM funded and Non-ICERM funded)

	Program Type	Summer@ICERM 2019	7 Collaboration Groups	Fall Semester '19								Spring Semester '20					Topical '19 - '20							
				Semester Program	Openning	Panel	Workshop 1	Workshop 2	Workshop 3	Workshop 4	% of # Reporting	Semester Program	Workshop 1	Workshop 2	Workshop 3	% of # Reporting	Workshop A	Workshop B	Workshop C	Workshop D	Workshop E	Workshop F	Workshop G	% of # Reporting
Gender and Ethnicity	Total Participants	29	31	86	12	9	86	15	53	51		49	101	77	96		56	58	94	67	55	57	44	
	Female	9	11	20	4	3	18	4	17	14	34%	14	17	22	30	28%	9	12	22	56	53	18	10	42%
	Other	1	0	1	0	0	0	0	0	0	0.4%	1	1	1	1	1%	0	0	0	0	0	0	0	0%
	# Reporting Gender	25	22	67	11	3	67	9	34	42		48	93	68	85		35	40	83	56	53	46	31	
	African American	0	1	0	0	0	0	0	1	1	1%	0	0	2	6	3%	1	2	2	0	1	1	0	2%
	American Indian	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	2	1	0	1	0	1%
	Asian	6	6	7	1	2	7	1	5	8	15%	20	32	20	28	37%	10	13	20	16	19	9	12	30%
	Hispanic	3	2	2	0	0	0	0	0	0	1%	1	4	3	2	4%	1	1	5	6	4	2	2	6%
	# Reporting Ethnicity	28	22	64	11	2	59	9	35	33		46	85	62	74		32	37	83	57	48	46	28	
Geographical Point of Origin	US Based	29	26	64	8	9	59	11	42	40	75%	35	72	58	78	75%	48	52	73	46	50	52	25	80%
	Foreign Based	0	5	22	4	0	27	4	11	11	25%	14	29	19	18	25%	8	6	21	21	5	5	19	20%

ICERM Funded Speakers

	Program Type	Summer@ICERM 2019	7 Collaboration Groups	Fall Semester '19								Spring Semester '20					Topical '19 - '20							
				Semester Program	Opening	Panel	Workshop 1	Workshop 2	Workshop 3	Workshop 4	% of # Reporting	Semester Program	Workshop 1	Workshop 2	Workshop 3	% of # Reporting	Workshop A	Workshop B	Workshop C	Workshop D	Workshop E	Workshop F	Workshop G	% of # Reporting
	Total Participants	0	0	5	0	2	20	5	17	15		13	22	20	22		19	21	7	6	0	6	18	
Gender and Ethnicity	Female	0	0	1	0	1	1	2	1	4	31%	3	4	6	3	27%	0	1	0	5	0	3	3	44%
	Other	0	0	0	0	0	0	0	0	0	0%	0	1	0	0	2%	0	0	0	0	0	0	0	0%
	# Reporting Gender	0	0	5	0	1	11	2	4	9		13	17	15	14		5	4	2	5	0	3	8	
	African American	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	1	0	0	0	0	0	4%
	American Indian	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	Asian	0	0	1	0	1	1	0	0	2	17%	4	0	4	1	20%	1	0	0	3	0	0	2	26%
	Hispanic	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	# Reporting Ethnicity	0	0	6	0	1	9	2	4	7		13	12	14	7		4	3	2	5	0	3	6	
Geographical Point of Origin	US - Midwest	0	0	0	0	0	4	0	3	2	14%	1	0	2	4	9%	1	7	2	0	0	2	4	21%
	US - Northeast	0	0	0	0	1	7	4	4	5	33%	4	5	2	5	21%	7	6	0	3	0	2	4	29%
	US - South	0	0	2	0	0	1	1	2	0	9%	4	6	6	3	25%	3	3	2	0	0	0	1	12%
	US - West	0	0	2	0	1	1	0	4	4	19%	2	2	4	7	19%	4	3	1	0	0	2	2	16%
	Africa	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	Asia	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	1	1	0	1	0	0	0	4%
	Canada	0	0	0	0	0	1	0	0	0	2%	0	0	1	0	1%	0	0	1	0	0	0	0	1%
	Europe	0	0	1	0	0	6	0	3	4	22%	2	9	5	3	25%	3	1	1	2	0	0	7	18%
	Latin & South America	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	Oceania	0	0	0	0	0	0	0	1	0	2%	0	0	0	0	0%	0	0	0	0	0	0	0	0%

All Speakers (ICERM funded and Non-ICERM funded)

	Program Type	Summer@ICERM 2019	7 Collaboration Groups	Fall Semester '19								Spring Semester '20					Topical '19 - '20							
				Semester Program	Openning	Panel	Workshop 1	Workshop 2	Workshop 3	Workshop 4	% of # Reporting	Semester Program	Workshop 1	Workshop 2	Workshop 3	% of # Reporting	Workshop A	Workshop B	Workshop C	Workshop D	Workshop E	Workshop F	Workshop G	% of # Reporting
Gender and Ethnicity	Total Participants	0	0	5	0	2	20	7	18	15		13	22	20	22		23	22	7	6	0	6	19	
	Female	0	0	1	0	1	1	2	2	4	33%	3	4	6	3	27%	0	1	0	5	0	3	3	41%
	Other	0	0	0	0	0	0	0	0	0	0%	0	1	0	0	2%	0	0	0	0	0	0	0	0%
	# Reporting Gender	0	0	5	0	1	11	2	5	9		13	17	15	14		7	5	2	5	0	2	8	
	African American	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	1	0	0	0	0	0	4%
	American Indian	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	Asian	0	0	1	0	1	1	0	0	2	17%	4	0	4	1	20%	2	0	0	3	0	0	2	29%
	Hispanic	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	# Reporting Ethnicity	0	0	6	0	1	9	2	5	7		13	12	14	7		5	3	2	5	0	3	6	
Geographical Point of Origin	US Based	0	0	4	0	2	13	6	14	11	75%	11	13	14	18	73%	18	20	5	3	0	6	12	77%
	Foreign Based	0	0	1	0	0	7	1	4	4	25%	2	9	6	4	27%	5	2	2	3	0	0	7	23%

ICERM Funded Postdocs

	Program Type	Summer@ICERM 2019	7 Collaboration Groups	Fall Semester '19								Spring Semester '20					Topical '19 - '20							
				Semester Program	Opening	Panel	Workshop 1	Workshop 2	Workshop 3	Workshop 4	% of # Reporting	Semester Program	Workshop 1	Workshop 2	Workshop 3	% of # Reporting	Workshop A	Workshop B	Workshop C	Workshop D	Workshop E	Workshop F	Workshop G	% of # Reporting
Gender and Ethnicity	Total Participants	0	4	11	0	0	8	0	7	5		11	24	15	13		1	5	10	19	7	12	4	
	Female	0	2	4	0	0	2	0	3	2	38%	4	3	3	3	23%	0	1	5	19	7	5	1	69%
	Other	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	# Reporting Gender	0	3	11	0	0	6	0	7	5		11	23	13	10		0	5	10	19	7	11	3	
	African American	0	0	0	0	0	0	0	1	0	3%	0	0	1	1	4%	0	0	0	0	0	0	0	0%
	American Indian	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	1	0	1	0	4%
	Asian	0	2	1	0	0	1	0	2	2	19%	4	9	6	4	42%	0	1	2	7	2	3	1	29%
	Hispanic	0	1	2	0	0	0	0	0	0	6%	1	1	1	0	5%	0	0	1	3	1	0	0	9%
	# Reporting Ethnicity	0	4	14	0	0	6	0	7	4		12	21	13	9		0	5	9	21	6	12	2	
Geographical Point of Origin	US - Midwest	0	0	2	0	0	0	0	1	1	13%	0	2	1	1	6%	0	3	0	2	1	5	1	21%
	US - Northeast	0	2	3	0	0	3	0	2	1	29%	4	9	8	3	38%	0	1	5	5	3	1	0	26%
	US - South	0	0	0	0	0	0	0	0	0	0%	1	3	2	4	16%	0	0	1	1	0	0	0	3%
	US - West	0	0	1	0	0	2	0	1	0	13%	1	2	1	4	13%	0	1	2	4	2	4	1	24%
	Africa	0	0	0	0	0	0	0	0	1	3%	0	1	1	0	3%	0	0	0	0	0	0	0	0%
	Asia	0	0	1	0	0	0	0	0	0	3%	0	0	0	0	0%	0	0	0	1	1	1	0	5%
	Canada	0	0	0	0	0	1	0	1	0	6%	0	0	0	0	0%	0	0	0	1	0	0	0	2%
	Europe	0	1	4	0	0	2	0	1	2	29%	5	7	2	1	24%	1	0	2	5	0	1	2	19%
	Latin & South America	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	Oceania	0	1	0	0	0	0	0	1	0	3%	0	0	0	0	0%	0	0	0	0	0	0	0	0%

All Postdocs (ICERM funded and Non-ICERM funded)

	Program Type	Summer@ICERM 2019	7 Collaboration Groups	Fall Semester '19								Spring Semester '20					Topical '19 - '20							
				Semester Program	Openning	Panel	Workshop 1	Workshop 2	Workshop 3	Workshop 4	% of # Reporting	Semester Program	Workshop 1	Workshop 2	Workshop 3	% of # Reporting	Workshop A	Workshop B	Workshop C	Workshop D	Workshop E	Workshop F	Workshop G	% of # Reporting
Gender and Ethnicity	Total Participants	0	4	12	0	0	8	1	7	5		11	28	16	15		3	7	13	19	8	13	4	
	Female	0	2	4	0	0	2	0	3	2	37%	4	4	4	3	24%	0	1	6	19	8	5	1	65%
	Other	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	# Reporting Gender	0	3	12	0	0	6	0	7	5		11	26	14	12		1	7	12	19	8	12	3	
	African American	0	0	0	0	0	0	0	1	0	3%	0	0	1	1	3%	0	0	0	0	0	0	0	0%
	American Indian	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	1	0	1	0	3%
	Asian	0	2	1	0	0	1	0	2	2	19%	4	10	6	5	41%	0	2	3	7	3	3	1	30%
	Hispanic	0	1	2	0	0	0	0	0	0	6%	1	1	1	0	5%	0	0	1	3	2	0	0	10%
	# Reporting Ethnicity	0	4	15	0	0	6	0	7	4		12	24	14	11		1	7	11	21	8	13	2	
Geographical Point of Origin	US Based	0	2	7	0	0	5	0	4	2	55%	6	18	13	13	71%	2	7	10	12	7	11	2	76%
	Foreign Based	0	2	5	0	0	3	1	3	3	45%	5	10	3	2	29%	1	0	3	7	1	2	2	24%

ICERM Funded Graduate Students

Program Type		Summer@ICERM 2019	7 Collaboration Groups	Fall Semester '19								Spring Semester '20					Topical '19 - '20							
				Semester Program	Opening	Panel	Workshop 1	Workshop 2	Workshop 3	Workshop 4	% of # Reporting	Semester Program	Workshop 1	Workshop 2	Workshop 3	% of # Reporting	Workshop A	Workshop B	Workshop C	Workshop D	Workshop E	Workshop F	Workshop G	% of # Reporting
Gender and Ethnicity	Total Participants	4	5	12	1	0	12	2	6	6		6	8	9	19		15	8	51	20	14	13	11	
	Female	0	3	4	0	0	3	0	3	1	29%	1	2	4	9	38%	5	5	14	20	14	4	3	50%
	Other	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	# Reporting Gender	3	5	11	1	0	12	2	6	6		6	8	9	19		13	8	51	20	14	12	11	
	African American	0	1	0	0	0	0	0	0	0	0%	0	0	0	3	8%	0	0	2	0	0	0	0	2%
	American Indian	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	2	0	0	0	0	2%
	Asian	1	1	4	0	0	2	1	1	1	23%	3	3	2	5	33%	5	4	13	4	9	3	6	34%
	Hispanic	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	1	0	3	2	1	1	1	7%
	# Reporting Ethnicity	3	4	13	1	0	12	2	7	5		5	8	9	18		13	8	54	20	13	12	10	
Geographical Point of Origin	US - Midwest	1	1	0	0	0	0	0	0	2	5%	0	2	1	2	12%	2	0	10	1	2	5	1	16%
	US - Northeast	2	1	2	0	0	2	0	3	1	21%	2	4	3	5	33%	6	3	14	3	6	3	1	27%
	US - South	1	3	2	0	0	3	1	0	1	18%	0	0	0	3	7%	4	2	12	5	2	1	1	20%
	US - West	0	0	2	0	0	1	0	2	1	15%	0	1	3	3	17%	1	2	4	3	4	3	0	13%
	Africa	0	0	0	0	0	0	0	0	0	0%	0	0	0	1	2%	0	0	0	0	0	0	0	0%
	Asia	0	0	0	0	0	0	0	0	0	0%	3	0	0	2	12%	0	0	0	0	0	0	4	3%
	Canada	0	0	1	0	0	0	0	0	0	3%	0	0	0	0	0%	1	0	0	0	0	0	0	1%
	Europe	0	0	5	1	0	6	1	1	1	38%	1	1	2	3	17%	1	1	10	8	0	1	3	18%
	Latin & South America	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	1	1%
	Oceania	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	1	0	0	0	0	1%

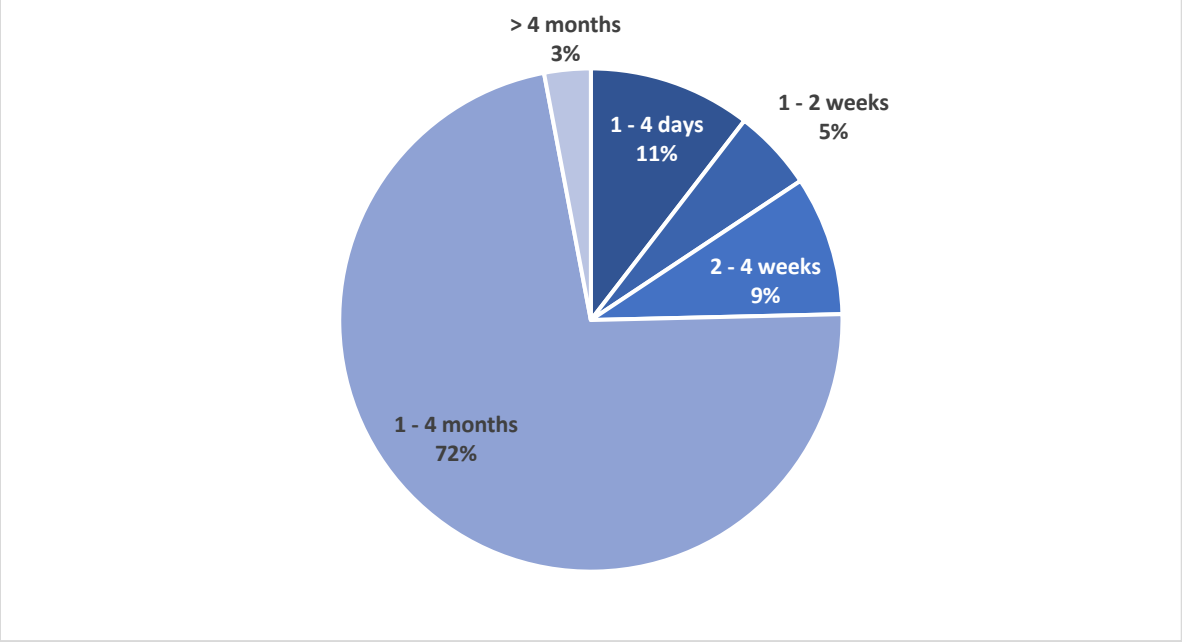
All Graduate Students (ICERM funded and Non-ICERM funded)

Program Type		Summer@ICERM 2019	7 Collaboration Groups	Fall Semester '19								Spring Semester '20					Topical '19 - '20							
				Semester Program	Openning	Panel	Workshop 1	Workshop 2	Workshop 3	Workshop 4	% of # Reporting	Semester Program	Workshop 1	Workshop 2	Workshop 3	% of # Reporting	Workshop A	Workshop B	Workshop C	Workshop D	Workshop E	Workshop F	Workshop G	% of # Reporting
Gender and Ethnicity	Total Participants	4	5	12	1	2	14	2	7	11		10	10	12	21		22	9	61	20	15	16	12	
	Female	0	3	4	0	1	3	0	3	1	28%	3	2	5	10	38%	7	6	14	20	15	6	4	49%
	Other	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	0	0	0	0	0	0%
	# Reporting Gender	3	5	11	1	1	12	2	6	10		10	10	12	21		18	9	59	20	15	15	12	
	African American	0	1	0	0	0	0	0	0	0	0%	0	0	0	4	8%	0	0	2	0	0	0	0	1%
	American Indian	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	2	0	0	0	0	1%
	Asian	1	1	4	0	1	2	1	1	2	24%	6	3	2	5	32%	7	5	14	4	9	3	6	32%
	Hispanic	0	0	0	0	0	0	0	0	0	0%	0	0	1	0	2%	1	0	3	2	1	1	1	6%
	# Reporting Ethnicity	3	4	13	1	1	12	2	7	9		9	9	12	20		17	9	62	20	14	15	11	
Geographical Point of Origin	US Based	4	5	6	0	2	7	1	6	10	65%	5	7	9	14	66%	18	8	50	12	15	15	4	79%
	Foreign Based	0	0	6	1	0	7	1	1	1	35%	5	3	3	7	34%	4	1	11	8	0	1	8	21%

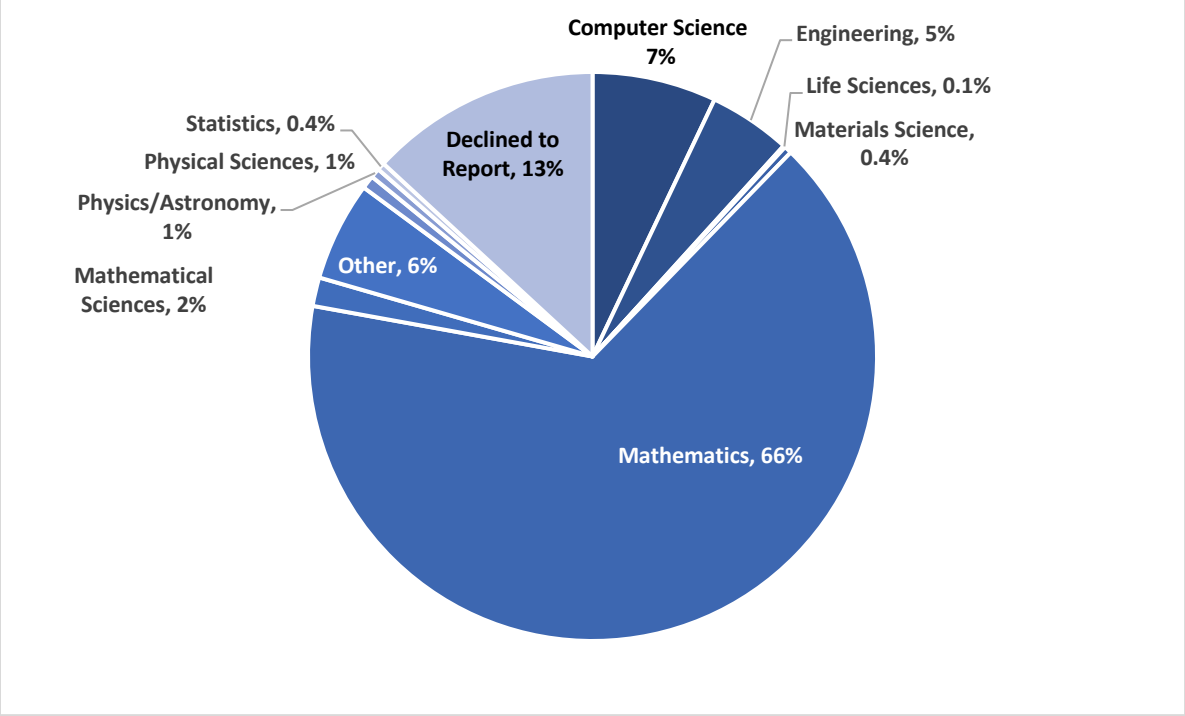
Additional Participant Data

The charts below display breakdowns of ICERM's confirmed NSF-funded participants by category during the reporting period for all funded programs. Each participant is only reflected once per chart regardless of the number of programs they attended.

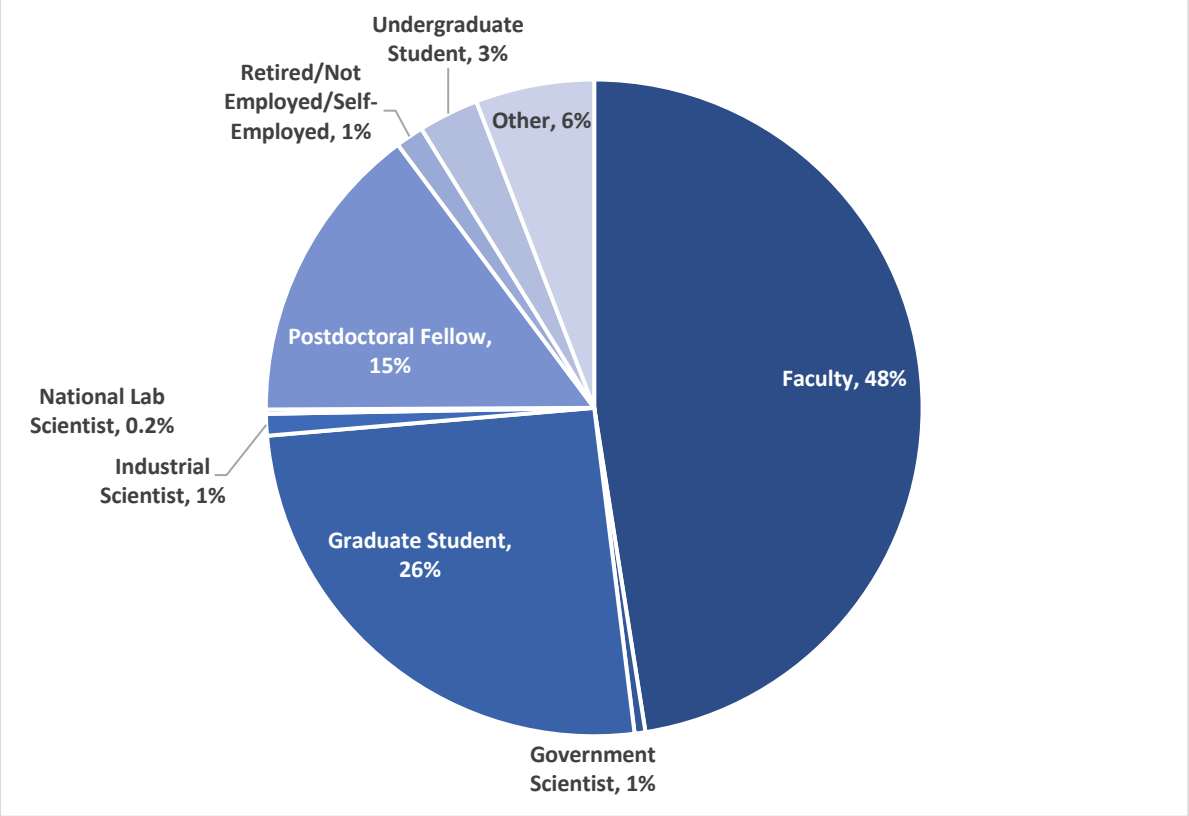
Semester Program Length of Stay



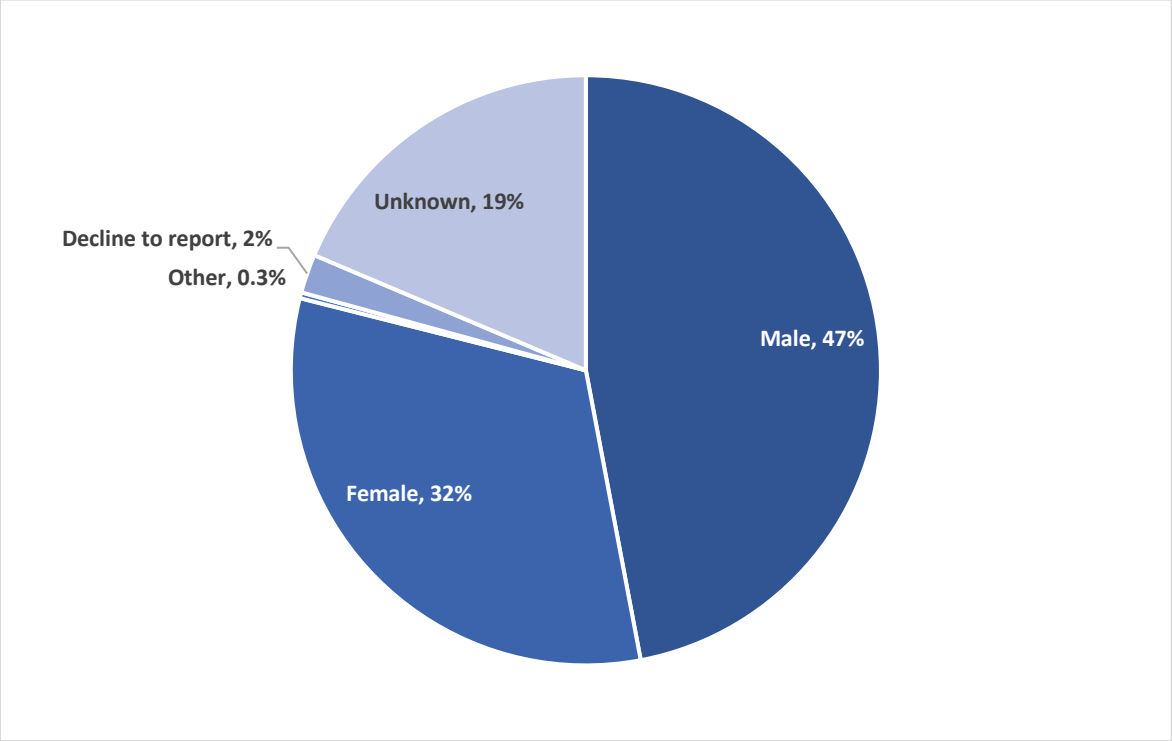
Primary Field of Interest



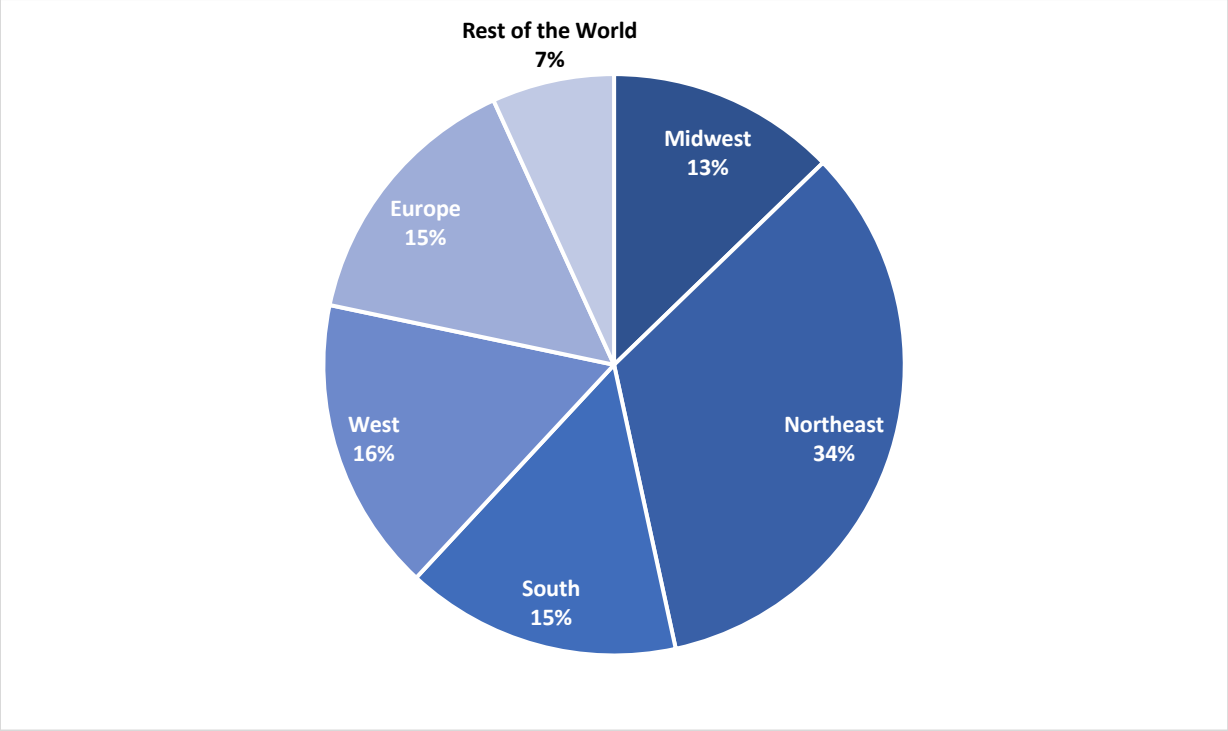
Position



Gender

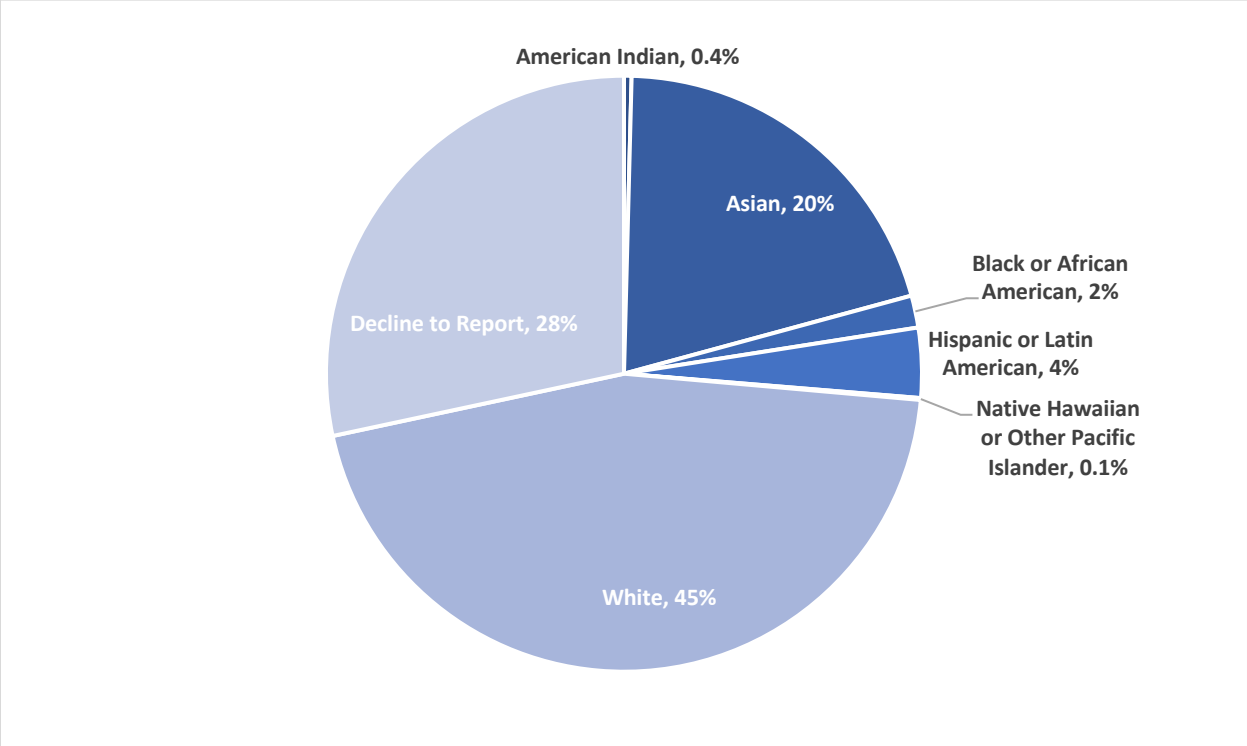


US vs Foreign Based Participants



Rest of the World includes: Africa, Asia, Canada, Latin & South America, and Oceania.

Ethnicity



Note: Participants can select multiple ethnicities so some are reflected in this pie chart more than once.

Semester Programs

Since its inaugural semester program in September 2011, a large portion of the Institute's activity has taken place in the context of semester long thematic programs together with their associated workshops. ICERM encourages proposals for programs that support its mission "to foster and broaden the relationship between mathematics and computation". The institute is open to proposals from any area of the mathematical sciences. Both pure and applied fields may benefit from the positive feedback between computation and theory that ICERM seeks to promote. ICERM Directors help proposers flesh out their ideas within the context of our mission; it is an iterative process, involving many conversations with ICERM Directors and proposal drafts in response to feedback from Directors and ICERM's boards, and fine-tuning after the event is publicly announced.

Semester Program Process

ICERM's Scientific Advisory Board SAB meets annually in November, and schedules conference calls as needed throughout the year. The 2019 annual meeting and a subsequent conference call in June resulted in the selection of semester programs and topical workshops through Fall 2022.

The semester program selection process follows these steps:

1. Solicitation of Proposals

ICERM hosts two semester programs per year. Each has organizers and long-term participants who are expected to be in residence for the majority of the semester. Semester programs typically incorporate three week-long associated workshops.

Semester Program Full Proposal Requirements

A semester program proposal should be 6-10 pages and contain:

- List of 5-10 organizers, including the main contact for organizing committee
- Short abstract of the program's basic goals and underlying philosophy
- Description of the program area/theme and central scientific challenges, written for a general mathematical audience
- Description of the experimental and computational aspects of the program
- Plan for ensuring the participation of underrepresented groups—As part of your plan please identify a main contact among the organizers that will take the lead in ensuring participation from underrepresented groups. The plan should also list potential participants of the program that are women and potential participants who are members of an underrepresented minority group (African American, Hispanic or Latino, American Indian or Alaskan Native).
- List of 8-10 high priority senior scientists likely to visit ICERM for a month or more
- Ranked list of 20+ potential long-term participants who will help form a critical mass for the scientific program
- Description of three proposed workshops, including potential organizers, if known
- Description of a 2-3 day opening event that will survey guiding problems or introduce key computational or experimental methodologies
- Concrete plans for involving and mentoring graduate students, postdocs, and early-career mathematicians in the program

Note: per the advice of ICERM's Scientific Advisory Board, Ulrica Wilson, ICERM's Associate Director of Diversity and Outreach, updated the "plan for ensuring the participation of underrepresented groups" bullet point, and the proposal guideline website was updated in spring 2020.

Deadline and Review Process
Proposals are submitted to the ICERM Director. Annual target deadlines are October 1st and May 1st. ICERM Directors and the Scientific Advisory Board (SAB) review all proposals. Proposers receive feedback within a month of the SAB meeting.

2. Proposal Selection
The Science Advisory Board SAB approves the semester programs. The deadline for proposals is at least a week prior to the annual November SAB meeting. Once a proposal is accepted, a member of the ICERM Directorate and members of a SAB subcommittee are assigned to assist the organizers who are also provided with a planning timeline. The "high priority" list of senior scientists are contacted and invited to participate immediately upon SAB approval. Program dates are scheduled with details posted on the ICERM website and various on-line math organization calendars SIAM, AMS, European Mathematical Society, National Math Institutes, and Conference Service Mandl. Program and/or workshop ads are placed in appropriate publications if recommended by the organizers and Directors. ICERM reserves some funds for applicants (non-invitees) to the program.

From this point on, organizers are involved in making decisions on the following: ICERM postdoc selection; applications for long-term visitors, graduate students, and workshop participants; mentoring of students and postdocs (an institute Director assists the organizers with mentor coordination). Members of the Directorate make the final decisions on all invitations. A designated organizer assists ICERM staff by providing appropriate program images for web and print ads and will be asked to review marketing materials.

3. Selection of Long-term Visitors/Research Fellows
The organizers propose a ranked list of 20 to 30 research fellows. ICERM Directors approve and/or suggest additions or re-rankings in consultation with assigned SAB members. The standard model for long-term participation for senior faculty is through paid leaves such as sabbatical.

4. Offers to Research Fellows
Once the list of research fellows has been finalized and funding determined, an invitation is sent to each. The invitation describes the program and outlines the support to be provided. During this reporting cycle, ICERM updated all of its research fellow invitations to include language regarding Brown University's "Code of Conduct", which addresses sexual harassment, discrimination, and other unprofessional behaviors. Using its Cube database, ICERM tracks demographic information about, and all interactions with, research fellows.

5. Semester Workshops
Semester program organizers recommend organizers each of the three-to-four workshops, taking into account feedback from ICERM's Scientific Advisory Board and responsible Directors. The

organizers propose an initial ranked list of 20-25 possible speakers and a list of 10 alternates. The ICERM Directorate approves and/or suggests additions or re-rankings in consultation with assigned SAB members. Formal invitations are sent by ICERM staff describing the program and outlining the support to be provided to those who indicate an interest. During this reporting cycle, ICERM updated all of its workshop invitations to include language regarding Brown University's "Code of Conduct", which addresses sexual harassment, discrimination, and other unprofessional behaviors. A designated workshop organizer assists ICERM staff by providing appropriate program images for the workshop's web and print ads, and will be asked to review marketing materials.

6. Application Process

Once the organizers and Directors agree there is enough critical mass in terms of confirmed long-term visitors and/or workshop speakers, the on-line application for that particular program is opened on the ICERM website. All applications are stored in the institute's "Cube" database (see also the "Recruiting and Selection of ICERM-Funded Postdocs" later in this report). The ICERM postdoctoral fellow applicants who were not hired via MathJobs.org are alerted that the ICERM postdoc positions have closed and that they should apply online for partial support to attend as a participant if they are still interested.

7. Applicant Selection

Program organizers can view the applicants and their supporting documents as well as prioritize them within Cube. A member of the ICERM Directorate reviews the prioritized list, re-ranks as appropriate and makes the final selections, taking into consideration the remaining space in the program, diversity, participant support requested, and whether or not the applicant is a young researcher who has an advisor already participating in the program. ICERM staff then updates the applicant about their status, and any support they are eligible for, as appropriate.

Financial Decisions for Semester Programs

Financial decisions are made by ICERM Directors based on discussions with organizers. For a typical program, ICERM provides travel and lodging support for 5-10 organizers (at least a month in residence, with some for the full semester); 20-30 long-term participants (4+ weeks); 1 Institute and 5 Semester postdoctoral fellows (salaried); 60 short-term participants (1-4 weeks); 10-15 graduate students (6+ weeks); and workshop attendees. ICERM helps essential long-term participants negotiate sabbatical leaves or teaching releases to foster their participation.

Opening, Closing, and Related Events

Semester program opening and closing events are tailored to each program. Here are some examples of planned events during semester programs.

Opening event(s)

During the first week of program and can include:

- Opening reception
- 10-15 minute introductory presentations by the postdocs and grad students, designed to get everyone acquainted
- Talks related to upcoming workshops

- IT tutorial led by ICERM's IT staff

Weekly Seminar non-workshop weeks

- The weekly seminar includes talks by visitors in residence at ICERM. Program organizers are provided with names and dates to facilitate scheduling.

Mini-Series (Optional)

- Mini-courses or other multi-session events are encouraged.

Research Clusters (Optional)

A Research Cluster takes place during a semester program and is an independently organized research group activity in a focused subfield of that semester program.

A typical Research Cluster lasts at least 10 days, and as long as 4-6 weeks, and focuses on immediate progress on a major problem or on several problems of significance in the field of the program. In addition to the invited participants, interested faculty, postdocs or graduate students in residence at ICERM may participate in the research cluster.

The activity period begins with a collection of tutorials or a short workshop. The research activities, planned by the organizers, may consist of teamwork, daily/weekly seminars, and closing presentations. In collaboration with an ICERM Director, Research Cluster organizers develop a list of 6-15 key scientists to form the core cohort of the cluster.

Prior to each of semester workshops (optional)

- Full-day tutorials the Thursday and Friday the week before each workshop
- Tutorials are given by long term visitors to the program

During Semester Workshops

- Workshops last 1 week and usually consist of 45-50 minute talks with 10 minutes of Q&A.
- Sometimes one afternoon is left "open" for collaborations and small groups
- A poster session is scheduled early in the workshop week
- Networking opportunities within workshops and semester programs, e.g., opportunities for women to come together for lunchtime discussions (optional)

Non-workshop weeks

- Lectures occur through either mini courses, research seminars, special talks, and/or computational working group meetings
- Young Researcher Seminar, where graduate students and postdocs meet sans faculty and discuss scientific questions
- Postdocs and grad students are mentored throughout the program, both informally and with formal professional development seminars and meetings

Final Event

During the first week of the program discussion about a closing event occurs with the organizing committee. Some possible models include:

- Short talks from all long-term visitors who are still in residence
- Special Colloquium to close out the event on the last day of the program
- Time set aside for takeaways
- Closing reception

Note: Sample schedules and organizer timelines can be found in Appendix A.

2019-2020 Semester Programs

Fall 2019 Semester Program: Illustrating Mathematics

September 4, 2019 – December 6, 2019

Organizing Committee:
David Bachman, Pitzer College
Kelly Delp, Cornell University
David Dumas, University of Illinois at Chicago
Saul Schleimer, University of Warwick
Richard Schwartz, Brown University
Henry Segerman, Oklahoma State University
Katherine Stange, University of Colorado
Laura Taalman, James Madison University

Program Description:
The Illustrating Mathematics program brings together mathematicians, makers, and artists who share a common interest in illustrating mathematical ideas via computational tools.
The goals of the program are to:

- introduce mathematicians to new computational illustration tools to guide and inform their research;
- spark collaborations among and between mathematicians, makers and artists;
- find ways to communicate research mathematics to as wide an audience as possible.

The program includes week-long workshops in Geometry and Topology, Algebra and Number Theory, and Dynamics and Probability, as well as master courses, seminars, and an art exhibition.

Mathematical topics include: moduli spaces of geometric structures, hyperbolic geometry, configuration spaces, sphere eversions, apollonian packings, kleinian groups, sandpiles and tropical geometry, analytic number theory, supercharacters, complex dynamics, billiards, random walks, and Schramm–Loewner evolution.
Illustration media include: animation, interactive visualization, virtual and augmented reality, games, 3D printing, laser cutting, CNC routing, and textile arts. In addition, we welcome mathematical journalists, writers, and videographers interested in communicating and illustrating mathematics.

This semester program is partially funded by the Alfred P. Sloan Foundation award G-2019-11406 and supported by a Simons Foundation Targeted Grant to Institutes.

All Long-term Visitors to Fall 2019 Semester Program (10+ Days)

Name	Institute	Days@ICERM
Aaron Abrams	Washington and Lee University	93
Silviana Amethyst	University of Wisconsin - Eau Claire	93
Roger Antonsen	University of Oslo	94
Pierre Arnoux	Université d'Aix-Marseille	34
David Bachman	Pitzer College	95
Arthur Baragar	University of Nevada Las Vegas	92
Sebastian Bozlee	University of Colorado, Boulder	98
Dina Buric	University of Victoria	51
J. Carter	University of South Alabama	93
Arnaud Chéritat	Institut de Mathématiques de Toulouse	95
Rémi Coulon	CNRS / Université de Rennes 1	95
Keenan Crane	Carnegie Mellon University	32
Diana Davis	Swarthmore College	93
Brian Day	Georgia Institute of Technology	78
Kelly Delp	Cornell University	97
Michael Dimitriyev	Georgia Institute of Technology	13
Emily Donovan	Queen Mary University of London	89
Gabriel Dorfsman-Hopkins	ICERM/Berkeley	93
David Dumas	University of Illinois at Chicago	94
John Edmark	Stanford University	93
Ellen Eischen	The University of Oregon	77
Bernat Espigule	Universitat de Barcelona	93
Frank Farris	Santa Clara University	93
Aaron Fenyes	Institut des Hautes Études Scientifiques	18
Rebecca Field	James Madison University	73
Herbert Gangl	Durham University	23
William Goldman	University of Maryland	30
Matthias Görner	Pixar Animation Studios	79
Helen Grundman	Bryn Mawr College	93
Edmund Harriss	University of Arkansas	95
Judy Holdener	Kenyon College	93
Alexander Holroyd	University of Washington	72
Pat Hooper	City College of New York	67
Sarah Koch	University of Michigan, Ann Arbor	14
Max Krause	Technische Universit	93
Oliver Labs	MO-labs	21
Evelyn Lamb	Freelancer	82
Daniel Lautzenheiser	University of Nevada Las Vegas	19
Samuel Lelièvre	Université Paris-Sud	118
Taneli Luotoniemi	Aalto University	42
Alba Málaga Sabogal	ICERM	97
Jason Manning	Cornell University	97
Serge Marchetta	Independent Artist	13

Daniel Martin	University of Colorado	19
Sabetta Matsumoto	Georgia Institute of Technology	90
Curtis McMullen	Harvard University	14
Greg McShane	University of Grenoble Alpes	72
Claire Merriman	Ohio State University	45
Michael Musty	Dartmouth College	93
Stepan Paul	Harvard University	93
Olga Romaskevich	Université de Rennes 1	19
Saul Schleimer	University of Warwick	93
Richard Schwartz	Brown University	97
Henry Segerman	Oklahoma State University	90
Tashrika Sharma	University of Vienna	95
Krishma Singal	Georgia Institute of Technology	13
Martin Skrodzki	Freie Universität Berlin	102
Katherine Stange	University of Colorado	95
Mark Stock	Applied Scientific Research, Inc.	24
John Sullivan	Technische Universität Berlin	76
Laura Taalman	James Madison University	97
Ryan Tavenner	Proof School	81
Timea Tihanyi	University of Washington	81
Steve Trettel	Stanford University	105
Mikael Vejdemo Johansson	CUNY College of Staten Island	63
Glen Whitney	StudioInfinity.org	93
Jonathan Wise	University of Colorado	93
Carolyn Yackel	Mercer University	95
Katherine Ye	Carnegie Mellon University	13

Note: This roster includes ICERM's participants who stayed in-residence for all of or the majority of the semester program, as well as participants who came and went and just attended multiple program workshops throughout the semester.

Here follows a sample of the most substantive comments from our long-term visitors:
Some Long-term Visitor Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *At ICERM I learned a myriad of new technologies including but not limited do, Rhino and grasshopper, Python, Unity, SageMath, OpenScad, Blender, and Javascript. These technologies helped me illustrate, communicate, and learn from the ideas within my research in dynamics. The conversations I had helped me further understand the theoretical developments in my research and were invaluable in motivating me to keep working on the problems I had been struggling with for the past few years of my PhD.*
- *I learn how to use a number of tools (3-d printers, laser cutters) from a practical as well as software viewpoint. I got the answers to several questions regarding embedding of manifolds in usual space I started to work on questions linking combinatorics, number theory and geometry*

- *The expertise of the participants was unusually broad and interesting, and there was an experimental attitude permeating the whole program. Every day I heard someone offer to help someone else with an experiment. Sometimes one of the people was me. As a mathematician with limited experience as a maker, I found the exposure to all the different media, software, and techniques of making to be very valuable. More specifically I expect to use laser cutting and mathematica and javascript a lot more than I have in the past. I also learned a great deal from the talks and from the geometry course taught by Richard Schwartz.*
- *It was an incredibly rich environment for sharing and teaching and starting collaborations. Many of us come from different backgrounds, and had different skills, creating a safe environment to build understanding from any level. I learned a lot about computer graphics, drawing, and differential geometry, things I had little mastery of before. I also taught people and shared my skills. This led to many budding collaborations and projects I will certainly take with me moving forward.*
- *I got an overview of uses of mathematics in art and craft that I completely ignored existed before. Conversely, and this is not independent, I discovered new ways of illustrating mathematics. To be more specific: knitting and textiles are good examples. About methodologies, there are the surface evolution methods (computer), but also more hands-on approaches: Carlo Sequin doing topology computations with everyday life objects, including plastic bags and pipe cleaners; Alexander Holroyd using Lego to demonstrate the belt trick, later attempted as a dance by Schleimer and Segerman. Many computer softwares, including Sage, Globular, Bertini, Rhino, etc. Original ideas involving VR: exotic geometries, Projective transformations on algebraic surfaces, visualization of 4D fractals, etc. Also improvement of drawing skills. Desings of mechanisms. Lots of other discoveries.*
- *I definitely feel like I leveled up my programming skills this semester. This Fall semester I got an introduction to two 3D modeling programs: OpenScad and Rhino. During the semester, I was able to use Rhino to create a 3D pattern, and with the grasshopper plug-in I was able to create a 2D pattern. The workshops by Bachman on grasshopper and Rhino enabled me to begin using these programs. The joint workshop between Taalman and Amethyst, along with their online resources that they provided, also was sufficient to get me started using these programs. As for theoretical knowledge, I definitely learned more about strictly convex real projective structures, and discrete differential geometry. This was mainly through conversations with Rich Schwartz, Steve Trettle, Sabetta Matsumoto, and Jason Manning.*
- *ICERM gave space for a community of practice to emerge, around the illustration of mathematics, helping to start to understand the practices that help turn a picture of a mathematical object or idea into a full illustration, capable of generating insight and understanding. Being able to work with such an amazing group of people has significantly pushed how I approach mathematical thinking and helped significantly develop my mathematical general knowledge.*
- *I learned about a lot of theoretical developments throughout the topical semester workshops that are relevant for my research area. The opportunity to give talks in the "special interest" seminar provided me with very constructive feedback and hints. The software courses organized by several participants helped me work with software I was not comfortable working with before.*

- *I was informed of modern areas of mathematics where complex continued fractions have applications, and I was shown how to tailor my research to facilitate its use in those applications. This was largely thanks to people I met for the first time at ICERM, and this will likely lead to future collaborations. Thank you!*

Some Long-term Visitor Comments for "Briefly describe program highlights":

- My main highlights were the meetings with so many of my personal mathematical illustration heroes!
- *The highlight of the program was being a part of a community of mathematicians that are inclusive, creative, and open. The camaraderie I felt during the workshop was unparalleled. Emails were sent out to all participates on social and work events. I never felt excluded and there was always an event going on. When I presented my ideas, I felt that they were valued and accepted. Being able to hear others' ideas was awe inspiring and eye opening. I came home every day with my head buzzing with so many mathematical/technological ideas. The whole experience was a creative whirlwind. My main problem was how I could capture this creative energy and keep it going when I'm no longer part of the workshop.*
- *As a visual artist, I don't have much interaction with mathematicians. The highlight of the program for me was learning about the panelists work, what motivates the work and their processes.*
- *There were so many highlights! Perhaps the best part was the organic interactions between researchers, educators, and artists, enthusiastically and supportively exploring interactions and new directions.*
- *Too many! -Rich Schwartz's class -John Edmark's talk -art exhibit in the building -playing with everyone's creations -weekly show and tell was a great idea -drawing with charcoal -many more I'm sure!*
- *The people involved. The community of people invited and the attention and support of the staff at ICERM all helped to make the semester a truly magical experience.*
- *I did not think that I would be interested in the computational textiles workshop, but I ended up attending every session and finding several connections with my previous work on symmetry. It inspired me to use my knowledge from Fourier theory to create virtual knit patterns and mathematical chain mail. It seems to me that this could lead to new developments in 3D printed materials.*
- *The ease with with collaboration was able to happen across disciplines since mathematicians from* so many areas were all in one place.

Workshop 1: Program Opener: Meet, Make and Design

September 5, 2019-September 6, 2019

Organizing Committee:
David Bachman, Pitzer College
Kelly Delp, Cornell
Richard Schwartz, Brown University

Program Description:
Participants will be introduced to projects, equipment, and one another. Activities will include:

- participant lightning talk show and tell

- project introductions
- start of the micro courses
- tour of equipment
- short course planning session

There will be ample time for discussions with potential semester collaborators.

Participant List Workshop 1

Name	Institute
Aaron Abrams	Washington and Lee University
Silviana Amethyst	University of Wisconsin - Eau Claire
Roger Antonsen	University of Oslo
David Bachman	Pitzer College
Arthur Baragar	University of Nevada Las Vegas
Sebastian Bozlee	University of Colorado, Boulder
J. Carter	University of South Alabama
Arnaud Chéritat	Institut de Mathématiques de Toulouse
Rémi Coulon	CNRS / Université de Rennes 1
Diana Davis	Swarthmore College
Kelly Delp	Cornell
Emily Donovan	Queen Mary University of London
Gabriel Dorfsman-Hopkins	ICERM/Berkeley
David Dumas	University of Illinois at Chicago
John Edmark	Stanford University
Ellen Eischen	The University of Oregon
Bernat Espigule	Universitat de Barcelona
Frank Farris	Santa Clara University
Aaron Fenyes	Institut des Hautes Études Scientifiques
Matthias Görner	Pixar Animation Studios
Herbert Gangl	Durham University
William Goldman	University of Maryland
Edmund Harriss	University of Arkansas
Judy Holdener	Kenyon College
Alexander Holroyd	University of Washington
Max Krause	Technische Universität Berlin
Oliver Labs	MO-labs
Evelyn Lamb	freelance
Samuel Lelièvre	Université Paris-Sud
Taneli Luotoniemi	Aalto University
Alba Málaga Sabogal	ICERM
Jason Manning	Cornell University
Sabetta Matsumoto	Georgia Institute of Technology
Curtis McMullen	Harvard University
Michael Musty	Dartmouth College
Stepan Paul	Harvard University
Olga Romaskevich	University of Rennes 1

Saul Schleimer	University of Warwick
Richard Schwartz	Brown University
Tashrika Sharma	University of Vienna
Martin Skrodzki	Freie Universität Berlin
Katherine Stange	University of Colorado
Mark Stock	Applied Scientific Research, Inc.
John Sullivan	Technische Universität Berlin
Laura Taalman	James Madison University
Timea Tihanyi	University of Washington
Steve Trettel	Stanford University
Mikael Vejdemo Johansson	CUNY College of Staten Island
Glen Whitney	StudioInfinity.org
Carolyn Yackel	Mercer University

There was no exit survey for this opening event.

Workshop 2: Illustrating Geometry and Topology

September 16, 2019-September 20, 2019

Organizing Committee:
Keenan Crane, Carnegie Mellon University
David Dumas, University of Illinois at Chicago

Program Description:
This workshop will focus on the interaction between visualization, computer experiment, and theoretical advances in all areas of research in geometry and topology. Fruitful interactions of this type have a long history in the field, with physical models and computer images and animations providing both illustration of existing work and inspiration for new developments. Emerging visualization technologies, such as virtual reality, are poised to further increase the tools available for mathematical illustration and experimentation. By bringing together expert practitioners of mathematical visualization techniques and researchers interested in incorporating such tools into their research, the workshop will give participants a clear picture of the state of the art in this fast-moving field while also fostering new collaborations and innovations in illustrating geometry and topology.

This workshop is partially funded by the Alfred P. Sloan Foundation award G-2019-11406 and supported by a Simons Foundation Targeted Grant to Institutes.

Organizers gathered workshop participants' input on objects from geometry and topology that they would like to see visualized. The list has been transcribed and made available here: cs.cmu.edu/~kmcrane/VisualizationChallenges

Participant List Workshop 2

Name	**Institute**
Aaron Abrams	Washington and Lee University
Henry Adams	Colorado State University

Silviana Amethyst	University of Wisconsin - Eau Claire
Roger Antonsen	University of Oslo
Alex Austin	NTID @ RIT
David Bachman	Pitzer College
Tom Banchoff	Brown University
Arthur Baragar	University of Nevada Las Vegas
Loretta Bartolini	Springer
Vincent Borrelli*	Institut Camille Jordan
John Bowers	James Madison University
Sebastian Bozlee	University of Colorado, Boulder
Matt Brand*	Zintaglio Arts
Vladimir Bulatov	Shapeways, Inc
Danny Calegari*	University of Chicago
J. Carter	University of South Alabama
Dorota Celińska-Kopczyńska	University of Warsaw
Teressa Chambers	Brown University
Indira Chatterji	Université de Nice
Arnaud Chéritat	Institut de Mathématiques de Toulouse
Albert Chern*	Technische Universität Berlin
Rhoslyn Coles	Technische Universität Berlin
Rémi Coulon	CNRS / Université de Rennes 1
Keenan Crane	Carnegie Mellon University
Brian Day	Georgia Institute of Technology
Luiz Henrique de Figueiredo	IMPA
Charles Delman	Eastern Illinois University
Kelly Delp	Cornell University
Elizabeth Denne	Washington & Lee University
Michael Dimitriyev	Georgia Institute of Technology
Emily Donovan	Queen Mary University of London
Gabriel Dorfsman-Hopkins	ICERM/Berkeley
David Dumas	University of Illinois at Chicago
Nathan Dunfield*	University of Illinois, Urbana-Champaign
John Edmark	Stanford University
Robert Edwards	UCLA
Ellen Eischen	The University of Oregon
Jeff Erickson*	University of Illinois at Urbana-Champaign
Bernat Espigule	Universitat de Barcelona
Frank Farris	Santa Clara University
Aaron Fenyes	Institut des Hautes Études Scientifiques
Rebecca Field	James Madison University
Martin Flashman	Humboldt State University
George Francis	University of Illinois at Urbana, Champaign
Michael Gage	University of Rochester
Sayonita Ghosh Hajra	California State University
Robert Ghrist*	University of Pennsylvania
William Goldman	University of Maryland

Chaim Goodman-Strauss	University of Arkansas
Matthias Görner	Pixar Animation Studios
Bathsheba Grossman	Bathsheba Sculpture
Charles Gunn*	Technische Universität Berlin
Wesley Hamilton	University of North Carolina, Chapel Hill
Andrew Hanson*	Indiana University, Bloomington
Edmund Harriss	University of Arkansas
Allison Henrich	Seattle University
Eriko Hironaka	AMS, Florida State University
Judy Holdener	Kenyon College
Alexander Holroyd	University of Washington
Alex Hornstein	Looking Glass Factory, Inc
Veronika Irvine	University of Waterloo
Yutaka Ishii	Kyushu University
Rajaa Issa	Robert McNeel & Associates
Richard Kenyon*	Yale University
Kevin Knudson	University of Florida
Aleksandr Kolpakov	University of Neuchâtel
Eryk Kopczyński	University of Warsaw
Hana Kourimska	Technische Universität Berlin
Max Krause	Technische Universität Berlin
Oliver Labs	MO-labs
Evelyn Lamb	Freelancer
Francis Lazarus	CNRS
Minh Le	SUNY Buffalo
August Lehrecke	Penuhaus/Rhode Island School of Design
Samuel Lelièvre	Université Paris-Sud
Jesse Levitt	University of Southern California
Isabel Liao	Tufts University
Jasper Liu	Brown University
Jesse Louis-Rosenberg*	Nervous System
Taneli Luotoniemi	Aalto University
Jason Manning	Cornell University
Sabetta Matsumoto*	Georgia Institute of Technology
Curtis McMullen*	Harvard University
Ralph Morrison	Williams College
Bjoern Muetzel	Dartmouth College
Michael Musty	Dartmouth College
Roice Nelson*	GE Aviation
Margaret Nichols	University at Buffalo
Caleb Nussear	Independent Artist
Nicholas Owad	Okinawa Institute of Science and Technology, Colby College
Marcel Padilla	Technical University of Berlin
Hugo Parlier*	University of Luxembourg
Stepan Paul	Harvard University
Ulrich Pinkall*	Technische Universität Berlin

Joseph Quinn	National Museum of Mathematics
Isabella Retter	Technische Universität Berlin
Olga Romaskevich	University of Rennes 1
Jessica Rosenkrantz*	Nervous System
Elissa Ross*	MESH Consultants Inc.
Anschel Schaffer-Cohen	University of Pennsylvania
Saul Schleimer*	University of Warwick
Richard Schwartz*	Brown University
Henry Segerman	Oklahoma State University
Carlo Séquin*	University of California, Berkeley
Tashrika Sharma	University of Vienna
Thomas Shifley	University of California Santa Barbara
Krishma Singal	Georgia Institute of Technology
Martin Skrodzki	Freie Universität Berlin
Katherine Stange	University of Colorado
Kenneth Stephenson*	University of Tennessee
John Sullivan	Technische Universität Berlin
Yuri Sulyma	Brown University
Moritz Sümmermann	University of Cologne
Laura Taalman	James Madison University
Ryan Tavenner	Proof School
Luciano Teresi	Université Grenoble Alpes
Mélanie Theillière	Institut Camille Jordan
Boris Thibert	Université Grenoble Alpes
Timea Tihanyi	University of Washington
Hamish Todd	University of Edinburgh
Steve Trettel*	Stanford University
Mikael Vejdemo Johansson	CUNY College of Staten Island
Joshua Vekhter	University of Texas Austin
Jeff Weeks*	Geometry Games
Glen Whitney	StudioInfinity.org
Jonathan Wise	University of Colorado
Runhan Xie	Brown University
Carolyn Yackel	Mercer University
Katherine Ye*	Carnegie Mellon University
Zihui Zhao	University of Chicago

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *I learned some new graphical tools, but the main benefit in this regard was gaining a variety of perspectives on mathematical visualization that will play a role in both my research and the exposition of my research. I was particularly intrigued by algorithmic simulation of growth and form and might well explore this area in the future (although it is not now my research area). I was also very intrigued by the poster presentations on*

refractive billiards and triangulations, having done work on reflective billiards, and by the talks on conformal and isometric embeddings. I developed some ideas for artistic and illustrative work. In general, a highly educational workshop with a nice variety of topics and good balance between digital and "low tech" approaches.

- *It was of great interest and extremely helpful to me to see what software and programs other people are using for several purposes. In most of the talks, it was emphasized in which framework software was developed, which I found quite useful. Also, to see what is possible today, e.g., in terms of real-time rendering and virtual reality, was very interesting.*
- *The talk I learned the most from was by Albert Chern. I also learned a lot from the two talks about embeddings of tori (smooth conformal and C^1-isometric). It was a clarifying a bunch of theoretical questions but also showed how to actually in practice get great visualizations.*
- *The Geometry and Topology workshop was an intense week with a ton of interaction and exposure to others in the field, both to their methods and theoretical approaches. I think this is the manner in which ICERM helped me the most. Absorbing all the information was like drinking from a firehose through a straw, but I left with many new connections and avenues for improvement in methods/theory.*
- *From the lectures and private I've learned what other researchers are doing for the visualization of group theory. In particularly informative for me were presentations by Saul Schleimer and Curtis McMullen. One significant aspect is change of visualization technologies caused by web software development. Unfortunate disappearance of java applets form on the web caused a lot of grief among researchers writing visualzation and education software. New web technologies like webgl are much more powerful, but much harder to use. As a result, very few mathematicians have started to use it.*
- *Knowledge of various computational tools (SnapPy, Rhino/Grasshopper etc.) that will help with computational experiments and visualization of knots and links.*
- *There were many different types of expertise and experience present and it was easy to strike up conversations.*
- *ICERM definitely added greatly to my knowledge of experimental / computational methodologies in visualizing geometric and topological structures and operations. I found many of the lectures to be generally informative and inspiring, especially: Adventures w the GPU by Roice Nelson; Circle Packing Beauties by Kenneth Stephenson; Physical Illustrations of Knot Deformations and Surface Eversions by Carlo Sequin; Illustrating String Theory by Andrew Hanson; Inscribing Rectangles in Jordan Loops by Rich Schwartz; Geometry or Random Stepped Surfaces by Richard Kenyon; and Illustrating Infinity by Curtis McMullen. I intend to several of the concepts I was introduced to here in future work and collaborations.*
- *The interchange among the diverse group of participants was extraordinary. I can't overstate how much I learned from this workshop!*
- *I was able to talk with other participants as well as the representative of Rhino to learn about how this tool can assist me in exploring my research area of computational textiles faster and take it farther. I was able to take to several people working on interesting surfaces and find out key information that will allow me to explore these surfaces in sculptural form.*

- *I have been wanting to learn computational techniques for a long time, and with its combined emphasis this conference has provided a road map for me to move forward with my learning process.*
- *In my research area of pure mathematics, illustration is not sought after by most researchers even though the objects we care about are very geometric. This is mostly due to the higher-dimensional and thus abstract nature of the research subject, but also (in my view) due to the fact that the effort to illustrate examples or proof argument is not well-rewarded. Through various wonderful talks during this workshop, I see how good illustrations, in the form of films, VR games, interactive pictures, or art objects, can have long-lasting impact on people's understanding of the research subjects. This definitely benefits an effective diffusion of knowledge between people in different times and from experts to learners. Even though I'm not likely to become an expert in computer graphics, I will certainly put more effort in making my work understandable by using various illustration tools I learnt here.*
- *I will receive the material to set up an experimental geometry lab. This will be open up new directions in research, especially in undergraduate research.*
- *Very helpful to see some of those at the leading edge in graphics and presentation, and learn more about the tools available and in development. Seeing the aesthetic side was newer to me and will be very valuable: how you can best reach your audience, whether students, researchers, or the general public. This can make a positive contribution both to those of us here and may spread out to mathematics communication more broadly.*
- *Every single talk is inspiring in both the math aspect and in the art and story-telling aspects. Although I vaguely knew the concept, it is this workshop that I really appreciate the computation tools such as shaders, beautiful theories of geometric algebra, artistic visualization methods, just to name a few.*
- *It would be nice if people more advanced in their computational methodologies could lead more interactive/collaborative workshops with resources of navigating the development of their technical work.*

Some Workshop Participant Comments for "Briefly describe workshop highlights":

- *Discussing different types of mathematically inspired jigsaw puzzles. Learning about shellability. Learning about spongogenesis as way of describing disordered minimal surface foam-like structures. Mostly meeting and talking to people in between sessions.*
- *My personal highlight was to see how Thurston's ideas on geometry and topology are explored further by today's computational possibilities.*
- *On the one hand, the topic of this workshop is very alive. On the other hand, there are still almost no workshops in this field.*
- *My favorite talks: Albert Chern, Steve Trettel, Vincent Borrelli. My least favorite talk of all of them: Kenneth Stephenson.*
- *There were two highlights: 1. The lecture by Nervous System contained many beautiful ideas and mathematical applications to design. 2. The lecture by Vincent Borricelli explained Gromov's theory of convex integration to me in a completely clear and lucid way. I learned a tremendous amount from the lecture.*
- *The rich display of geometric sculptures and of mathematical visualization models, and the opportunity to talk to the artists about those models.*

- *It's very difficult to pick one, but I think the highlight was meeting and interacting with Charlie Gunn. His videos have had a big influence on my mathematical work. It turned out his presentation was not only in-line with my current interests, but that there are opportunities to get involved with his efforts.*
- *Main highlight was to make personal contacts with many researchers who I knew before only form the publications. Those contacts helped to initiate new collaboration.*
- *Spending two weeks in an office full of people who feel the pull of visualization, art, and design as deeply as I do was one of the most heartening and motivating research experiences I've had in the last few years. The amounts of energy and expertise drawn by the Illustrating Mathematics program are extraordinary, and I hope I'll keep tapping into them through correspondence and collaboration over the years to come.*
- *The breadth of interests and expertise, and the serious interplay between mathematics and art were truly inspiring. I honestly can't remember a research workshop that I've enjoyed more!*
- *Two things: 1. The high quality of the talks. 2. The effectiveness of informal conversations and collaborations between and after the formal talks. ICERM is very well organized for this -- visitors can chat informally in the main area just outside the lecture hall, and then when needed step off into the small seminar room at the side for a quieter environment (but still with a chalkboard and table) to work with people on more focused projects. The open area on the 10th floor provided another useful space for working with people. Over the course of the week I found myself taking advantage of all those facilities.*
- *The lectures I listed in the first question were all excellent and very informative for me. Generally, I couldn't imagine enjoying an academic conference more than I enjoyed my week at ICERM. In my sculptural work applying geometric and topological concepts to the field of fine art, I often like I am working in isolation. After this past week I understand the depth of the community working on these intersections - that is my overall highlight in a week filled with highlights...*
- *The highlight of the workshop was connecting with so many helpful and supportive people from the field of topology and geometry. I met several people whose work I have long admired and who have influenced my career path. They were all supportive, kind and helpful. I also met several people that I had not heard of before but whose work could be useful in furthering my research.*
- *The recurring highlight was having the opportunity to interact with so many makers who have very different skill sets from mine but who also have a genuine interest in cross-disciplinary interaction and collaboration.*
- *The participants were very vibrant and from diverse research areas. They really made this workshop a success. The sense of community and collaboration was great.*
- *Reconnecting with old friends and meeting new young ones, all the time seeing impressive way of illustrating mathematics.*
- *The poster session allowed me to engage in dialogue about my work without having to handle the feeling of being overwhelmed and needing to talk to everyone.*

Workshop 3: Computational Textiles Working Group

September 23 - 27, 2019

Organizing Committee:
Sabetta Matsumoto, Georgia Institute of Technology
Saul Schleimer, University of Warwick
Henry Segerman, Oklahoma State University
Laura Taalman, James Madison University

Program Description:
The aim of this working group is to bring together theorists and practitioners of computational fiber arts and will have three related themes.

First, we would like to prove theorems about the geometry and topology of knitting. Second, we would like to explore the idea that knitting and textiles can be a physical embodiment of ideas in computational geometry. Third, we will use knitting and other textile arts as a way of visually communicating mathematical ideas to a broader audience.

Participant List Workshop 3

Name	Institute
Rena Alisa	Artist
Roger Antonsen	University of Oslo
Daria Atkinson	UMass Amherst
Sarah-Marie Belcastro*	Smith College
Dina Buric	University of Victoria
Kelly Delp*	Cornell University
Michael Dimitriyev*	Georgia Institute of Technology
Emily Donovan	Queen Mary University of London
Gabriel Dorfsman-Hopkins	ICERM/Berkeley
John Edmark	Stanford University
Bernat Espigule	Universitat de Barcelona
Frank Farris*	Santa Clara University
Rebecca Field*	James Madison University
Anna Gitelson-Kahn*	RISD
Susan Goldstine*	St. Mary's College of Maryland
Helen Grundman	Bryn Mawr College
Brooks Hagan	Rhode Island School of Design
Veronika Irvine*	University of Waterloo
Max Krause	Technische Universität Berlin
Taneli Luotoniemi	Aalto University
Alba Málaga Sabogal	ICERM
Shashank Markande	Georgia Tech
Sabetta Matsumoto*	Georgia Institute of Technology
Jim McCann*	Carnegie Mellon University
Eleftherios Pavlides	Roger Williams University
Saul Schleimer	University of Warwick
Henry Segerman	Oklahoma State University
Tashrika Sharma	University of Vienna
Krishma Singal	Georgia Institute of Technology

Katherine Stange	University of Colorado
John Sullivan	Technische Universität Berlin
Laura Taalman	James Madison University
Daina Taimina*	Cornell University
Carolyn Yackel*	Mercer University

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *ICERM's Computational Textiles Working Group has opened me a new world of possibilities when it comes to finding applications to my mathematical research on plane-filling curves, analysis on fractals, 3D-printing exotic topologies, etc. I've been able to learn the foundations of this emerging new field from the world's leading experts.*
- *Learned a lot on axiomatization of textiles, and got some ideas for interesting work on linear stability of rod models and its application to textile mechanics.*
- *I learned a lot about how physicists' study complex problems.*
- *I got a strong sense from Edmund Harriss that I could use Rhino+Kangaroo to make useful simulations for my work. The research taking place in Sabetta's lab and in Jim McCann's lab closely parallels the work I have been doing but using a different fabrication method. I learned quite a bit from observing how they explore the open problems. Prior to this conference, I was not aware of their work.*
- *I found new ways to connect my previous research to design of 3D printed fabrics, such as those produced by Nervous System.*
- *I have learned how different physical techniques for creating fabric work (knitting, weaving etc.), and learned about the status of research into links in the thickened torus.*

Some Workshop Participant Comments for "Briefly describe workshop highlights":

- *The greatest benefit for me was being in the same place as colleagues with the same interests and having time to discuss ideas. In particular, I was able to take an afternoon with one of the semester-long visitors in which he walked me through the process he uses to create his digital images. During that afternoon, I was able to see and ask more about a number of packages I've wanted to adopt than in any previous conversation or talk.*
- *Really enjoyed meeting people interested in similar fields as me. I wish there were more current graduate students to speak with and maybe even more undergraduates to spark more interest.*
- *Veronika Irvine's talk on the mathematics of bobbin lace! A real tour de force, and very inspiring work.*
- *Touring the RISD textiles facilities was eye-opening, but I think the real highlight for me was Sabetta's explanation of how to transform a knot on a torus to a link in the plane.*
- *I found the discussion groups very productive and an excellent way to kick off new collaborations and research ideas. I found this type of interaction much more useful than attending talks and socializing during coffee breaks.*
- *I was happy that my talk was so well received. I'm not in the field of computational textiles, but I found an audience very receptive to the possible application of my work in symmetry to textile design.*

- *So many terrific talks! Two stood out for me. * Diana Tamima's hyperbolic crocheting * Frank Ferris' wallpaper*
- *The selection of speakers was excellent. It was nice to have plenty of time for collaboration among participants. ICERM provided great support for participants in all possible ways - technical support, answering questions, organizing stay in Providence, nice tea/coffee breaks etc.*

Workshop 4: Illustrating Number Theory and Algebra

October 21- 25, 2019

Organizing Committee:
Ellen Eischen, The University of Oregon
Joel Kamnitzer, University of Toronto
Alex Kontorovich, Rutgers University
Katherine Stange, University of Colorado

Program Description:
The symbiotic relationship between the illustration of mathematics and mathematical research is now flowering in algebra and number theory. This workshop aims to both showcase and develop these connections, including the development of new visualization tools for algebra and number theory. Topics are wide-ranging, and include Apollonian circle packings and the illustration of the arithmetic of hyperbolic manifolds more generally, the visual exploration of the statistics of integer sequences, and the illustrative geometry of such objects as Gaussian periods and Fourier coefficients of modular forms. Other topics may include expander graphs, abelian sandpiles, and Diophantine approximation on varieties. We will also focus on diagrammatic algebras and categories such as Khovanov-Lauda-Rouquier algebras, Soergel bimodule categories, spider categories, and foam categories. The ability to visualize complicated relations diagrammatically has led to important advances in representation theory and knot theory in recent years.

This workshop is partially funded by the Alfred P. Sloan Foundation award G-2019-11406 and supported by a Simons Foundation Targeted Grant to Institutes.

Participant List Workshop 4

Name	Institute
Aaron Abrams	Washington and Lee University
Silviana Amethyst	University of Wisconsin - Eau Claire
Roger Antonsen	University of Oslo
Pierre Arnoux*	Université d'Aix-Marseille
Arthur Baragar*	University of Nevada Las Vegas
Sebastian Bozlee	University of Colorado, Boulder
Dina Buric	University of Victoria
J. Carter	University of South Alabama
Anne Carter	University of Hawaii at Manoa
Nathan Carter*	Bentley University
Arnaud Chéritat	Institut de Mathématiques de Toulouse
Rémi Coulon	CNRS / Université de Rennes 1

Stephen Davis	Brown University
Mahadi Ddamulira	Graz University of Technology
Kelly Delp	Cornell University
Emily Donovan	Queen Mary University of London
Gabriel Dorfsman-Hopkins	ICERM/Berkeley
David Dumas	University of Illinois at Chicago
Tom Edgar	Pacific Lutheran University
John Edmark	Stanford University
Ellen Eischen	The University of Oregon
David Eisenbud	Mathematical Sciences Research Institute and University of California, Berkeley
Bernat Espigule	Universitat de Barcelona
Frank Farris*	Santa Clara University
Amy Feaver	The King's University
Michal Ferov*	University of Newcastle, Australia
Rebecca Field	James Madison University
Holley Friedlander	Dickinson College
Elena Fuchs*	University of Illinois at Urbana-Champaign
Matthias Görner	Pixar Animation Studios
Stephan Garcia*	Pomona College
Eva Goedhart	Williams College
Hester Graves	IDA/CCS
Camille Gros	RISD Illustration
Helen Grundman	Bryn Mawr College
Nadir Hajouji	University of California, Santa Barbara
Edmund Harriss*	University of Arkansas
Sachi Hashimoto	Boston University
Judy Holdener	Kenyon College
Alexander Holroyd	University of Washington
Catherine Hsu*	University of Bristol
Joel Kamnitzer	University of Toronto
Kimia Kazemian	Cornell university
Margaret Kepner*	Independent
Seoyoung Kim	Queen's University
Allen Knutson*	Cornell University
Jerzy Kocik	Southern Illinois University
Alex Kontorovich	Rutgers University
Max Krause	Technische Universität Berlin
Evelyn Lamb	freelance
Daniel Lautzenheiser	University of Nevada Las Vegas
Samuel Lelièvre	Université Paris-Sud
Li-Mei Lim	Boston University
Matthew Litman	University of California, Davis
Dana Mackenzie	Freelance Writer
Jason Manning	Cornell University
Daniel Martin*	University of Colorado

Vince Matsko	Independent consultant
Sabetta Matsumoto	Georgia Institute of Technology
Alex McDonough	Brown University
Greg McShane	University of Grenoble Alpes
Claire Merriman*	Ohio State University
David Moore*	University of California, San Diego
Michael Musty	Dartmouth College
Robert Muth	Washington & Jefferson College
Brooke Ogrodnik	Rutgers University
Stepan Paul	Harvard University
Emily Peters*	Loyola University Chicago
Lam Pham	Brandeis University
David Rainford*	Unknown
Johannes Rau*	University of Tübingen
David Rose*	University of North Carolina at Chapel Hill
Natasha Rozhkovskaya	Kansas State University
Sayan Samanta	Brown University
Grant Sanderson*	3Blue1Brown
Saul Schleimer	University of Warwick
Richard Schwartz	Brown University
Henry Segerman	Oklahoma State University
Tashrika Sharma	University of Vienna
Arseniy Sheydvasser*	City University of New York, Graduate Center
Jennifer Shin	8 Path Solutions | New York University | NBCUniversal
Olena Shmahalo*	Simons Foundation / Quanta Magazine
Martin Skrodzki	Freie Universität Berlin
Katherine Stange	University of Colorado
John Sullivan	Technische Universitat Berlin
Yuri Sulyma	Brown University
Laura Taalman	James Madison University
Ryan Tavenner	Proof School
Steve Trettel	Stanford University
Elias Wegert*	Freiberg University of Mining and Technology
Marty Weissman*	University of California, Santa Cruz
Glen Whitney	StudioInfinity.org
Jonathan Wise	University of Colorado
David Wright*	Oklahoma State University
Carolyn Yackel	Mercer University
Benjamin Young*	University of Oregon

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *The Illustrating Number Theory and Algebra organized at ICERM has added many interesting topics and new techniques to my knowledge. Deformation of lattices,*

versatility of Cayley graphs, cutting sequences, continued fractions, Apollonian circle packings, locally-finite infinite vertex-transitive graphs, sphere packings, rational curves, and Coxeter graphs, seeing the monodromy group of a Blaschke product, fractal objects that arise from iteration of various zeta functions, algebraic relations and integrality of limit sets of maximal cusp groups.

- *By putting an emphasis on the methods of deriving and finding the results as compared to on how to prove the results, I felt that I was able to gain a deeper appreciation for the different subfields of algebra and number theory. The illustrations created by a myriad of different approaches to solving problems exemplified the versatility of mathematics as a whole, and getting to see that was quite rewarding.*
- *Not only do I have new ideas on how to add illustrations to my previously image-free work, I now know who to contact and have ideas on how to do this well. I also met someone how has just developed the theoretical tools that I need to complete a 3-year-long research project.*
- *I learned a lot about how to better use existing technology to visualizing data in number theory. The speakers did a great job acknowledging the problems one runs into and proposed lots of effective work-arounds.*
- *The topic of this workshop is far from my expertise, so the new connections are especially valuable. My work is more closely connected to rings of quadratic integers than I had previously believed.*
- *I have acquired new skills in computer algebra and in 3D printing; this has dramatically advanced my research and diffusion projects. I got access to new ideas, and found unexpectedly the answer to several questions I had been researching for some time. I met several new persons working in neighboring fields.*
- *ICERM has provided me with a basic understanding of higher-level mathematics terminology. The lecture series has also allowed me to meet new figures in this field, which invigorates me to study further in this subject.*
- *Seeing all of the different things people are doing with software and mathematics really inspired me to finally learn coding. Have specific goals and projects really helps.*
- *I was inspired by the range of methods that the participants used to render their mathematical concepts: 3D prints, animations, phase portraits, and even Minecraft*

Some Workshop Participant Comments for "Briefly describe workshop highlights":

- *The highlight of this workshop was seeing so much exciting mathematics! The atmosphere was much different than other conferences that I've attended, and I really enjoyed all of the talks.*
- *The development of new visualization tools for algebra and number theory was very impressive.*
- *Seeing a presentation on the current research on the arithmetic of Apollonian circle packings.*
- *The highlight of the workshop for me was seeing people communicate their ideas through various means. Many of the ideas presented has helped me kickstart my own research and showed me how to better communicate my own ideas. The talks were wonderful and the lightning talks helped me initiate conversations. It was a creative whirlwind of ideas that I was very happy to be a part of.*

- *I enjoyed presenting my work, because for the first time ever, I got a collaborator from my presentation. I enjoyed Olena's and Grant's presentations, which made me really think about how art and visuals can lessen cognitive and emotional loads to ease transmission of knowledge.*
- *It was a pleasure to her Grant Sanderson's talk and then sit and talk with him afterward. This is definitely a fresh new voice in our mathematical community.*
- *It was really inspiring to see the ways people explored interdisciplinary research connected with algebra and number theory, and to benefit from their insights about communicating mathematics effectively.*
- *The highlight of this workshop was the excellent talks that were both interesting and accessible. This conference was one of the most fun that I have been to in a long time - partly because of the subject matter and partly because of the welcoming environment.*
- *Making new and old connections. Talks on Apollonian circles (both official talks and informal chats) gave me ideas for future articles. Art work was amazing and inspiring, and may also be a subject for future writing.*
- *Seeing animations of the hyperbolic geodesics I've been studying was really exciting. I've really wanted animations to help visualize what was happening, so it was super exciting to see Edmund and Pierre's work.*
- *I thought that the Animating the deformation of Lattices talk as well as Galaxy Leggings, Truth Serum, & the Visibility Cloak were absolutely inspiring talks that just made me want to go and create.*
- *I have several in addition to being invited to speak: (a) the Minecraft-based presentation by Benjamin Young of the University of Oregon; (b) the unique presentation by Olena Shmahalo of Quanta Magazine; (c) the art displays at ICERM and the gallery, including the 3D printed items*
- *The conference was truly unique in its overriding theme of building bridges between the arts and mathematics. This made many of the talks very pleasant and surprising in the connections that were found in these disciplines.*

Workshop 5: Illustrating Dynamics and Probability

November 11- 15, 2019

Organizing Committee:
Jayadev Athreya, University of Washington
Alexander Holroyd, University of Washington
Sarah Koch, University of Michigan, Ann Arbor

Program Description:
This workshop will focus on the theoretical insights developed via illustration, visualization, and computational experiment in dynamical systems and probability theory. Some topics from complex dynamics include: dynamical moduli spaces and their dynamically-defined subvarieties, degenerations of dynamical systems as one moves toward the boundary of moduli space, and the structure of algebraic data coming from a family of dynamical systems. In classical dynamical systems, some topics include: flows on hyperbolic spaces and Lorentz attractors, simple physical systems like billiards in two and three dimensional domains, and flows on moduli spaces. In

probability theory, the workshop features: random walks and continuous time random processes like Brownian motion, SLE, and scaling limits of discrete systems.

This workshop is partially funded by the Alfred P. Sloan Foundation award G-2019-11406 and supported by a Simons Foundation Targeted Grant to Institutes.

Participant List Workshop 5

Name	Institute
Aaron Abrams	Washington and Lee University
DarV≠o Alatorre	UNAM
Silviana Amethyst	University of Wisconsin - Eau Claire
Roger Antonsen	University of Oslo
Pierre Arnoux	Université d'Aix-Marseille
Jayadev Athreya	University of Washington
Arthur Baragar	University of Nevada Las Vegas
Peter Benson	Cherry Arbor Design, LLC
Chris Bishop*	Stony Brook University
Patrick Bishop	George Mason University
Ahmed Bou-Rabee	University of Chicago
Sebastian Bozlee	University of Colorado, Boulder
Florestan Brunck	McGill University
Dina Buric*	University of Victoria
J. Carter	University of South Alabama
Arnaud Chéritat*	Institut de Mathématiques de Toulouse
Subhadip Chowdhury	Bowdoin College
Tim Chumley	Mount Holyoke College
Rémi Coulon	CNRS / Université de Rennes 1
Christopher Cox	Tarleton State University
Kelly Delp	Cornell University
Laura DeMarco*	Northwestern University
Emily Donovan	Queen Mary University of London
Gabriel Dorfsman-Hopkins	ICERM/Berkeley
David Dumas	University of Illinois at Chicago
John Edmark	Stanford University
Ellen Eischen	The University of Oregon
Bernat Espigule	Universitat de Barcelona
Frank Farris	Santa Clara University
Khashayar Filom*	Northwestern University
Behrang Forghano	Bowdoin College
Matthias Görner*	Pixar Animation Studios
Janko Gravner*	University of California, Davis
Helen Grundman	Bryn Mawr College
Edmund Harriss	University of Arkansas
Jordan Hartzell	Brown University
Yan Mary He*	University of Luxembourg
Paige Helms	University of Washington

Christopher Hoffman	University of Washington
Judy Holdener	Kenyon College
Alexander Holroyd	University of Washington
Pavel Javornik	City College of New York
Isabelle Kemajou-Brown	Morgan State University
Sarah Koch	University of Michigan, Ann Arbor
Max Krause	Technische Universität Berlin
Evelyn Lamb	freelance
Sara Lapan	University of California, Riverside
Greg Leclerc	University of Rhode Island
George Legrady*	University of California, Santa Barbara
Samuel Lelièvre	Université Paris-Sud
Lionel Levine*	Cornell University
Feng Liang	Cornell University
Kathryn Lindsey*	Boston College
Patrick Liscio	Brown University
Alba Málaga Sabogal	ICERM
Jason Manning	Cornell University
Sabetta Matsumoto*	Georgia Institute of Technology
Alex McDonough	Brown University
Greg McShane	University of Grenoble Alpes
Claire Merriman	Ohio State University
Jason Miller*	University of Cambridge
Michael Musty	Dartmouth College
Stepan Paul	Harvard University
Wesley Pegden*	Carnegie Mellon University
Lam Pham	Brandeis University
Afroditi Psarra*	University of Washington
Remus Radu*	Institute for Mathematics of the Romanian Academy
Heidi Robb	Cherry Arbor Design
Steffen Rohde*	University of Washington
Dan Romik*	University of California, Davis
Evelyn Sander	George Mason University
Saul Schleimer	University of Warwick
Richard Schwartz	Brown University
Henry Segerman	Oklahoma State University
Thomas Sharland*	University of Rhode Island
Tashrika Sharma	University of Vienna
Sunrose Shrestha	Tufts University
Martin Skrodzki	Freie Universität Berlin
Katherine Stange	University of Colorado
Ivan Sudakov	University of Dayton
John Sullivan	Technische Universitat Berlin
Laura Taalman	James Madison University
Diaaeldin Taha	University of Washington-Seattle
Raluca Tanase*	Institute for Mathematics of the Romanian Academy

Ryan Tavenner	Proof School
Timea Tihanyi*	University of Washington
Giulio Tiozzo*	University of Toronto
Steve Trettel	Stanford University
Xiaoguang Wang	Zhejiang University
Glen Whitney	StudioInfinity.org
Peter Winkler*	Dartmouth College
Jonathan Wise	University of Colorado
Carolyn Yackel	Mercer University
Lingjiong Zhu	Florida State University

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *Several of the talks on things like experimental mathematics and sandpile models provided helpful ideas for things that I've been working on. The workshop also provided the chance to meet and talk to a lot of great mathematicians working on similar research.*
- *This is not my primary field but the presentations were inspirational. I especially enjoyed learning about developments with sandpiles and 3d printing of ceramics.*
- *I am an artist who partners with a mathematician and we will use what we have learned to collaborate on projects in the future. There are several mathematicians who have shared code with us and we hope to collaborate with them and hopefully create some beautiful pieces.*
- *ICERM has contributed to my knowledge of computational methodologies by introducing me to different tools for computing dynamical systems via talks and the "sage" working group, showing me different ways other researchers use computers in their research, and giving me more experience using Sage. I spent 4 of the lunch periods with the sage working group, which was a fantastic way for me to learn much more about how to use Sage and see how other people are using Sage/other programs for their research. ICERM also introduced me to different ways in which one can make use of 3D printers to create hands-on mathematical models -- this was the first time I saw a 3D printer in person and I had the chance to see people work with the printer to create different types of models, which was very interesting and useful for me to use one in the future.*
- *I learned about many computational packages I will definitely start using.*
- *As one of the few artist participants, I was lacking the foundation in math to understand many of the lectures. However, fellow participants made a great effort to include me in conversations and explain content in layperson's terms. Having the chance to discuss various issues around mathematical visualization/representation and art with the mathematician participants, I also gained further insight to the relationship between math and visual form. We had great conversations about this area (for example during the art&math brown bag lunch I hosted). I have developed a new collaboration with Frank Farris on the math of algorithmic knitting translated into the process of ceramic 3D printing.*
- *By introducing me to research outside my field of expertise, specifically to Polynomials and the Abelian sandpile algorithm.*

- *ICERM gave me the occasion of practicing a number of things that had remained theoretical up to now (3 d-printing, laser cutting), and it also allowed me to work with computer experts in a very productive environment. I also met a number of researchers with similar interests who greatly advanced my understanding on a number of questions.*
- *In this workshop, it was the talks by artists that most opened my eyes to new possibilities.*

Some Workshop Participant Comments for "Briefly describe workshop highlights":

- *Learning about new developments with sandpiles, and also the work people are doing with materials.*
- *I loved the math art panel and the informal talk by the artist from the University of Washington.*
- *I thought the few talks by mathematicians who did not give a standard research talk were the most interesting to me.*
- *Having so many cool people who are thinking about cool stuff together in one place and all talking to each other. It was very inspiring.*
- *Chris Bishop and Dan Romik talks.*
- *I particularly enjoyed hearing about how artists are using mathematics to create artwork as this is a very interesting topic that I have not heard discussed much in the past.*
- *The workshop was perfectly suited for my work. Which is mathematics outreach through digital arts. I met both digital artist and mathematicians with whom I share several interests.*
- *The interactions between artists and mathematicians, the spirit of generosity.*
- *The workshop was interdisciplinary in nature, and it was a great opportunity to hear lectures of different (particularly artistic) flavor.*
- *The highlights for me where my participation to the Art and Math panel, where I had the opportunity to share my point of view with some other incredible artists which work I did not know before, as well as my keynote that allowed me to share my artistic research with mathematicians, to get feedback and questions from them, that will help me push my work forward.*
- *New understanding on harmonic measure and dynamical system*
- *As a younger mathematician, I enjoy going to conferences to gain exposure to other areas of mathematics that I've not had the chance to explore. As someone who works in holomorphic dynamics, this conference has motivated me to take a step back and actually look at some of the objects I research, instead of solely getting lost in the math.*
- *Show and Tell was a great set of on-going sessions. Each day, even though often swamped with ideas that needed to be completed, I would come in excited to see what my colleagues were doing. I was able to walk around the corner or down the hall and gain guidance or tutoring in specific media. In other cases, I was able to explain ideas to novices.*
- *For me personally, the highlight was seeming so many other women in the field. Being able to meet and collaborate with other women mathematicians always makes me feel more comfortable and welcome in the field and the physical space. Having non-experts in the room really helped as well, because it forced the speakers to reevaluate how they would convey their knowledge, not just use the most fancy vocabulary and technical machinery.*

- *Timea Tihanyi helped the mathematicians among us see how to treat potential artist collaborators. Very useful information.*
- *It was great to see people from different backgrounds (math and art) talk to each other! Moreover, it's nice to be surrounded by other mathematicians who think seriously (some semi-professionally) about visualizing mathematics. For instance, one can learn a lot of useful tricks to use cool technologies.*

Dissemination (broader impacts and public engagement)

The Illustrating Mathematics program held at ICERM during the fall of 2019 was singular among ICERM's semester programs. The program's participants represented a diverse set of mathematical interests: number theory, probability, representation theory, geometric topology, dynamics, and beyond. Their common interest was an intense exploration of the question: *How do visualizations of mathematical concepts allow us to explore and understand them in new ways?*

Early in fall 2019, ICERM hosted an Illustrating Math-themed open house as part of the Big Bang Science Fair at Waterfire Providence 2019. During this popular city-wide event, members of the local community toured ICERM, interacted with the art pieces, and learned some of the mathematical ideas underpinning the works directly from the ICERM-based mathematicians who created them. A highlight of that event was a visitor-powered installation of a 10-foot tall stellated dodecahedron bright enough to be viewed from the riverfront below. Glen Whitney, a co-founder of the Museum of Mathematics, created and directed this installation.

In addition, semester program organizers Jayadev Athreya and Richard Schwartz collaborated with local artists Allison Paschke and Masha Ryskin to organize five Math+Art panels (supported by Brown University funds) featuring the work of program participants and artists who use mathematics prominently in their work. The goal of these panel discussions was to explore the different ways that mathematicians and artists approach mathematical concepts, with the hope that the conversations might lead to future collaborations.

Throughout the semester, ICERM displayed a wide variety of artwork provided by the program participants. Curated pieces were displayed both on-site at ICERM and off-site at the Atrium Gallery of the Perry and Marty Granoff Center, home of the Brown Arts Initiative.

Before the end of the fall semester, ICERM published a 2019 Illustrating Mathematics Art Exhibit book featuring the curated art selected and displayed during the Illustrating Mathematics semester program. It was made available for sale online. To date, 114 of the 200 copies have been sold. A subset of these books will be used to present as gifts to board members, donors, etc.

Laura Taalman, a co-organizer for the Illustrating Mathematics program, is maintaining a "Math+Art project gallery website so that participants can share the progress of their research initiated while at the institute: https://im.icerm.brown.edu/

To help fund the art-focused activities of this semester program, ICERM received additional support from the Simons Foundation Targeted Grants for Institutes program and the Alfred P. Sloan Foundation.

Spring 2020 Semester Program: Model and dimension reduction in uncertain and dynamic systems

January 27 - May 1, 2020

Organizing Committee:
Yanlai Chen, University of Massachusetts, Dartmouth
Serkan Gugercin, Virginia Tech
Misha Kilmer, Tufts University
Yvon Maday, Sorbonne Université
Shari Moskow, Drexel University
Akil Narayan, University of Utah
Daniele Venturi, University of California, Santa Cruz

Program Description:
Today's computational and experimental paradigms feature complex models along with disparate and, frequently, enormous data sets. This necessitates the development of theoretical and computational strategies for efficient and robust numerical algorithms that effectively resolve the important features and characteristics of these complex computational models. The desiderata for resolving the underlying model features is often application-specific and combines mathematical tasks like approximation, prediction, calibration, design, and optimization. Running simulations that fully account for the variability of the complexities of modern scientific models can be infeasible due to the curse of dimensionality, chaotic behavior or dynamics, and/or overwhelming streams of informative data.

This semester program focuses on both theoretical investigation and practical algorithm development for reduction in the complexity - the dimension, the degrees of freedom, the data - arising in these models. The four broad thrusts of the program are (1) Mathematics of reduced order models, (2) Algorithms for approximation and complexity reduction, (3) Computational statistics and data-driven techniques, and (4) Application-specific design. The particular topics include classical strategies such as parametric sensitivity analysis and best approximations, mature but active topics like principal component analysis and information-based complexity, and promising nascent topics such as layered neural networks and high-dimensional statistics.

This program will integrate diverse fields of mathematical analysis, statistical sciences, data and computer science, and specifically attract researchers working on model order reduction, data-driven model calibration and simplification, computations and approximations in high dimensions, and data-intensive uncertainty quantification. Various workshops will be designed to stimulate interaction between these research areas and establish cross-disciplinary collaboration. Investigation and assimilation of complementary approaches through other program events will achieve cross-fertilization and serve as a nexus for multiple research communities.

All Long-term Visitors to Spring 2020 Semester Program (10+ Days)

Name	Institute	Dates@ICERM
Terrence Alsup	Courant Institute of Mathematical Sciences	12
Mazlum Ferhat Arslan	Middle East Technical University	97
Brian Avants	UPenn	95

Christopher Beattie	Virginia Tech	108
Amina Benaceur	MIT	12
Peter Benner	Max Planck Institute	94
Jeff Borggaard	Virginia Tech	12
Sergiy Borodachov	Towson University	14
Kevin Carlberg	University of Washington	12
Jesse Chan	Rice University	12
Yanlai Chen	University of Massachusetts, Dartmouth	95
Zheng (Leslie) Chen	University of Massachusetts Dartmouth	95
Yingda Cheng	Michigan State University	86
Paul Constantine	University of Colorado Boulder	98
Gregory Darnell	ICERM	274
Julio de Lima Nicolini	Ohio State University	11
Eric de Sturler	Virginia Tech	10
Mingchang Ding	University of Delaware	18
Vladimir Druskin	Worcester Polytechnic Institute	100
Fariba Fahroo	AFOSR	11
Lihong Feng	Max Planck Institute	56
Guosheng Fu	University of Notre Dame	12
Nathan Gibson	Oregon State University	10
Ion Victor Gosea	Max Planck Institute	12
Rachel Grotheer	Goucher College	12
Serkan Gugercin	Virginia Tech	114
Wei Guo	Texas Tech University	12
Christian Himpe	Max Planck Institute	84
Jeffrey Hokanson	University of Colorado Boulder	95
Xiaozhe Hu	Tufts University	62
Muhammad Izzatullah	King Abdullah University of Science and Technology	88
Lijie Ji	UMass Dartmouth/Shanghai University	95
Jiahua Jiang	Virginia Tech	97
Misha Kilmer	Tufts University	95
Gerhardus Kirsten	University of Bologna	32
Peter Kramer	Rensselaer Polytechnic Institute	250
Christian Kuemmerle	Johns Hopkins University	10
Sanda Lefteriu	IMT Lille Douai	112
Fengyan Li	Rensselaer Polytechnic Institute	250
Xingjie Li	University of North Carolina at Charlotte	12
Yong Liu	USTC	95
Alba Málaga Sabogal	ICERM	284
Yvon Maday	Sorbonne Université	11
Youssef Marzouk	Massachusetts Institute of Technology	95
Petar Mlinarifá	Max Planck Institute	94
Peter Monk	University of Delaware	98
Ryleigh Moore	University of Utah	12
Akil Narayan	University of Utah	193
Carmeliza Navasca	University of Alabama at Birmingham	96

Nicole Nellesen	RWTH Aachen University	10
Davide Palitta	Max Planck Institute	75
Benjamin Peherstorfer	Courant Institute, New York University	25
Zhichao Peng	Rensselaer Polytechnic Institute	97
Elizabeth Qian	MIT	95
Rosemary Renaut	Arizona State University	12
Viktor Reshniak	Oak Ridge National Laboratory	18
Gianluigi Rozza	SISSA	12
Neeraj Sarna	Max Planck Institute	44
Michael Schneier	University of Pittsburgh	289
Devin Smith	Rensselaer Polytechnic Institute	116
Benjamin Stamm	RWTH Aachen University	46
Shannon Starr	University of Alabama at Birmingham	95
Jemima Tabeart	University of Edinburgh	109
Qi Tao	USTC	95
Daniele Venturi	University of California, Santa Cruz	190
Karen Veroy-Grepl	TU Eindhoven	12
Min Wang	Duke University	109
Zhu Wang	University of South Carolina	108
Yang Yang	Michigan Technological University	16
Mikhail Zaslavsky	Schlumberger	96
Yangwen Zhang	University of Delaware	108
Jia Zhao	Utah State University	12
Ming Zhong	Johns Hopkins University	12
Xueyu Zhu	University of Iowa	12
Jorn Zimmerling	University of Michigan	10

Note: This roster includes ICERM's participants who stayed in-residence for all of or the majority of the semester program, as well as participants who came and went and just attended multiple program workshops throughout the semester.

Here follows a sample of the most substantive comments from our long-term visitors:
Some Long-term Visitor Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *I learned about some new directions of research and about new classes of problems.*
- *During the semester, I learned a lot about interpolatory reduced order modeling with respect to its theory and numerical algorithms. It is invaluable and boards my research interests.*
- *I thought Christian Himpe's talk about computer experiments was really valuable. Additionally, I learned a lot about dimension reduction, especially through the tutorials. Finally, the third workshop provided me a broad scope of ideas related to my own research to think more about.*
- *The tutorial in the beginning of the semester is really a great starting point. It also provides great opportunities to talk and interact with leading researchers, and I do learn a lot from them.*

- *ICERM provided an atmosphere that allowed creative discussions and enabled focused work. However, the offices for four postdocs seemed overcrowded.*
- *This has been an amazingly productive/intellectually fulfilling program for me. In the model reduction community, there are groups that use systems theoretic method (rooted in control theory) and there are some who use reduced basis method (rooted in PDEs) Even though these two groups work on similar problems, the interactions between the two have not been as fruitful as one wishes. This semester program literally brought these diverse groups under one umbrella and allowed us to talk to each other in person and learn/understand from each other. I can safely state that my understanding of the reduced basis community has improved significantly. Moreover, I were able to explain the system theoretical tools I use to reduced basis community in detail.*
- *Bringing in people from different sub-communities helped understanding several approaches better, and the discussion on-site deepened this.*
- *I am relatively new to the model reduction field. But I learned several new things this semester and plan to apply them to my own research.*
- *The organization of the tutorials and the accessibility of the working groups made for a nice way to stretch outside one's own research comfort zone. Having the slides from tutorials remain accessible has also been helpful.*
- *The tutorial series helped me to see how SVD has been applied to solve the system dynamic problems. How RB methods can be adopted to solve the parametric PDEs. The analysis aspect of the tutorial has also been quite insightful which expanded my understanding of the challenges of the model reduction problems.*
- *The introductory tutorial series was a big help in becoming familiar with the different topics and how they related to each other. The working groups really helped me become aware of challenges in different fields.*
- *This is a good platform for communication. For me, different talks here indeed give me more idea for research cooperation and learning plan. This will be the first step for new methodology development.*

Some Long-term Visitor Comments for "Briefly describe program highlights":

- *Very informative.*
    - *Excellent tutorials - Great team of organizers, and knowledgeable and professional staffs - Ethics discussion with excellent cases stud (I participated as a faculty) - Workgroups - Talks at workshops*
- *It brought experts in model reduction methods together and discussed several emerging research topics. 2. It provided opportunities for participants including faculty, postdocs and graduate students to talk to each other and start/continue collaborations on common research interests. 3. The ICERM environment is friendly: staff is always there to help; everyone is so easy to talk with; the workspaces are well organized for our discussions.*
- *I had a conversation with a faculty member of Brown's applied math department which suggested an important new direction for my research. Additionally, I think Christian Himpe's computer experiments talk made me think about meta-research in a way that will ultimately make me a much more effective scientist.*
- *The opportunity to know other researchers, I actually develop new collaborations, and know great new friends. (2) The tutorial, three workshops and discussions with other researchers will broaden my horizon. And I developed new future research direction. (3)*

I stayed in Providence after the workshop became virtual. I had some medical issues and I got great support and help form the people and other participants in ICERM.

- *The first workshop had a major impact, as people from all sub-communities really listened to each other, and started mature discussions on competing and common aspects of the different methodologies in the area of the program. This was hardly achieved so far by the at least existing three workshop series. The second workshop was for me an enlightening moment in the sense that an online workshop can be really of use.*
- *Informal discussion times (coffee, going out to lunch with colleagues, etc.) was as important as formal discussions/presentations. It's difficult to pinpoint a highlight because I so thoroughly enjoyed the semester.*
- *Get to know other young researchers that shares similar research interests and background*

Impact of COVID-19 on Spring 2020 programming

Due to the COVID-19 pandemic, this semester program was converted to a virtual platform starting March 13. Its last two workshops, Algorithms for Dimension and Complexity Reduction (March 23 - 27) and Computational Statistics and Data-Driven Models (April 20-24), were held via Zoom. Registered participants were given Zoom credentials to join the workshop presentations. We continued to live-stream presentations to the web, which allows anonymous public viewing but no opportunity for questions.

The "Algorithms" workshop had 122 participants registered before it shifted to virtual format. Of these, 95 attended at least one of the presentations. The "Statistics" workshop had 140 participants, and 111 attended at least one of the presentations. In the transition to virtual programming we lost 27 participants in the "Algorithms" workshop and 29 participants in the "Statistics" workshop. We also picked up a handful of participants, e.g. applicants from outside the US that were not offered travel support. It was clear that participants were selective about which talks they chose to attend.

Workshop 1: Mathematics of Reduced Order Models

February 17 - 21, 2020

Organizing Committee:
Peter Benner,Max Planck Institute, Magdeburg
Albert Cohen, Sorbonne Université
Serkan Gugercin, Virginia Tech
Olga Mula, Paris Dauphine University
Akil Narayan, University of Utah
Karen Veroy-Grepl, TU Eindhoven

Program Description:
Mathematical models of scientific applications often involve simulations with a large number of degrees of freedom that strain even the most efficient of algorithms. A clear need is the rigorous development of models with reduced complexity that retain fidelity to the application. Mathematics-based reduced-order modeling applies techniques in nonlinear approximation, projection-based discretizations, sparse surrogate construction, and high-dimensional

approximation, in order to construct a model surrogate with near-optimal approximation properties. This workshop focuses on theoretical and algorithmic advances in mathematics-based model order reduction of various types: reduced basis methods, projection-based methods for dynamical systems, and sparse and low-rank approximations in high dimensions.

Participant List Workshop 1

Name	Institute
Terrence Alsup	Courant Institute of Mathematical Sciences
Manuchehr Aminian	Colorado State University
Thanos Antoulas*	Rice University
Mazlum Ferhat Arslan	Middle East Technical University
Brian Avants	Penn Image Computing and Science Laboratory at UPenn
Ashwin Babu	Dassault Systemes Simulia Corp
Christopher Beattie*	Virginia Tech
Amina Benaceur*	MIT
Peter Benner	Max Planck Institute, Magdeburg
Raed Blel	CERMICS
Jeff Borggaard*	Virginia Tech
Tan Bui-Thanh	University of Texas at Austin
Kevin Carlberg*	University of Washington
Jesse Chan	Rice University
Yanlai Chen	University of Massachusetts, Dartmouth
Zheng (Leslie) Chen	University of Massachusetts, Dartmouth
Yingda Cheng	Michigan State University
Karim Cherifi	MPI Magdeburg, Germany
Albert Cohen	Sorbonne Université
Paul Constantine	University of Colorado Boulder
Wolfgang Dahmen*	University of South Carolina
Gregory Darnell	ICERM
Julio de Lima Nicolini	Ohio State University
Eric de Sturler	Virginia Tech
David Del Rey Fernádez	National Institute of Aerospace contracted to NASA
Mingchang Ding	University of Delaware
Adi Ditkowski	Tel Aviv University
Vladimir Druskin*	Worcester Polytechnic Institute
Virginie Ehrlacher*	CERMICS
Heike Faßbender*	Technische Universität Braunschweig
Fariba Fahroo	AFOSR
Ionut Farcas	The University of Texas at Austin
Lihong Feng	Max Planck Institute
Guosheng Fu	University of Notre Dame
Nathan Gibson	Oregon State University
Silke Glas*	Cornell University
Ion Victor Gosea	Max Planck Institute
Pawan Goyal*	MPI Magdeburg
Carmen Gräßle *	Max Planck Institute

Rachel Grotheer	Goucher College
Serkan Gugercin	Virginia Tech
Diane Guignard*	Texas A&M University
Wei Guo	Texas Tech University
Tom Hagstrom	Southern Methodist University
Dirk Hartmann	SIEMENS
Matthias Heinkenschloss*	Rice University
Christian Himpe	Max Planck Institute
Jeffrey Hokanson*	University of Colorado Boulder
Xiaozhe Hu	Tufts University
Jingwei Hu	Purdue University
Juntao Huang	Michigan State University
Muhammad Izzatullah	King Abdullah University of Science and Technology
Ameya D. Jagtap	Division of Applied Mathematics
Lijie Ji	UMass Dartmouth/Shanghai Jiao Tong University
Jiahua Jiang	Virginia Tech
Dimitris Kamilis	University of Edinburgh
Parisa Khodabakhshi	UT Austin
Misha Kilmer	Tufts University
Boris Krämer *	University of California San Diego
Peter Kramer	Rensselaer Polytechnic Institute
Jeonghun Lee	Baylor University
Sanda Lefteriu	IMT Lille Douai
Xingjie Li	University of North Carolina at Charlotte
Fengyan Li	Rensselaer Polytechnic Institute
Xiantao Li	Pennsylvania State University
Yuwen Li	Pennsylvania State University
Yong Liu	USTC
Hannah Lu	Stanford University
Yvon Maday*	Sorbonne Université
Romit Maulik	Argonne National Laboratory
Volker Mehrmann*	TU Berlin
Petar Mlinarifá	Max Planck Institute
Peter Monk	University of Delaware
Olga Mula	Paris Dauphine University
Akil Narayan	University of Utah
Carmeliza Navasca	University of Alabama at Birmingham
Indranil Nayak	The Ohio State University
Ron Ofir	Technion - Israel Institute of Technology
Karl Otness	New York University
Cecilia Pagliantini*	EPFL, Ecole Polytechnique Federale de Lausanne
Davide Palitta	Max Planck Institute
Anthony Patera*	MIT
Benjamin Peherstorfer*	Courant Institute, New York University
Zhichao Peng	Rensselaer Polytechnic Institute
Vasilije Perovic	University of Rhode Island

Armenak Petrosyan	Oak Ridge National Laboratory
Blake Pollard	National Institute of Standards and Technology
Igor Pontes Duff*	Max Planck Institute
Thomas Prescott	University of Oxford
Elizabeth Qian	MIT
Viktor Reshniak	Oak Ridge National Laboratory
Donsub Rim	New York University
Steven Rodriguez	U.S. Naval Research Laboratory
Gianluigi Rozza	SISSA
Neeraj Sarna	Max Planck Institute-Magdeburg
Michael Schneier	University of Pittsburgh
Devin Smith	Rensselaer Polytechnic Institute
Benjamin Stamm	RWTH Aachen University
Shannon Starr	University of Alabama at Birmingham
Jemima Tabeart	University of Edinburgh
Qi Tao	USTC
Daniel Tartakovsky	Stanford University
Zoran Tomljanovic	University of Osijek
Daniele Venturi	University of California, Santa Cruz
Karen Veroy-Grepl	TU Eindhoven
Pedro Vilanova Guerra	NJIT
Zhu Wang	University of South Carolina
Min Wang	Duke University
Ting Wang	US Army Research Laboratory
Karen Willcox*	UT Austin
Xiaojie Wu	University of California, Berkeley
Qing Xia	Rensselaer Polytechnic Institute
Yang Yang	Michigan Technological University
Felix Ye	Johns Hopkins University
Mikhail Zaslavsky	Schlumberger
Xu Zhang	Oklahoma State University
Yangwen Zhang	University of Delaware
Jia Zhao	Utah State University
Ming Zhong	Johns Hopkins University
Xueyu Zhu	University of Iowa
Jorn Zimmerling	University of Michigan

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *I had almost no actual background in model order reduction before attending the workshop, and I have a much better understanding of the topic and current research and applications now.*
- *Additions to my knowledge of computational methodologies: Multiple approaches for fast model reduction for nonlinear systems New methods for data driven model reduction*

Important work on port-Hamiltonian systems modeling errors in nonlinear model reduction

- *Important was the merging of two up-to-now mostly distinct directions in model reduction: reduced basis methods (RB) and the rest which I will term "projection based" methods.*
- *This community (reduce order modeling) is not exactly my research community (uncertainty quantification). However, I found this workshop is very intriguing and I learned many new ideas by attending this workshop.*
- *The workshop brought experts in the field of model reduction. I learned new developments in the computational and theoretical developments such as the lift and learning technique and optimal transport theory.*
- *I learnt the Loewner framework for model reduction and the nonlinear model reduction tools from this workshop. In particular, the nonlinear approaches will help my current research.*
- *Feedback I received from my talk included a link to an unpublished algorithm that might allow an application of my software to calculate low degree feedback controls for large, sparse systems. I also learned that the connection between PDEs and n-Widths can be extended to nonlinear PDEs in some cases.*
- *Excellent overview of current methodologies for ROM.*
- *The workshop had at least three important communities come together. The reduced basis community, the control community and the machine learning community, which made great efforts to bring the techniques closer together. This was absolutely necessary to bring the different techniques and methodologies together so that each can profit from each other more.*
- *This workshop was excellent. I obtained a very broad overview of current and future research directions with respect to reduced order modeling. The workshop has already resulted in a collaborative effort and the idea vectors generated are likely to influence my research for the foreseeable future.*
- *I am newer to the field of reduced order modeling, so the workshop expanded my understanding of the field at Large.*
- *I did this work for my PhD but haven't looked at it much since. As a result of all the talks, I am now more aware of the different methodologies and have a good set of papers to look at it. This should help me strengthen/edit a paper of mine in this area so that I will be able to resubmit it for publication. Further, it has given me ideas of other directions I could go in as I look to expand my research.*
- *The talks at workshop provided state-of-the-art computational methodologies that can be transcended to other fields.*
- *Conversation with one of the visiting postdocs stimulated a theoretical question that I plan to continue discussing with other long-term program participants. Two of the Friday morning talks were provocative and stimulating, and I saw new approaches that I will probably remember. One I plan to discuss with a colleague at my home institution.*
- *I'm working on a research project which has some connection with Reduced Order Modeling, but this workshop has opened my eyes, I have learned a lot about ROM both in breadth and in depth, really helpful workshop. Wish there were more talks on data-driven models related to ROM.*

Some Workshop Participant Comments for "Briefly describe workshop highlights"

- *Since I am relatively new to the field of model reduction, this workshop offered me a great opportunity to get familiar with the latest advancements in the field. Moreover, I got in contact with peers with engaged in stimulating conversations throughout the five workshop days.*
- *Interactions with the many early career attendees.*
- *The workshop highlights some new trends of combining traditional reduced order modeling technique with modern data assimilation/learning approaches, which is very interesting.*
- *The diversity of the speakers and their research topic.*
- *ICERM is very well-run institute. I am pretty impressed with lectures as well as with the overall organization of this workshop.*
- *To bring various experts in the fields in one place. There was enough free time between talks to have a discussion with them.*
- *Recent developments in model reduction methods including reduced basis method, proper orthogonal decomposition and interpolatory model reduction. Different methods met together and idea exchanges were great!*
- *Excellent talks from great researchers, motivating atmosphere, lots of time for discussions possible*
- *Making connections with other researchers in this area and getting a good overview of current research work and directions. I especially enjoyed the poster blitz with very fast-paced, short introductions to the highlights of each presented poster.*
- *The diverse set of topics covered within the broad area of model reduction. Also, the setting and ample opportunities for collaborations were also exceptional given that this is the first time I am was at ICERM.*
- *I really enjoyed the talk "Predictive data science for physical systems- From model reduction to scientific machine learning" in which some connections between model order reduction and scientific machine learning have been presented. In general, the informal, friendly atmosphere made this workshop a very nice, fruitful experience.*
- *Besides the very good networking and community building activities, the highlights were the presentations by Thanos Antoulas, Matthias Heinkenschloss and Jeff Boogard, Chris Beattie and Kevin Carlberg on data-based model reduction for computational fluid dynamics, a field where I think important developments take place. The talk by Carmen Grässle, about bring optimal control and model reduction together.*
- *Discussion of emerging methodologies*
- *Longer presentations from both established and up-and-coming researchers (as opposed to the usual 20 minutes in conferences). - Longer breaks for discussions.*
- *The highlight of the workshop was getting exposure to the many areas of research within this field and learning techniques that I will be able to apply to my own research projects and possibly be able to use in the classroom as well.*
- *All the talks were excellent. However, the talk by Willcox, Carlberg and Patera were inspiring and creative and gave future outlook in the field.*
- *Talking with one of the postdocs who came up with a way to apply the general ideas to a problem closer to my research interest.*

- *a lot of ROM talks which are very interesting 2) some data-driven modeling talks were very useful to me 3) poster presentation helped me known to others*
- *The highlight was the seminars given by pioneers/word experts in the field, in particular W.Dahmen/Y.Maday/A.Patera.*
- *Meeting/exchanging ideas with a diverse group of scientists who are leaders in the area, presenting the state-of-the-art in model reduction. And talking to many junior people throughout the week and especially during the poster presentation.*
- *Interesting talks.*
- *vision on how to include ML-techniques into rigorous ROM-framework - on the other hand: rigorous results lying out the foundations of ROM.*
- *Got to see the latest research over the topic of model reduction and attempts researchers have been made to utilize deep learning.*
- *It was a new experience to take a closer look at the field of reduced order models and techniques involved. This will help me develop new algorithms in my own research field.*

Workshop 2 (VIRTUAL): Algorithms for Dimension and Complexity Reduction

March 23 - 27, 2020

Organizing Committee:
Kevin Carlberg, University of Washington
Yanlai Chen, University of Massachusetts, Dartmouth
Francisco Chinesta, ENSAM
Misha Kilmer, Tufts University
Yvon Maday, Sorbonne Université
Gianluigi Rozza, SISSA – International School for Advanced Studies

Program Description:
Mathematical advances that reduce the complexity of models are complemented by algorithms that achieve the desired reduction in computational effort. This workshop focuses on the synthesis and development of algorithmic approaches to model order reduction. These methods tackle fundamental problems in structure- and topology-preserving reductions, low-rank models and dimension reduction, multi-level approaches, and empirical interpolation and approximations, etc. Complementary approaches that target computational efficiency include strategies with offline and online phases and divide-and-conquer algorithms.

Participant List Workshop 2

Name	Institute
Zamurat Adegboye	Institute of Mathematical and Physical Sciences
Mazlum Ferhat Arslan	Middle East Technical University
Selin Aslan*	Argonne National Laboratory
Christopher Beattie	Virginia Tech
Amina Benaceur*	MIT
Peter Benner	Max Planck Institute, Magdeburg
Jeff Borggaard	Virginia Tech
Sergiy Borodachov	Towson University

Olena Burkovska	Oak Ridge National Laboratory
Jared Callaham*	University of Washington
Kevin Carlberg	University of Washington
Jesse Chan	Rice University
Yanlai Chen	University of Massachusetts, Dartmouth
Zheng (Leslie) Chen	University of Massachusetts, Dartmouth
Yingda Cheng	Michigan State University
Francisco Chinesta	ENSAM
Paul Constantine	University of Colorado Boulder
Gregory Darnell	ICERM
Eric de Sturler	Virginia Tech
Mingchang Ding	University of Delaware
Alireza Doostan	University of Colorado Boulder
Vladimir Druskin	Worcester Polytechnic Institute
Karthik Duraisamy*	University of Michigan
Fariba Fahroo	AFOSR
Charbel Farhat*	Stanford University
Lihong Feng	Max Planck Institute
Jinchao Feng	Johns Hopkins University
Guosheng Fu	University of Notre Dame
Roger Ghanem*	University of Southern California
Marcella Gomez	University of California Santa Cruz
Ion Victor Gosea	Max Planck Institute
Rachel Grotheer	Goucher College
Sara Grundel*	Max Planck Institute
Serkan Gugercin*	Virginia Tech
Wei Guo	Texas Tech University
Bernard Haasdonk	University of Stuttgart
Aidan Hamilton	University of Delaware
Jeffrey Hokanson	University of Colorado Boulder
Traian Iliescu*	Virginia Tech
Muhammad Izzatullah	King Abdullah University of Science and Technology
Lijie Ji	UMass Dartmouth/Shanghai Jiao Tong University
Jiahua Jiang	Virginia Tech
Misha Kilmer	Tufts University
Gerhardus Kirsten	University of Bologna
Peter Kramer	Rensselaer Polytechnic Institute
Christian Kuemmerle	Johns Hopkins University
Pierre Ladeveze*	University of California San Diego
Sanda Lefteriu	IMT Lille Douai
Fengyan Li	Rensselaer Polytechnic Institute
Zexin Liu	University of Utah
Fei Lu	Johns Hopkins University
Alba Málaga Sabogal	ICERM
Yvon Maday	Sorbonne Université
Michael Patrick Martin	Johns Hopkins University

Romit Maulik	Argonne National Laboratory
Petar Mlinarifá	Max Planck Institute
Peter Monk	University of Delaware
Ryleigh Moore	University of Utah
Lin Mu	University of Georgia
Akil Narayan*	University of Utah
Carmeliza Navasca	University of Alabama at Birmingham
Nicole Nellesen*	RWTH Aachen University
Davide Palitta	Max Planck Institute
Zhichao Peng	Rensselaer Polytechnic Institute
Rebecca Pereira	University of Massachusetts Dartmouth
Sara Pollock*	University of Florida
Elizabeth Qian	MIT
Jingmei Qiu	University of Delaware
Annalisa Quaini*	University of Houston
Rosemary Renaut	Arizona State University
Viktor Reshniak	Oak Ridge National Laboratory
Gianluigi Rozza	SISSA
Jennifer Ryan	Colorado School of Mines
Arvind Saibaba*	North Carolina State University
Michael Schneier	University of Pittsburgh
Christoph Schwab	ETH Zürich
Kathrin Smetana*	University of Twente
Devin Smith	Rensselaer Polytechnic Institute
Benjamin Stamm*	RWTH Aachen University
Shannon Starr	University of Alabama at Birmingham
Jemima Tabeart	University of Edinburgh
Manuel Tiglio	Universidad Nacional de Córdoba
Shashanka Ubaru*	IBM T.J. Watson Research Center
Daniele Venturi	University of California, Santa Cruz
Pedro Vilanova Guerra	NJIT
Aaron Villanueva	National University of Cordoba
Min Wang	Duke University
Yating Wang	Purdue University
Zhu Wang*	University of South Carolina
Yulong Xing	The Ohio State University
Yang Yang	Michigan Technological University
Masayuki Yano*	University of Toronto
Yangwen Zhang	University of Delaware
Ming Zhong	Johns Hopkins University

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *I felt that these talks were more "here's a PDE I've had trouble with and what I did to make it less complex" than "here is a class of problems with low dimensional structure and here is how we can exploit that"*
- *The workshop has been very well organized in terms of exploring different directions within the field of reduced order modeling. Although I am not in the area, I develop a sense of the area history and recent development from the talks.*
- *ICERM staff has done an excellent job to organise this virtual workshop. This workshop further expands my knowledge in reduced order model techniques both computationally and mathematically.*
- *The computational methodologies field is new to me and the talks gave a very good introduction to the field and the kind of work going on.*
- *Tensor star-M product SVDs for compression Port-Reduced Reduced Basis Component for incompressible fluid flows Interpretable data-driven model reduction*
- *There were some very enlightening talks at the intersection of theoretical ML and applications to numerical methods, particularly inverse problems: Sensor Selection for Bayesian Inverse Problems and Data Assimilation via Dimension Reduction - Nicole Nellesen, Efficient randomized algorithms for subspace system identification - Arvind Saibaba, North Carolina State University, Interpretable data-driven model reduction for multiscale nonlinear dynamics - Jared Callaham, University of Washington.*
- *It has given an interesting window on the today topics in Complexity Reduction,*
- *I am able to learn how numerical analysis/simulation work in stabilizing a reduce order model algorithm. Also, about practical application of some stochastic processes (quantifying the mixing rate of the cool and hot water in ocean).*
- *This workshop focuses on algorithms of model complexity and dimensionality reduction. It is nice to know so many real-world applications people have been working on using different model reduction techniques, from computational fluid dynamics, solid mechanics to energy network and data assimilations.*
- *A lot of the work presented was in reduced basis methods, a field that I don't actually work in. However, in at least one or two of the talks, I started to see how my work might relate to it, and how I might be able to consider convergence of adaptive methods using RBM. I think this will influence me more in the long-term than in the short-term, but it is very important to have ideas about where work could go, rather than only thinking about the next result.*
- *This workshop covered some dimensions of reduced order modeling I hadn't seen previously in the program, particularly with regard to data-driven closures for turbulence models. I particularly appreciated learning more about how auto encoders are used for reduced modeling in dynamical systems, and how RBM is used in Bayesian experimental design.*
- *Since I have been out of the field for a couple of years, I definitely have some better ideas of current algorithms and papers to look at. Most helpful was the talk with the application to Diffuse Optical Tomography since that was the same application I was looking at previously. I now have some ideas for new directions in that area.*
- *I work primarily in full order models, so it's been extremely helpful to get to know the culture within the reduced order modeling community. There are some technical aspects which have been helpful, but my main takeaways have been a wider perspective on the tools people use, relevant literature, and philosophical approaches to ROMs.*

- *This virtual workshop brought together a diverse set of experts and allowed them to share/exchange ideas. Here is an example from my own experience after my talk: I consider myself to belong to system-theory model reduction community. Most of the questions after my talk were from the reduced-basis community; which I appreciated to a great extent. This was the one main goal of this workshop (and the semester in general) Bring the communities together.*

Some Workshop Participant Comments for "Briefly describe workshop highlights":

- *Outstanding talks, engaged audience, and smooth virtual experience (attributed to the dedicated ICERM team)*
- *I learned a lot from the CFD talks by Farshat and Iliescu.*
- *Just in general it worked so much better than expected and I truly wish, it is something that can replace some of the travel that really takes away time from everybody to create good research.*
- *Opportunity to collaborate in difficult times*
- *Organizers who pulled off a successful virtual workshop with minimal issues.*
- *Great interaction between presenters and audiences.*
- *I'm very happy that the organizers continued this workshop, despite the fact that it had to be virtual. I think it was a great success despite the fact that it had to arranged very quickly.*
- *The virtual workshop exceeds my expectation greatly.*
- *The by far best highlight was hearing that the workshop was going to take despite the global situation and not be cancelled. It was great by the organizers and ICERM staff to hold on to it and make it possible. Thank you. In the workshop itself, there were a number of talks that I really enjoyed, and I liked that people asked questions after my talk. Also, when I told people that the talks were going to be in a live stream, there was much more interest in attending the livestream than I had expected given that the talks are also available in the archive later. It was nice when people contacted me directly after my talk to say they had heard it :)*
- *The virtual workshop is a completely new experience to me. It went smoothly and brought experts in the fields. There was one main topic per day. I really enjoyed all the presentations.*
- *I loved Annalisa Quaini's talk, and we had an interesting discussion about it later, over email. I also felt a strong sense of community within the workshop which is particularly important during these uncertain times.*
- *I very much enjoyed the research talks, and found that in this format, they were fairly straightforward to follow (at least the parts of the talks with which I was most familiar) and it was easy to ask questions after each talk. It was particularly encouraging that so many people were willing to participate despite the logistical inconveniences. It gave a sense of community to be able to have technical discussions with colleagues all around the world, and that's really important in these difficult times.*
- *Being able to have the workshop in the first place. I think everyone was glad that we could still continue the workshop despite what is currently happening in the world. I enjoyed many of the speakers and I particularly liked the diverse group of people and the range of topics. Most of the talks contained similar materials, but all of the topics had their own "twist" which kept everything interesting.*

- *The talk about the auto encoders for dynamical systems.*
- *Talks by Arvind Saibaba and Misha Kilmer Maintaining contact in difficult situations*
- *Watching lectures from home.*
- *Tensor produce 2. Applications of Model Reduction*
- *In general, having the experience of a virtual workshop was new and of great inspiration for future events like this.*

Workshop 3 (VIRTUAL): Computational Statistics and Data-Driven Models

April 20 – 24, 2020

Organizing Committee:
Lexin Li, University of California, Berkeley
Youssef Marzouk, Massachusetts Institute of Technology
Shari Moskow, Drexel University
Benjamin Peherstorfer, Courant Institute, New York University
Abel Rodriguez, University of California, Santa Cruz
Daniele Venturi, University of California, Santa Cruz
Rachel Ward, University of Texas at Austin

Program Description:
The advancement in computing and storage capabilities of modern computational clusters fosters use of novel statistical techniques in machine learning and deep networks. Such data-driven techniques allow one to learn model features and characteristics that are difficult for mathematical methods alone to reveal. Many computational methods achieve model and complexity discovery using methods that lie at the nexus of mathematical, statistical, and computational disciplines. Statistical methods often employ "big data" approaches that glean predictive capability from diverse and enormous databases of information. Emerging methods in machine learning and deep networks can provide impressive results. This workshop gathers researchers at the frontier of large-scale statistical computation, data science, tensor decompositions and approximations, and data-driven model learning, to focus on modern challenges that use data to reduce complexity of models.

Participant List Workshop 3

Name	Institute
Faten Alamri	Virginia Commonwealth University and Princess Nourah Bint Abdul Rahman University
Terrence Alsup	Courant Institute of Mathematical Sciences
Andrea Arnold	Worcester Polytechnic Institute
Mazlum Ferhat Arslan	Middle East Technical University
Saed Asaly	Ariel University
Yonatan Ashenafi	Rensselaer Polytechnic Institute
Karim Azumah	Pan African University for Basic Sciences, Technology and Innovation
Zhe Bai	Lawrence Berkeley National Lab
Christopher Beattie	Virginia Tech
George Biros*	ICES

Liliana Borcea*	University of Michigan
Tamara Broderick*	Massachusetts Institute of Technology
Peter Challenor*	University of Exeter
Yanlai Chen	University of Massachusetts, Dartmouth
Zheng (Leslie) Chen	University of Massachusetts, Dartmouth
Haiyan Cheng	Willamette University
Merlise Clyde	Duke University
Paul Constantine	University of Colorado Boulder
Keisha Cook	Tulane University
Gregory Darnell	ICERM
Julio de Lima Nicolini	Ohio State University
Anton Dereventsov	Oak Ridge National Laboratory
Mingchang Ding	University of Delaware
Alireza Doostan	University of Colorado Boulder
Kathryn Drake	Boise State University
Vladimir Druskin	Worcester Polytechnic Institute
Fariba Fahroo	AFOSR
Lihong Feng	Max Planck Institute
Guosheng Fu	Brown University
Khaled Furati	King Fahd University of Petroleum and Minerals
Nathan Gibson	Oregon State University
Anna Gilbert*	University of Michigan
Marcella Gomez*	University of California Santa Cruz
Serkan Gugercin*	Virginia Tech
Christian Himpe	Max Planck Institute
Jeffrey Hokanson	University of Colorado Boulder
Muhammad Izzatullah	King Abdullah University of Science and Technology
Lijie Ji	UMass Dartmouth/Shanghai Jiao Tong University
Sebastian Kaltenbach	Technical University of Munich - Continuum Mechanics Group
Isabelle Kemajou-Brown	Morgan State University
Abdul Khaliq	Middle Tennessee State University
Misha Kilmer	Tufts University
BONGSIK KIM	American University of Ras Al Khaimah
Liang Kong	University of Illinois at Springfield
Peter Kramer	Rensselaer Polytechnic Institute
Christian Kuemmerle	Johns Hopkins University
J. Nathan Kutz*	University of Washington
Sanda Lefteriu	IMT Lille Douai
Xingjie Li	University of North Carolina at Charlotte
Fengyan Li	Rensselaer Polytechnic Institute
Jichun Li	University of Nevada Las Vegas
Guang Lin	Purdue University
Anna Ma*	University of California Irvine
Mauro Maggioni*	Johns Hopkins University
Michael Mahoney*	University of California, Berkeley
Reza Malek-Madani	U.S. Naval Academy

Krithika Manohar*	California Institute of Technology
Youssef Marzouk	Massachusetts Institute of Technology
F. Patricia Medina	Yeshiva University
Petar Mlinarifá	Max Planck Institute
Ryleigh Moore	University of Utah
Shari Moskow	Drexel University
Akil Narayan	University of Utah
Carmeliza Navasca	University of Alabama at Birmingham
Nicole Nellesen	RWTH Aachen University
Kayode Olumoyin	Middle Tennessee State University
Melkior Ornik	University of Illinois at Urbana-Champaign
Juming Pan	Rowan University
Benjamin Peherstorfer	Courant Institute, New York University
Zhichao Peng	Rensselaer Polytechnic Institute
Paris Perdikaris*	University of Pennsylvania
Elizabeth Qian	MIT
Jeffrey Regier*	University of California, Berkeley
Rosemary Renaut	Arizona State University
Viktor Reshniak	Oak Ridge National Laboratory
Abel Rodriguez	University of California, Santa Cruz
Quratulan Sabir	National College of business administration and economics
Themistoklis Sapsis*	MIT
Robert Scheichl*	University of Heidelberg
Michael Schneier	University of Pittsburgh
Babak Shahbaba*	University of California - Irvine
Yeonjong Shin	Brown University
Devin Smith	Rensselaer Polytechnic Institute
Sarah Soleiman	Université Paris 1 Panthéon Sorbonne
Susanna Spektor	Sheridan college institute of technology
Georg Stadler*	CIMS NYU
Jemima Tabeart	University of Edinburgh
Sui Tang	Johns Hopkins University
Qi Tao	USTC
Shanyin Tong	New York University
Thomas Torku	Middle Tennessee State University
Wayne Isaac Uy	Courant Institute of Mathematical Sciences, NYU
Daniele Venturi	University of California, Santa Cruz
Karen Veroy-Grepl*	TU Eindhoven
Soledad Villar*	NYU
Zhu Wang	University of South Carolina
Min Wang	Duke University
Xiaoyu Wang	Florida State University
Rachel Ward	University of Texas at Austin
Jonathan Weare*	Courant Institute, New York University
Jinlong Wu	California Institute of Technology
Yiming Xu	University of Utah

Yang Yang	Michigan Technological University
Uzma Yasmeen	Comstas Islamabad Lahore campus
Mikhail Zaslavsky	Schlumberger
Jia Zhao	Utah State University
Cong Zhou	Indiana University
Shouhao Zhou	Penn State College of Medicine
Xueyu Zhu	University of Iowa
Lingjiong Zhu	Florida State University
Jorn Zimmerling*	University of Michigan

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *I learned from talks and discussions about new nonlinear MOR technologies, such as DEIM, Koopman and DMD. Also learned about new data driven passive methods.*
- *I don't think I learn very much from the virtual workshop (due to limited interaction and my missing some talks because of time zone difference and my virtual teaching too).*
- *ICERM is a fabulous venue for initiating and expanding research collaborations, certainly rivaling fabled locales such as Oberwolfach. I especially valued the cross-over interactions between model reduction and computational statistics - opportunities for these sorts of interactions are pretty unusual. The very peculiar circumstances of the nCoV outbreak during the time of this program created a major disruption naturally, that Zoom meetings could only partially patch.*
- *I realized some interesting aspects of LASSO when Tamara Broderick explained her Bayesian method.*
- *I find the programs offered by ICERM to be critical to my career as an applied mathematician.*
- *ICERM well-organized presentation topics and researchers from various disciplines, which gave me a great opportunity of exploring new ideas and expanding mathematical virtues. Especially, data-driven modeling and analysis topics are far-front subjects right now and will hugely impact on our future world as progress in theoretical and computational understanding. I especially learned a lot of physics-informed deep learning ideas theoretically and computationally, which definitely benefit my research.*
- *This workshop covered a rather broad range of data-driven approaches and I learned quite a bit about current research directions. The computational aspects were more pronounced than the theoretical ones.*
- *It was enlightening to experience new direction of research involving Data driven models and wide range of applications thereon, I am biased towards Time series analysis and I have obtained valuable lesson learned on several presenters.*
- *I learned new state-of-the-art methods like how deep neutral networks are being applied/used in complex problems as well as new learning methods for UQ problems from the world's experts!!!*
- *Various application and new methods presented by top notch scientific team with years efforts were inspiring. Many innovative ways of integrating cross discipline methods and successful case studies were presented. It's a great opportunity to learn.*

Some Workshop Participant Comments for "Briefly describe workshop highlights":

- *Talk by Nathan Kurtz about DND and Koppman.*
- *The talks by Karen Veroy-Grepl, Jorn Zimmerling, and Robert Scheichl I found especially enlightening.*
- *Tamara Broderick's talk and Mauro Maggioni's talk. I could not attend many others, but I particularly enjoyed these talks.*
- *I especially enjoyed the talks by Themis Sapsis and Jonathan Weare. Thank you for making all of the talks available for future viewing.*
- *Some very good quality talks, and it was nice to see high numbers of virtual participants.*
- *I didn't have to make a long trip to Boston. Still, I could see and participate in the workshop.*
- *The talks which integrated mechanistic and data-driven approaches.*
- *The idea of joining a cluster of wonderful world researchers and scholars via Zoom is a great feeling. The use Gradient descent methodology, Koopman theory, Dynamic mode decomposition, Advanced techniques on neural networks and it application*
- *I enjoyed all the talks, but in particular, I like the talks of Nathan Kutz, Tamara Broderick, Karen Veroy Serkan Gugercin and George Biros.*
- *I was able to see the slides and follow through the talks much better. Note-taking can be as easy as a screen capture. Thanks to the organizers and session chairs. Everything went smoothly.*
- *Really great audience questions, participation, and feedback during and surrounding my research talk.*
- *I couldn't thank more to the organizers to come up this virtual workshop in the midst of Covid19. The only improvement I can suggest is that in the future, if the schedule is changes, it would be nice to email us in addition to just updating the schedule online.*

Note: for a list of upcoming semester programs, see Appendix B.

Topical Workshops

ICERM's topical workshops run over 5 weekdays and focus on a timely and exciting theme that aligns with the institute's mission of supporting and broadening the relationship between mathematics and computation. ICERM hosts several topical workshops each year. They are typically scheduled in December, January, and May through August (around the dates of the semester programs).

1. Solicitation of Topical Workshop Proposals

A topical workshop proposal should be 2-4 pages and contain:

- List of 3-6 organizers, and the main contact for the organizing committee
- Description of the program area/theme, written for a general mathematical audience
- Description of the experimental and computational aspects of the program
- Plan for ensuring the participation of underrepresented groups—As part of your plan please identify a main contact among the organizers that will take the lead in ensuring participation from underrepresented groups. The plan should also list potential

participants of the program that are women and potential participants who are members of an underrepresented minority group (African American, Hispanic or Latino, American Indian or Alaskan Native).

Note: per the advice of ICERM's Scientific Advisory Board, Ulrica Wilson, ICERM's Associate Director of Diversity and Outreach, updated the "plan for ensuring the participation of underrepresented groups" bullet point, and the proposal guideline website was updated in spring 2020.

2. Topical Workshop Selection

Proposals are submitted to the ICERM Director. The Science Advisory Board (SAB) approves the topical workshops. The deadline for proposals is October 1, prior to the annual November SAB meeting, and May 1, prior to a mid-May conference call.

Approved program dates are scheduled and the workshop's lead organizer will assist ICERM staff by providing appropriate program images for web and print ads, and will be asked to review marketing materials. Details are posted on the ICERM website and various on-line math organization calendars SIAM, AMS, European Mathematical Society, National Math Institutes.

3. Recommendation of Speakers

The organizers propose a ranked list of 20-25 speakers, which the ICERM Directors approve and make additional suggestions as needed.

4. Invitations to Speakers

Once the list of workshop speakers has been finalized and funding determined, an invitation is sent to each. The invitation describes the program and outlines the support to be provided. During this reporting cycle, ICERM updated all of its topical workshop invitations to include language regarding Brown University's "Code of Conduct", which addresses sexual harassment, discrimination, and other unprofessional behaviors.

5. Application Process

Once the organizers and Directorate agree there is enough critical mass in terms of confirmed speakers, applications are opened and accepted on-line for that particular workshop on the ICERM website. All applications are stored in the institute's "Cube" database.

6. Applicant Selection

Program organizers can view the applicants and their supporting documents as well as prioritize them within Cube. A member of the ICERM Directorate reviews the prioritized list, re-ranks as appropriate and makes the final selections, taking into consideration the remaining space in the program, diversity, participant support requested, and whether or not the applicant is a young researcher who has an advisor already participating in the program. ICERM staff then updates the applicant about their status, and any support they are eligible for, as appropriate.

Financial Decisions for Topical Workshops

Financial decisions are made by ICERM Directors based on discussions with organizers. ICERM covers travel and lodging expenses of the organizers and 20-25 invited speakers/lead participants; some applicants to the workshop may also be supported.

Topical Workshops in 2019-2020

ICERM hosted 7 topical workshops from May 2019 to May 2020. These workshops focus on topics of current interest in the mathematical sciences.

Topical Workshop 1: Encrypted Search

June 10 – 14, 2019

Organizing Committee:
Alexandra Boldyreva, Georgia Tech
David Cash, University of Chicago
Seny Kamara, Brown University
Hugo Krawczyk, Algorand Foundation
Tarik Moataz, Brown University
Charalampos Papamanthou, University of Maryland

Workshop Description:
The area of encrypted search focuses on the design and cryptanalysis of practical algorithms and systems that can search on end-to-end encrypted data. With encrypted search algorithms, data can remain encrypted even in use. As such, encrypted search algorithms have a wide array of applications including in data management, healthcare, cloud computing, mobile security, blockchains, and censorship- and surveillance-resistant systems.

Participant List Topical Workshop 1

Name	Institute
Akshima	University of Chicago
Archita Agarwal*	Brown University
Elie Alhajjar	US Military Academy
Amr Amr El Abadi*	UCSB
Megumi Ando	Brown Univ. / MITRE
Dmytro Bogatov	Boston University
Alexandra Boldyreva	Georgia Tech
Raphael Bost*	Direction Générale de L'armement
Elette Boyle*	IDC Herzliya
Chloe Cachet	University of Connecticut
David Cash	University of Chicago
Nathan Chenette*	Rose-Hulman
Ran Cohen	Northeastern and Boston Universities
Luke Demarest	University of Connecticut
Ioannis Demertzis*	University of Maryland

Francesca Falzon	The University of Chicago
Peter Fenteany	University of Connecticut
Benjamin Fuller	University of Connecticut
Samprit Ghosh	University of Toronto
Paul Grubbs*	Cornell University
Ariel Hamlin*	Northeastern University
David Heath	Georgia Institute of Technology
Mireya Jurado	Florida International University
Seny Kamara	Brown University
Murat Kantarcioglu*	University of Texas at Dallas
Anurag Khandelwal	UC Berkeley
Vlad Kolesnikov*	Georgia Institute of Technology
Evgenios Kornaropoulos*	Brown University
Hugo Krawczyk	Algorand Foundation
George Markowsky	Missouri University of Science & Technology
William Martin	Worcester Polytechnic Institute
Brice Minaud*	INRIA and ENS
Tarik Moataz	Brown University
Adam O'Neill*	University of Massachusetts - Amherst
Charalampos Papamanthou	University of Maryland
John Partridge	SIFR Systems, Inc.
Giuseppe Persiano*	Universita di Salerno
Alexander Pilyavsky	CUNY
Raluca Ada Popa*	UC Berkeley
Khem Poudel	Middle Tennessee State University
Lucy Qin	Boston University
Mariana Raykova*	Google
Michael Rosenberg	University of Maryland
Sarah Scheffler	Boston University
Vitaly Shmatikov*	Cornell Tech
Jesse Stern	University of Chicago
Tianxin Tang	Georgia Tech
Stefano Tessaro*	University of Washington
Amos Treiber	TU Darmstadt
Mayank Varia	Boston University
Charles Wright*	Portland State University
David Wu*	University of Virginia
Arkady Yerukhimovich	George Washington University
Li Zhang	The Citadel
Cong Zhang*	Rutgers University
Zheguang Zhao*	Brown University

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *I felt at-ease enough to approach groups of people more senior than me and ask stupid questions.*
- *The variety of talks were well balanced and included both experimental methodologies and theoretical developments, both which were rigorously explained.*
- *The literature represents a complex array of security and adversary models (some of which are not clearly articulated). It is only in this interactive format, with a variety of experts present, that matters can be clarified and speakers are challenged to justify their assumptions.*
- *I am extremely honored to attend this workshop. I am able to learn about Hash Table and MPC Ideas on crypto.*
- *I think that as a whole we talked a lot of where the gaps between theory and practice exist and what can be done from both sides to build bridges.*
- *I learned from the talks about recent developments in the broad field of encrypted search, including mathematical insights and new systems that have been built. I had plenty of time to meet and talk to the leaders in this field.*
- *Wide overview of the topic involving leading researchers in the area. Perfect talk duration to get meaningful presentations (45min + 15min questions).*
- *Great opportunity to meet and collaborate with researchers working on specific focused topic. Available time to have offline conversations.*

Some Workshop Participant Comments for "Describe the highlight of this workshop":

- *interactions with colleagues over ongoing research questions received during my talk will improve the presentation of the results when they will be submitted for publication*
- *blockchain talk, it was great*
- *This gave me a few good ideas that I'm following up on currently. But more importantly, this was a fantastic networking opportunity for a 1st year PhD student.*
- *The talks on yet-to-be-published work were most interesting to me.*
- *The quality and the diversity of the talks were amazing.*
- *The many opportunities to take breaks and speak to other participants, as well as a lightning talk on garbled circuits.*
- *Opportunity to meet most of the people in my area.*
- *Learning about the research of other participants at the opening reception.*
- *I enjoyed meeting eminent and new figures in the field and making connections with them*
- *Good crowd of experts, friendly atmosphere*
- *Getting up to date in the research area of Encrypted Search, interacting with researchers, particularly young ones, and observing the interest on the subject in the community.*
- *Able to get chance to discuss with research group at Brown, GTECH and UC Berkeley regrading recent trends in Crypto.*

Topical Workshop 2: Mathematical Optimization of Systems Impacted by Rare, High-Impact Random Events

June 24-28, 2019

Organizing Committee:
Mihai Anitescu, Argonne National Laboratory and the University of Chicago
Güzin Bayraksan, Ohio State University
Jim Luedtke, University of Wisconsin-Madison
Jonathan Weare, Courant Institute, New York University

Workshop Description:
Designing, planning, and operating many systems is challenging due to the possibility of high-impact rare events. A motivating application is the electricity power grid, whose operation can be significantly disrupted by rare weather events such as a severe storm or a polar vortex. This workshop will explore optimization and simulation approaches to designing, planning, and operating systems impacted by such events. Stochastic optimization is one approach for optimizing such systems, in which the uncertain outcomes are modeled with random variables. Rare and high-impact events provide a challenge for stochastic optimization because (1) it is difficult to estimate the likelihood of rare events, (2) estimates of expected values with outcomes that have very low probability but high costs are inherently unstable, and (3) the actual distribution of the random events is often not known. Alternatively, robust and distributionally robust optimization models attempt to identify a solution that is best in the worst-case over a given set of possible outcomes. While robust optimization may protect against the impact of rare events by including them in the set of possible outcomes, doing so may lead to overly conservative solutions. The goal of this workshop is to bring together researchers with different perspectives on optimization under uncertainty to encourage the investigation of new models and solution approaches that address these and related challenges.

This workshop is partially supported by the DOE-funded MACSER project.

Participant List Topical Workshop 2

Name	Institute
Mihai Anitescu*	Argonne National Laboratory and the University of Chicago
Esra Büyüktahtakin-Toy*	New Jersey Institute of Technology
Manish Bansal	Virginia Tech
David Barajas-Solano*	Pacific Northwest National Laboratory
Gvºzin Bayraksan*	Ohio State University
Getachew Befekadu	Morgan State University
Jeremiah Birrell	University of Massachusetts Amherst
Jose Blanchet*	Columbia University and Stanford University
Thushara De Silva M.	Vanderbilt University
Laurel Dunn	University of California Berkeley
Paul Dupuis*	Brown University
Bernardo Freitas Paulo da Costa	Universidade Federal do Rio de Janeiro
Harsha Gangammanavar	Southern Methodist University
Akshay Gupte	Clemson University
René Henrion*	Weierstrass Institute for Applied Analysis and Stochastics
Ruiwei Jiang*	University of Michigan
Simge Küçükyavuz*	Northwestern University

Rohit Kannan	University of Wisconsin-Madison
Markos Katsoulakis	University of Massachusetts Amherst
Ioanna Kavvada	University of California, Berkeley
Kibaek Kim*	Argonne National Laboratory
Colin Klaus	The Ohio State University
Henry Lam*	Columbia University
Vincent Leclere	Ecole des Ponts
Shu Lu	UNC Chapel Hill
Jim Luedtke	University of Wisconsin-Madison
Rahul Mazumder	Massachusetts Institute of Technology
Merve Merakli	Northwestern University
David Morton*	Northwestern University
Linda Novak	Argonne National Lab
Nilay Noyan*	SABANCI University
Lewis Ntaimo*	Texas A & M University
Melkior Ornik	University of Illinois at Urbana-Champaign
Hamed Rahimian	Northwestern University
Line Roald*	University of Wisconsin - Madison
Clement Royer	University of Wisconsin-Madison
Alexander Shapiro*	Georgia Institute of Technology
Sara Shashaani	North Carolina State University
Bismark Singh	Sandia National Laboratories
Georg Stadler*	CIMS NYU
Panos Stinis	Pacific Northwest National Laboratory
Nazanin Takbiri	University of Massachusetts Amherst
Johannes Thürauf	Friedrich-Alexander Universität Erlangen-Nürnberg
Shanyin Tong	New York University
Brian Van Koten*	University of Massachusetts, Amherst
Phebe Vayanos	USC
Alexander Vladimirsky	Cornell University
Andreas Waechter*	Northwestern University
Homer Walker	Worcester Polytechnic Institute
Jonathan Weare	Courant Institute, New York University
Weijun Xie*	Virginia Tech
Hongxia Yin	Minnesota State University Mankato
Jin-Zhu Yu	Vanderbilt University
Victor Zavala*	University of Wisconsin - Madison
Yu Zhang	UC Santa Cruz
Yiling Zhang	University of Minnesota
Benjamin Zhang	Massachusetts Institute of Technology
Lili Zhang	Kennesaw State University

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *This workshop brought together researchers in the different fields of stochastic optimization, robust optimization, and rare-event simulation. I come from the stochastic optimization field, so I learned a lot from talks, and interactions between talks, by the participants from the other fields.*
- *Coming from a control theoretic background, this conference has introduced me to optimization-based and statistical methods for solving problems similar to the ones I am dealing with.*
- *I really appreciated the format of the workshop, which left a lot of time for discussion and connection between participants. I think shorter, more focused talks and more breaks is a good way to go! The mix of participants was also very inspiring. I came away from the workshop with new connections and several concrete follow ups, which will hopefully lead to collaborations and a proposal.*
- *The organizers of this workshop invited experts from various of related areas of this topic, both theoretical, numerical and experimental. Discuss periods provided opportunities to exchange ideas and deepen understanding on rare events.*
- *Through this workshop, I learned how the rare event problem was addressed from the perspective of stochastic programming. My current research focuses on improving the machine learning solutions for the rare event prediction. And I also got opportunities to discuss with other researchers how machine learning can potentially help reduce uncertainty and improve solutions of stochastic programming.*
- *It was possible to meet with top experts in my field (probabilistic programming) and to extensively discuss new challenging perspectives (PDE constrained optimization under random state constraints; dynamical models of chance constraints).*

Some Workshop Participant Comments for "Describe the highlight of this workshop":

- *The poster sessions and a couple of very interesting talks*
- *I was very happy to learn new and interesting perspectives on rare events simulation and optimization during this workshop. I particularly enjoyed the scientific discussions and debates, especially during the lunch time and tea breaks. I wished to thank ICERM and all the organizers for providing me this unique learning experience, and for the excellent arrangement of the program that facilitates discussions.*
- *The workshop missed a lot things and most of presenters are from robust optimization area with marginal backgrounds on rare events. Although it is good meet up and attend such workshop.*
- *I was amazed by the level of interaction between participants with different backgrounds. There were also a very large number of questions after most of the presentations, with many of the questions leading toward "big questions" for the research community. The poster session was a great opportunity for the more junior participants to share their work, and provided a great opportunity for discussions. The ICERM staff was extremely helpful in making the workshop run smoothly.*
- *I very much enjoyed Phebe Vayanos' talk. Both the topic, presentation, and the mathematics behind it were very interesting.*
- *The opportunity to talk with some more senior researchers about my ideas and work.*
- *I like all talks of this workshop and have learned from them. I am a very junior researcher. It is very helpful for me to learn how these senior researchers make efforts with their expertise to make power system robust for rare events. And through talks and*

discussions, I learned the importance of being a socially responsible researcher for public benefits.

- *Several talks could qualify as highlights of this workshop, but I would say that the discussions during the breaks and the open problem sessions were the most interesting part of the workshop.*

Topical Workshop 3: Perspectives on Dehn Surgery

July 15 - 19, 2019

Organizing Committee:
Kenneth Baker, University of Miami
Nathan Dunfield, University of Illinois, Urbana-Champaign
Joshua Greene, Boston College
Sarah Rasmussen, University of Cambridge

Workshop Description:
Dehn surgery has played a central role in the development of low-dimensional topology since it was first introduced by Max Dehn in 1910. Its study has stimulated several fascinating techniques that incorporate ideas from across mathematics: hyperbolic geometry, representation varieties, combinatorics, sutured manifold theory, and Floer homology, to name a few. These tools have led to sensational progress in understanding problems about Dehn surgery and low-dimensional topology at large. Furthermore, they seem well-suited to attack the major open problems in the area, such as the Berge conjecture and the L-space conjecture.

The workshop will function as a graduate summer school. At its core, the school will feature a sequence of mini-courses delivered by a cast of leading experts and distinguished expositors. The courses will unveil Dehn surgery and this suite of techniques to the next generation of researchers in the area. The school will additionally feature guided problem sessions and special presentations on the important role that computation has played and will continue to play in the field.

While targeted at graduate students, the school welcomes applications from qualified future and former graduate students, as well. The main goal will be to enjoy a stimulating week of exploration around a fascinating and active area.

The five mini-courses will be led by Steve Boyer, Cameron Gordon, Marc Lackenby, Yi Ni, and Rachel Roberts.

This workshop is partially supported by NSF CAREER Award DMS-1455132. Please request the funding that you would require in order to be able to attend. Please disregard the standard language on the ICERM application page concerning limited graduate student funding. In particular, you do not need to prepare a poster to be eligible for funding.

Participant List Topical Workshop 3

Name	Institute
Antonio Alfieri	Central European University

Samantha Allen	Dartmouth College
Christopher Anderson	University of Miami
Kenneth Baker*	University of Miami
Adam Baranowski	University of Cambridge
Brandon Bavier	Michigan State University
Fraser Binns	Boston College
Steven Boyer*	Université du Québec à Montréal
Jacob Caudell	Boston College
Mustafa Cengiz	Boston College
Tamunonye Cheetham-West	Rice University
Sangbum Cho	Hanyang University
Michelle Chu	University of California, Santa Barbara
Irving Dai	Princeton University
Subhankar Dey	University at Buffalo, SUNY
Nathan Dowlin	Columbia University
Joshua Drouin	Kansas State University
Nathan Dunfield*	University of Illinois, Urbana-Champaign
Felix Eberhart	Universitaet Regensburg
Viktória Földvári	Eötvös Loránd University
Samuel Freedman	Brown University
David Freund	Harvard University
Xinghua Gao	University of Illinois, Urbana-Champaign
Cameron Gordon*	University of Texas
Joshua Greene	Boston College
Ji-Young Ham	Chung-Ang University
Robert Haraway	Oklahoma State University
Michael Harrison	Pennsylvania State University
Kyle Hayden	Columbia University
Eriko Hironaka	AMS, Florida State University
Adam Howard	Montana State University
Marius Huber	Boston College
Kristóf Huszár	IST Austria
Jonathan Johnson	University of Texas at Austin
Sungmo Kang	The University of Texas at Austin
Marc Kegel	Humboldt-Universität zu Berlin
Juhyun Kim	California Institute of Technology
Douglas Knowles	Dartmouth College
Aleksandr Kolpakov	University of Neuchâtel
Feride Ceren Kose	The University of Texas at Austin
Siddhi Krishna	Boston College
Marc Lackenby*	University of Oxford
Michael Landry	Yale University
Justin Lanier	Georgia Tech
Khanh Le	Temple University
Chaeryn Lee	University of Illinois Urbana-Champaign
Rachel Lehman	University of Arkansas

Dustin Leininger	North Carolina State University
Tao Li	Boston College
Beibei Liu	University of California, Davis
Clayton McDonald	Boston College
Joseph Melby	Michigan State University
Stefan Mihajlovifá	Central European University
Maggie Miller	Princeton University
Kyle Miller	University of California, Berkeley
Jesse Moeller	University of Nebraska - Lincoln
Kai Nakamura	University of Texas Austin
Yi Ni*	Caltech
Jeffrey Norton	Washington University in St. Louis
Sinem Onaran	Hacettepe University
Jesus Oyola Pizarro	Washington University in St. Louis
Insung Park	Indiana University Bloomington
Anna Parlak	University of Warwick
Lisa Piccirillo	University of Texas
Sarah Rasmussen	University of Cambridge
Rachel Roberts*	Washington University in St. Louis
Thomas Rodewald	Georgia Institute of Technology
Carson Rogers	Boston College
Nur Saglam	University of California - Riverside
Geoffrey Sangston	University of Maryland
Tanushree Shah	Glasgow University
Oliver Singh	Durham University
Alexander Stas	Graduate Center, CUNY
Tom Stone	Brown University
Luis Torres	San Jose State University
Lev Tovstopyat-Nelip	Boston College
Eric Towers	Oklahoma State University
Samuel Tripp	Dartmouth College
Linh Truong	Columbia University
Bena Tshishiku	Brown University
Anastasiia Tsvietkova	Okinawa Institute of Science and Technology, Japan / Rutgers University, Newark
Hannah Turner	University of Texas at Austin
Franco Vargas Pallete	institute for Advanced Study
Konstantinos Varvarezos	Princeton University
Laura Wakelin	University of Cambridge
Yuhan Wang	Brown University
Zachary Winkeler	Dartmouth College
Adam Wood	The University of Melbourne
William Worden	Rice University
Ana Wright	University of Nebraska at Lincoln
Andrew Yarmola	Princeton University
Raphael Zentner	University of Regensburg

Yanqing Zou	Dalian Minzu University
Jonathan Zung	Princeton University

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *The Perspectives in Dehn Surgery workshop at ICERM gave me the opportunity to learn about a number of tools that will be useful in my research. Most notably, Cameron Gordon's workshop on exceptional triples was a great introduction to a set of tools for studying exceptional Dehn surgeries, and was my first exposure to methods suited for studying low parameter Dehn-surgeries. These tools provide new directions for current research projects.*
- *In terms of low-dimensional topology, field of mathematics that I am interested in the most, this was an extremely rare occasion that someone incorporated both theoretical and computational aspects of the topic. And both of those with great taste and quality. When it comes to computational aspects, after a long time of no programming, I immediately got an urge to install programs presented and see how I can use them. Theoretically speaking, lecturers were top mathematicians and expositors, no doubt in that.*
- *This ICERM workshop exposed me to KLO (KLO-Software.net), which was new to me. It also highlighted the friction involved in using the poorly composable software for low-dimensional topology. Also, this workshop has associated faces to several names I had only seen on papers and in source code comments, together with the opportunity to ask a few questions to help me automate my own studies.*
- *The main lectures and problem sets were based on theoretical developments, but there were a couple of presentations that donated computational techniques, along with handouts to help try out the programs at home. The problem sessions were especially good at letting us discuss and better digest the content of the lectures.*
- *I learned about different aspects of Dehn surgery that I had not seen previously and further uses for snapPy, but the balance was in favour of theoretical.*
- *Concerning computation, Baker's and Dunfield's sessions gave me a deeper look at the possibilities within programs that I already had some cursory familiarity with: KLO, SnapPy, Sage, etc. The lecture series were fantastic, as anticipated. Gordon's and Ni's themes are already very well-known to me, but, like rereading a great book several times, I picked up a little more from their expositions. The same was true of Roberts's series, which I know a little less well. Boyer's gave me a very good framework for thinking more about 3-manifold group representations, highlighting the key points. Lastly, Lackenby's series was truly fantastic. I was most ignorant about his theme, and it suddenly came into clear focus through his lectures.*
- *The computational demonstrations were helpful, although the pace was a little fast for me since I'm not the most computer-savvy. I was very grateful to learn that the slides from both demonstrations are available online.*
- *I got hands-on experience with certain mathematical software that I have wanted to learn how to use. I learned about certain software that others would like to see developed, and I began work writing this software with encouragement and help from experts. Simply*

put, having multiple experts distill what they thought was important to communicate about Dehn surgery was enormously illuminating.

- *I was able to discuss with more experienced users of computational techniques what software already existed that could handle the sorts of computations my algorithms use. In my case my algorithms are just couldn't run because they weren't efficient enough, or needed code more complicated than I could possibly write in the near future, but Nathan Dunfield made me aware of a couple software packages that will open up new areas of experimental possibility.*
- *The courses were very well done. I wish that the first computational demonstration had occurred later in the week so that we would be familiar with the specific objects and problems in advance.*
- *I've learned new and more effective ways of using the existing software for experimentation in the field. This has completely simplified installation and scripting. I can now more efficiently perform large experiments rather than do them individually.*
- *The computation demonstrations were really helpful, especially having the notes available on ICERM's website. Now I have a reference next time I want to compute something using one of several different programs we talked about during the conference.*
- *The minicourses on Dehn surgery were excellent, the "office hour" problem sessions were well coordinated, and the sessions on software were put together thoughtfully. A very effective workshop!*
- *I was able to follow courses from people who are predominant in their field of research. Some of the lecture series really helped me to better understand important techniques that go into the proofs of big theorems. I particularly appreciate Cameron McA Gordon's lectures.*
- *Before this workshop, I was completely unaware of how to utilize SnapPy. I have become much more comfortable with the technology and thought of ways I could incorporate it into my research.*
- *Many kinds of new software for low-dimensional topology and geometry have been developed in the recent decade. This includes SnapPy, Regina and KLO. Even though SnapPy is already classical, it has been linked to SAGE and thus got a programmable Python interface that enhances its experimental capabilities. Same interface allows linking this software to group-theoretic and number-theoretic computational tools like GAP and PARI. The tutorials on using this combined computational complex software were extremely interesting and helpful.*

Some Workshop Participant Comments for "Describe the highlight of this workshop":

- *Other than an amazing lecture series by Marc Lackenby and the choice of topics, it was definitely the time left in between the lecture courses ("office hours"), that we could use to do problems but moreover freely interact. Usually at similar schools and conferences these free interactions are limited to lunches and conference dinners (when people usually need to relax), but I think this time organizers did a great move with making daily ~2 hours (lunch not included) for spontaneous interaction.*
- *The office hours were great. Chewing on problems with others in my field was refreshing.*

- *The exercise sessions were great. They provided a good space for deepening understanding of the ideas presented, and also, they were a good opportunity to network. I also really liked the open problem session. Having one person write all the problems was a good way to prevent "lectures" during the open problem session, but it still allowed for useful discussion.*
- *The workshop as a whole was very well structured. Problem sets helped me engage with other graduate students. From those engagements I was able to decide who I like working with and as a result of that I have built some collaborations.*
- *The courses by Cameron Gordon and Mark Lackenby. Meeting Nathan Dunfield.*
- *The problem sessions are the highlight of the workshop since I have opportunities to apply the theoretical concepts in a concrete way.*
- *The masterful lecture series: getting nearly 17 hours of exquisite, understandable, exciting, and well-honed lectures, from the masters, around a central theme, all in one place.*
- *I thought the format was wonderful and allowed me to process a lot of information effectively because the lecturers were able to give so much background. I particularly enjoyed the lectures by Marc Lackenby and Rachel Roberts.*
- *I greatly appreciated the format of lectures interspersed with office hours. I felt the office hours made it easier to absorb the deluge of information while also giving time to forge research connections with other participants.*
- *The atmosphere. I felt it was very conducive to learning for a grad student at my stage of research/learning. In particular, more senior people of all kinds, professors, postdocs, and graduate students, were very willing to speak slowly and answer elementary, and even less than thoughtful questions. Every time I didn't understand or know something it felt like an opportunity to talk about it and learn, and not like a situation where I should feel bad about not already knowing it, then nod like I already understand and go off and learn it by myself.*
- *I appreciated the wide variety of topics within the workshop, and the grad-student focus made the week feel far more productive than most conferences I attend. This laid a good foundation to be comfortable and capable of making connections with other researchers.*
- *Steven Boyer's lecture course was very well-organized and highlighted a wide range of techniques and connections between geometric group theory, number theory, Algebraic geometry and Dehn surgery.*
- *There are many very profound theories with striking applications to low-dimensional topology which aren't covered in the literature in a fashion which is very suitable for learning these theories (i.e. standard self-contained text book treaties). These include the theory of foliations, Culler-Shalen theory, Gordon-Luecke theory, hyperbolic 3-manifold topology, and, to some extent, Heegaard Floer homology, as well as the use of Snappy and other computer aided tools. This summer covered the mentioned theories in a very convenient way. It couldn't of course treat all the details in these theories, but it provided a very good structural understanding of these which will enable the attendees of the summer school to read the foundational research articles of these theories much better than if the reading has to start from scratch.*
- *I enjoyed working with my peers on the homework sets, especially for Rachel Roberts' course.*

- *The open problem session at the end. Hearing what questions are most interesting to experts (as well as relevant remarks) is very useful.*
- *Honestly, the highlight was not so much any particular piece of the program, but how well all of the pieces came together cohesively. The workshop truly did give a number of complementary perspectives on Dehn surgery, and I came away with a clear picture of the variety of methods and approaches used in this research area.*
- *SNAPY presented by Ken Baker and Nathan Dunfield.*
- *Professor Lackenby had made a very clear talk on his and many other professors work on Hyperbolic dehn filling theorem and the Gordon conjecture. Professor Ni had presented the great power of Heeggard flower homology. Professor Gordon had showed the beauty of combinatorial label graph theory. There are many also very fascinating talks. Well done.*
- *Interactions with young mathematicians*
- *The computational demonstrations combined with the sessions dedicated to working on problems with the software*
- *Blend of most recent theoretic developments with the newest software for computation and performing experiments.*
- *Seeing the algebra/algebraic geometry in the definition of SL(2,C) character variety.*

Topical Workshop 4: Women in Symplectic and Contact Geometry and Topology workshop (WiSCon)

July 22 - 26, 2019

Organizing Committee:
Bahar Acu, Northwestern University
Catherine Cannizzo, University of California, Berkeley
Dusa McDuff, Barnard College
Ziva Myer, Duke University
Yu Pan, Massachusetts Institute of Technology
Lisa Traynor, Bryn Mawr College

Workshop Description:
The Women in Symplectic and Contact Geometry and Topology workshop (WiSCon) is a Research Collaboration Conference for Women (RCCW) in the fields of contact and symplectic geometry/topology and related areas of low-dimensional topology. The goal of this workshop is to bring together researchers at various career stages in these mathematical areas to collaborate in groups on projects designed and led by leaders in the field.

The mathematical fields of symplectic and contact geometry/topology, rooted in concepts from classical physics, have experienced huge growth in the past few decades. This growth has come in many forms, including multiple flavors of homology theories, symplectic embedding problems, techniques for regularizing spaces of pseudoholomorphic curves, and examples of mirror symmetry, to name a few. This workshop aims to generate research collaborations which build on the growing momentum in these topics, while fostering a network for the traditionally underrepresented groups of women and nonbinary mathematicians. Successful applicants will be assigned to a research project based on their expertise. Participants in this workshop will form

groups of 4-6 members, each led by 2 research leaders, and tackle open problems in a variety of such topics as described in the group descriptions below, perhaps incorporating computational techniques using ICERM's exceptional computing resources.

Partially supported by NSF-HRD 1500481 - AWM ADVANCE grant.

Participant List Topical Workshop 4

Name	Institute
Elaina Aceves	University of Iowa
Bahar Acu	Northwestern University
Akram Alishahi	Columbia University
Haniya Azam*	Lahore University of Management Sciences
Franziska Beckschulte	Justus-Liebig-Universität Gießen
Maria Bertozzi	Ruhr University of Bochum
Sarah Blackwell	University of Georgia
Catherine Cannizzo	University of California, Berkeley
Orsola Capovilla-Searle	Duke University
Carmen Caprau	California State University, Fresno
Celeste Damiani	University of Leeds
Ipsita Datta	Stanford University
Viktória Földvári	Eötvös Loránd University
Agnes Gadbled*	Uppsala University (Sweden)
Sherry Gong	University of California Los Angeles
Nicolle Gonzalez**	UCLA
Julia Grigsby	Boston College
Kristen Hendricks	Michigan State University
Tara Holm**	Cornell University
Jennifer Hom**	Georgia Institute of Technology
Diana Hubbard	Brooklyn College
Keiko Kawamuro	University of Iowa
Ailsa Keating**	University of Cambridge
Feride Ceren Kose	The University of Texas at Austin
Siddhi Krishna*	Boston College
Christine Ruey Shan Lee**	University of South Alabama
Heather Lee	University of Washington
Noémie Legout	Shanghai Tech University
Caitlin Leverson	Georgia Institute of Technology
Joan Licata	Australian National University
Maylis Limouzineau	Mathematical Institute of the University of Cologne
Chiu-Chu Melissa Liu**	Columbia University
Beibei Liu	University of California, Davis
Aleksandra Marinkovic	University of Belgrade
Gage Martin	Boston College
Emily Maw	University College London
Dusa McDuff*	Barnard College
Maggie Miller	Princeton University

Allison Moore**	University of California, Davis
Emmy Murphy**	Northwestern University
Grace Mwakyoma	ShanghaiTech University
Ziva Myer	Duke University
Yu Pan**	Massachusetts Institute of Technology
Ina Petkova**	Dartmouth College
Samantha Pezzimenti	Penn State Brandywine
Lisa Piccirillo	University of Texas
Juanita Pinzon-Caicedo	University of Notre Dame
Ana Rita Pires**	The University of Edinburgh
Olga Plamenevskaya**	Stony Brook University
Katherine Raoux	Michigan State University
Sumeyra Sakalli	Max Planck Institute for Mathematics
Radmila Sazdanovic**	North Carolina State University
Irene Seifert	University of Heidelberg, Germany
Laura Starkston**	UC Davis
Lara Simone Suarez	Ruhr Universitat Bochum
Lisa Traynor**	Bryn Mawr College
Linh Truong*	Columbia University
Hannah Turner	University of Texas at Austin
Vera Vértesi	University of Strasbourg – IRMA
Saraswathi Venkatesh	IAS
Anna-Maria Vocke	Heidelberg University
Abigail Ward	Stanford University
Katrin Wehrheim**	UC Berkeley
Morgan Weiler	Rice University
Biji Wong	UQAM
Angela Wu	University College London
Melissa Zhang	University of Georgia

*Workshop speaker, **Group leader

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *There is a combinatoric/computational aspect of our project totally new to me that the working group projects allowed me to learn. There are several theoretical aspects of our project that were quite far from my work till now. Some of my group members could explain them to me very pedagogically. I realize that these new techniques/constructions are extremely relevant also for my projects on my own and will incorporate them in my research in the future.*
- *During and while preparing for ICERM I had to lean a completely new way of describing moduli space. With my group we spent time going through a paper in a level of detail that I was comfortable in and was required for the project.*
- *ICERM organized the workshop WiSCon. In this workshop, I was working on a project about Polyfolds (project group 4), which was a new topic for me. I learned a lot and will continue the collaboration which started in this workshop!*

- *The fact that ICERM has made available the supercomputing facilities within the program has encouraged my research group to discuss computer implementations of solutions to mathematical problems. These discussions have greatly enhanced my knowledge of the computational methodologies of our research topic.*
- *The possibility of working with other people and especially senior one's in my field, gave me a lot of insights into how to tackle problems and solve them. This was very encouraging and helpful for my research.*
- *I learned practical new ways to compute the fractional Dehn twist coefficient from the group activity.*
- *Having the opportunity to work together with a group at ICERM allowed us to probe some new (and old) theoretical developments.*
- *I have been writing some programs to do computations related to ribbon concordance. It has been really helpful to get some intuition from other researchers here related to these computations.*
- *This workshop format was great. We organized our own mini-talks on specific interests but spent most of our time working on projects. This felt much more productive than a typical conference.*

Some Workshop Participant Comments for "Describe the highlight of this workshop":

- *Meeting with my research team in person for five days straight was incredibly productive. The problem we decided to focus on required the expertise of everyone on my team, and we were able to prove something by the second day!*
- *I thought that the combination of a focused problem and tightly-scheduled work time meant that we got approximately the maximum amount of utility out of our time.*
- *It was fun to do such focused research with so advanced researchers. I would have never considered working with so many people, but it was interesting, and we made enough progress to keep us working on this topic.*
- *I think this is the *best* workshop I've ever gone to. Since there were fewer talks and more work time, I got to see how other people in my field think about finding new problems and solving ones at hand. Moreover, I got to network with a lot of women post-docs and faculty members and seek their career advice. Finally, I got to think about some problems that are adjacent to my current work, and started some collaborations with people in my working group, and in a different one too! WISCON is the first conference where I really felt like I learned a LOT by the end of the week. I learn the most when working on problems (rather than just listening to talks), and so it was great to work with other people. This was one of the best conferences I've ever been to, and I hope I can attend more conferences like this in the future!*
- *Excellent structure to incubate a new research collaboration, and a fantastic opportunity to build a professional network of women in the field*
- *There were several: - new research ideas after given the opportunity to make a research talk; - panels that acted somehow as a pep up talk; - a lot of new and relevant research connections made; - and fantastic (interesting, productive and in a positive atmosphere) group work;*
- *The highlight of the workshop was a relaxed yet energized environment to work and collaborate. I did not know anyone except one participant before coming here. However, I felt quite at home and welcomed.*

- *Working with a very skilled mentor was awesome. She made me feel very smart and useful! I also love the space for socializing at ICERM. The snacks really brought people out of their collaborations to chat!*
- *Getting to form research collaborations with amazing people in a very comfortable environment was great!*
- *The opportunity to collaborate with such amazing mathematicians! I have so many ideas moving forward based on conversations we had during this workshop.*
- *My group was truly fantastic. I was nervous that the workshop would be intimidating, but I felt very comfortable asking questions and expressing my ideas in my group. I also like that the days were broken up with talks, panels, and tea breaks.*
- *I had not collaborated before, and the pace of work was much faster than what I was used to, which was very good -- I felt we focused on what was important much more quickly than I would have been able to on my own. It was amazing to have a research workshop focused on underrepresented genders. I have never been so happy doing mathematics.*
- *It was the first time I was in a collaborative project. I really enjoyed working in groups. The environment was very friendly and welcoming. I was able to go up to senior mathematicians and start a conversation.*
- *Wonderful community and perfect environment to do collaborative research and learn new math!*
- *The opportunity to start a collaboration of leaders in the field. The joy of working on research, especially with leaders and women who I greatly admire. The general healthy atmosphere among workshop participants and collaborators which reminded me of how much I enjoy mathematics and that it is possible to obtain such an atmosphere.*
- *Compared to other conferences, it was much easier to really participate actively. The group work was excellent, and I am sure that in future I will collaborate with people I first met at this workshop.*
- *The main highlight of this workshop was the opportunity to develop a working relationship with talented female researchers of different backgrounds and career stages.*
- *The highlight was being able to meet with so many women in my research field. Usually when at a conference or workshop there is one or two women I can connect with. It was amazing to see how many women are in my field and know that I am not alone in my experiences. I have made a stronger support network and feel energized to continue my studies in mathematics.*
- *Seeing so many young and senior diverse group of women working enthusiastically on projects and listening to their presentations.*
- *Great planning and organizations; lots of networking opportunities; friendly and extremely supportive audience; good working space.*
- *It was an excellent opportunity to form new scientific connections with women across many sub-disciplines of geometry and symplectic topology. Most of my research is in low-dimensional topology and Heegaard Floer homology, and sometimes the conferences can become too focused on topics of narrow interest. I really appreciate the diversity at this conference. Not only demographic diversity, but variety of research interests within the overarching theme of symplectic and contact topology. There were people working on everything from mirror symmetry to Legendrian knots to Khovanov homology and in between. I also appreciate the time and flexibility to work on topics that arose spontaneously. Our group for example, became very interested in the relationship between*

homotopy and concordance in manifolds of nonzero first Betti number; it was great to have the time and flexibility to jump into this.

Topical Workshop 5: Women in Data Science and Mathematics (WiSDM) 2019

July 29 – August 2, 2019

Organizing Committee:
Ellen Gasparovic, Union College
Kathryn Leonard, Occidental College
Linda Ness, Rutgers Universit

Workshop Description:
WiSDM 2019 is a research collaboration workshop targeted toward people working in data science and mathematics. This program will bring together researchers at all stages of their careers, from graduate students to senior researchers, to collaborate on problems in data science.

Data science is typically characterized as work at the intersection of mathematics, computer science, statistics, and an application domain. The scientific focus will be on cutting-edge problems in network analysis for gene detection, group dynamics, graph clustering, novel statistical and topological learning algorithms, tensor product decompositions, reconciliation of assurance of anonymity and privacy with utility measures for data transfer and analytics, as well as efficient and accurate completion, inference and fusion methods for large data and correlations.

Participant List Topical Workshop 5

Name	Institute
Miju Ahn	Southern Methodist University
Loulwah Alsumait	Kuwait University
Elena Balashova	Princeton University
Allison Beemer	New Jersey Institute of Technology
Andrea Bertozzi**	UCLA
Haripriya Chakraborty	The Graduate Center, CUNY
Yang Chen	University of Michigan
Jocelyn Chi	NC State
Julia Chuang	Boston College
Carlotta Domeniconi**	George Mason University
Sanghamitra Dutta	Carnegie Mellon University
Nicole Eikmeier	Grinnell College
Noha El-Zehiry	Siemens
Emily Evans	Brigham Young University
Amrina Ferdous	Boise State University
Asli Genctav	Middle East Technical University
Rachel Grotheer	Goucher College
Weihong Guo	Case Western Reserve University
Jamie Haddock	University of California, Los Angeles
Giseon Heo**	University of Alberta

Genesis Islas	Arizona State University
Haewon Jeong	Carnegie Mellon University
Lara Kassab	Colorado State University
Misha Kilmer**	Tufts University
Anna Konstorum	Center for Computing Sciences, Institue for Defense Analyses
Alona Kryshchenko	California State University of Channel Islands
Esther Lamken	Independent Researcher
Harlin Lee	Carnegie Mellon University
Kathryn Leonard	Occidental College
Anna Little	Michigan State University
Yifei Lou	The University of Texas at Dallas
Anna Ma	University of California, San Diego
Priya Mani	George Mason University
F. Patricia Medina	Yeshiva University
Denali Molitor	University of California, Los Angeles
Anarina Murillo	Arizona State University and Brown University
Deanna Needell**	UCLA
Linda Ness	Rutgers University
Umut Ozbek**	Mount Sinai
Brenda Praggastis	Pacific Northwest National Laboratory
Emilie Purvine	Pacific Northwest National Laboratory
Elizabeth Qian	MIT
Jing Qin	University of Kentucky
Anusha Madushani Rajapaksha Wasala Mudiyanselage	Boston Medical Center
Cynthia Rush	Columbia University
Kritika Singhal	Ohio State University
Emina Soljanin**	Rutgers University
Mansi Sood	Carnegie Mellon University, Pittsburgh
Melissa Stockman	Grabango
Kaisa Taipale	University of Minnesota
Sibel Tari	Middle East Technical University
Sarah Tymochko	Michigan State University
Marilyn Vazquez Landrove	ICERM
Chuntian Wang	The University of Alabama
Xu Wang	Wilfrid Laurier University
Li Wang	University of Texas at Arlington
Emily Winn	Brown University
Karamatou Yacoubou Djima	Amherst College
Miju Ahn	Southern Methodist University
Loulwah Alsumait	Kuwait University

**Group leader

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *WiSDM at ICERM provided me with the unique opportunity to collaborate with outstanding researchers with diverse strengths towards solving a problem in an interdisciplinary domain. I hail from an engineering background and I am more inclined towards solving fundamental theoretical problems. WiSDM gave me the opportunity to learn from and work with expert mathematicians. I learnt a lot about a relatively nascent field and identified new problems which theoreticians can approach with an engineering or mathematical toolkit. I hope to pursue the work that we initiated to completion and continue to collaborate with my team in the coming years. Overall, WiSDM was a fantastic opportunity for me to grow as a researcher and to meet wonderful researchers. I am grateful to my team leader, organizers, and ICERM for providing me with this great opportunity.*
- *The project I was on, while interesting, had nothing particularly novel in its design. I was hoping to acquire new skills and be exposed to new theory in my area of interest. Because of the daily reporting demands we found ourselves driven to produce results instead of feeling free to investigate and learn. The final day of reporting would better have been spent engaging with peers and exchanging ideas. The teams instead felt pressed to deliver polished power point presentations. These were huge time sinks for the limited time we had together.*
- *I was introduced to new methods of applying my background in spectral methods to image processing*
- *I worked on the project in tensor analysis. I definitely feel more capable and prepared to work with tensors on both the computational and theoretical level after the workshop. I did feel that there was not quite enough guidance for project development as I would have liked, which may have improved my capabilities after the workshop.*
- *In our research group, we made several readings related to our research problem. Then, we formulated our solution with the guidance of our group leaders. After implementing our solution, we experimented with it using an available dataset. All of these steps enabled me to add to my knowledge of experimental/computational methodologies and theoretical developments within our topic.*
- *My participation in Andrea Bertozzi and Yufei Lou's group exposed me to PDE-based optimization and to the whole compendium of research begun by Andrea's ~2012 paper with Flenner, summarized in her ICML talk with many references to related work. Her papers are very clearly written and include algorithm sketches. She has demonstrated that a number of different problems (graph cut, network modularity, etc.) can all be scalably implemented using her optimization methods. She also very clearly explains the MBO heat-kernel based approach. Thank you, Andrea! In addition, witnessing the young participants implement and debug everything in real time was very informative.*
- *ICERM provides a great environment for learning and working. Everything is organized for your comfort; the staff is amazing. They try to help with anything one might need.*
- *During this workshop, I had the opportunity to review literature and explore algorithms for nonegative matrix and tensor decompositions. It definitely added to my knowledge in this area and sped up the process of learning how to use software in real data.*
- *My project didn't involve computational methodologies. I learned a lot about the theoretical foundations of my project though, as it was a new area for me. My project leader did a nice job of recommending papers to each member, based on their*

background in the area and which aspect of the project they seemed particularly interested in.

- *I had opportunities to talk to people with different background and different expertise, which helps to broaden my understanding of my research problems.*
- *Our project didn't do much math (a.k.a. proofs and analyzing theoretical properties of our problem/solution) this week, but we looked at a lot of interesting methods and implemented new algorithms on matlab.*
- *At WisDM I learned a lot about tensors, current research on tensors and also several open questions and areas for future exploration. I also learned a bit about other areas of research in data science such as anonymity and graph-based methods.*
- *By working with people from different communities, I have gained other information and expanded my knowledge.*
- *We got to learn a brand-new topic and actually do real work during the week! This was fantastic.*
- *the WiSDM workshop format of working in small groups to investigate research questions in a hands-on manner during the week is super for learning about new methodologies; I was able to implement and test several new ideas, and had good discussions on theory with other members of my group. You simply do not get the same level of understanding from more conventional workshops packed full of lecture-style talks.*

Some Workshop Participant Comments for "Describe the highlight of this workshop":

- *The best part was listening to what other teams were doing. I was particularly interested in the tensor work being done in another group. I would have liked more opportunities to mix with the other groups. While I liked my team leader and the women on my team, I found myself data crunching a scanty dataset most of the week instead of exploring novel approaches to working with data.*
- *The workshop was a wonderful experience for me as a young researcher. I got the opportunity to collaborate with outstanding researchers to work towards solving a crucial problem in the domain of data privacy. We postulated several new problems which can be solved with a theoretician's tool kit. I am eager to pursue some of the exciting discussions that we discussed and build upon the theoretical understanding of privacy preserving communication. My team leader and team members were fantastic and we had an amazing time working together. I hail from an engineering background and I love Mathematics. One of the highlights for me was getting the opportunity to learn from expert mathematicians who were part of the team. In addition to learning about new problems and techniques, I enjoyed the insightful discussions that we had about tiding challenges at different stages of our careers.*
- *Informative discussions within our group on cutting edge methods in computer science.*
- *The highlight for me was getting to the end and having a tangible analysis of a problem. In particular, one that should lead to a paper!*
- *Meeting lots of great and smart women and started a future collaboration.*
- *Working with other highly intelligent and skilled women.*
- *This was my first workshop that had a group setting with direct project goals. I enjoyed it more than I expected, and feel more capable of working in teams on projects with quick turnover.*

- *Wonderful, interactive, informative, effective, knowledge and skill improving workshop. I loved this. This gives me a new dimension of my PhD thesis research.*
- *The highlight of the workshop is getting to meet other women with interests similar to mine and really dive into an area that was relatively new to all of us, asking the fundamental questions, running experiments, and try to figure out cutting edge definitions and theorems. I also got to meet a co-author on a paper I cited in my dissertation.*
- *The technical highlight was learning Andrea Bertozzi's approach to data: view everything as a similarity graph and then use supervised or unsupervised optimization methods with geometric meaning to understand the data. The community highlight was the final set of group presentations. It appears that the quality of the technical work and the collaborations has increased since WiSDM 2017. Thanks to all of the group leaders, especially the new group leaders!*
- *Meeting and being able to work with a group of women on a challenging problem in data science, being part of a collaborative process for a research project interacting with highly talented mathematicians to understand and build the math foundation of a problem being all women in the field.*
- *I met a lot of wonderful, smart and motivated women. We worked on a highly valuable research project and obtained preliminary results.*
- *Developing collaborations with other women in math and data science.*
- *Getting preliminary results that might lead to publications.*
- *Meeting a group of brilliant women doing excellent and interesting work, while at the same time learning new math and working in new directions.*
- *the format of the workshop is the highlight - it allowed for truly in-depth discussions and prototyping of new algorithms on the spot, with many enthusiastic researchers around to give feedback and help solve problems.*
- *The group of people I worked with were the highlight. We worked well as a group and I am hopeful that we will continue to collaborate in the future.*

Topical Workshop 6: Applied Mathematical Modeling with Topological Techniques

August 5 - 9, 2019

Organizing Committee:
Henry Adams, Colorado State University
Maria D'Orsogna, California State University, Northridge
Rachel Neville, University of Arizona
Jose Perea, Michigan State University
Chad Topaz, Williams College

Workshop Description:
Mathematical modelers face a variety of challenges, including summarizing large data sets to understand and explore a system of interest, inferring the model parameters most accurate for describing a given data set, and assessing the goodness-of-fit between data sets. Computational topology provides a lens through which these challenges may be addressed. At the same time, just as topological techniques provide opportunities for modelers, the challenges that modelers face give rise to opportunities for applied topologists. For instance, topologists may develop techniques that make model predictions based on the topology of experimental or simulation

data, that analyze time-varying data, or that turn model outputs into formats suitable for machine learning.

This workshop brings together the applied mathematical modeling and applied topology communities, aiming to give modelers exposure to topological techniques still not commonly used in their community, and to give topologists exposure to modeling challenges that might stimulate the development of new techniques.

The workshop will include tutorial sessions on modeling and on applied topology, during which participants will learn by doing hands-on computational exercises. Because the broad goal of this workshop is to encourage collaboration between members of the applied modeling and topology communities, a significant portion of the week will be devoted to participants initiating research on problems proposed by the organizers. The research problems will afford the potential for continued collaboration beyond the workshop.

Participant List Topical Workshop 6

Name	Institute
Henry Adams	Colorado State University
Erik Amezquita	Michigan State University
Manuchehr Aminian	Colorado State University
Robin Belton	Montana State University
Heather Brooks	UCLA
Vladislav Bukshtynov	Florida Institute of Technology
Johnathan Bush	Colorado State University
Yu-Min Chung**	UNC Greensboro
Veronica Ciocanel*	Mathematical Biosciences Institute / Ohio State University
Padraig Corcoran**	Cardiff University
Maria D'Orsogna	California State University, Northridge
David Damiano	College of the Holy Cross
Sarah Day**	College of William and Mary
Stephanie Dodson	Brown University
Steven Ellis	Columbia University
Elin Farnell	Colorado State University
Brittany Fasy*	Montana State University
Hitesh Gakhar	Michigan State University
Cliff Joslyn	Pacific Northwest National Laboratory
Jisu Kim	INRIA Saclay
Woojin Kim	The Ohio State University
Minh Le	SUNY Buffalo
Michał Lipiński	Jagiellonian University
Hengrui Luo	The Ohio State University
Kara Maki*	RIT College of Sciences
Dr. Santanu Manna	Keele University
Reginald McGee	College of the Holy Cross
Melissa McGuirl**	UT Austin/ Brown University
Joshua Mike	Michigan State University

Nikola Milicevic	University of Florida
Joshua Mirth	Colorado State University
Chul Moon	Southern Methodist University
Francis Motta**	Florida Atlantic University
Akil Narayan	University of Utah
Tom Needham	The Ohio State University
Rachel Neville	University of Arizona
Alice Patania	Indiana University
Jose Perea	Michigan State University
Emilie Purvine	Pacific Northwest National Laboratory
Michael Robinson*	American University
Nancy Rodriguez**	University of Colorado at Boulder
Hwayeon Ryu	Elon University
Daniel Scott	Brown University
Nick Scoville	Ursinus College
Martin Short*	Georgia Tech
Michael Sinhuber**	Max Planck Institute for Dynamics
Elchanan Solomon	Duke
Kathleen Storey**	University of Michigan
Chad Topaz	Williams College
Bridget Torsey	Rochester Institute of Technology
Sarah Tymochko	Michigan State University
Mikael Vejdemo Johansson**	CUNY College of Staten Island
Alexandria Volkening	Northwestern University
David White	Denison University
Emily Winn	Brown University
Ming Zhong	Johns Hopkins University
Lori Ziegelmeier*	Macalester College

*Workshop speaker, **Group leader

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *My awareness of certain methodologies increased as a result of participating in the workshop. One of the biggest benefits was having an opportunity to work with others on new research collaborations; hopefully, some of those will continue beyond the end of the workshop. I felt that the tutorials were at too low of a level, especially on the first day, and were too rushed to get into the mathematics on the second day. I was hoping to get more depth in the two main topics in the workshop.*
- *I don't have the opportunity to work closely with modelers very often, this workshop gave me the opportunity to learn current methods and techniques from experts in the field as well as to learn mindsets and approaches to problems.*
- *The part on topology and its related topic (including TDA) appears to have on intersection with my current research. The part on modeling (especially the flint water crisis) is very interested, wished the organizers would have spent more time on this modeling and analysis behind it.*

- *I learned some of topological data analysis techniques that can be applied for genomic cancer data using Mapper algorithm.*
- *Attending the workshop at ICERM introduced me to new ways of mixing topology with Mathematica modeling.*
- *The workshop gave me an opportunity to observe in real time how people attack data science problems. It was also nice that I was a part of the process.*
- *Studied new computational methodologies on how to involve TDA and some topological components into analysis of the data available for my particular research. Will involve it at the next step. Gained very fruitful collaborations that will hopefully end up with the new research direction to explore and make some contribution. Still want to make more theoretical development to look deeper into the topological methods for data analysis.*
- *I have long wished to learn how to apply the "mapper" method of data analysis. At the workshop I did learn how and acquired the necessary software so I can apply the method in my own research.*
- *It was good to actually use some of the software in practice and get familiar with its capabilities in the context of our group's data set. I had already had extensive theoretical knowledge so the workshop did not add to that but it was a nice review. It remains to be seen whether the group will continue collaboration.*
- *During my week at ICERM I learned about networks and how to use networks to analyze temporal data.*
- *I commend the organizers for their ambitious goals of bringing together two very different fields of mathematics for this workshop. I'm not sure that the workshop actually met this goal very well, though. From what I could see of the projects, few if any actually did any modeling, while it seems a couple did do some theoretical topology. Mostly it seemed to just boil down to topological data analysis, which is fine but not exactly what I had been expecting. So, the workshop did introduce me to some techniques of TDA (basically CROCKER plots and Mapper), but not much else.*
- *I have never had a mathematical modeling class. Everything I know I've learned by experience. It was nice to see the tutorial presentation on modeling!*
- *I have better insight into how topological methods might be used to examine experimental data with regard collective motion. This was aided significantly by reading the material suggested by our group leader prior to attending the workshop.*
- *I learned how to actually run python's kmapper. The workshop also piqued my curiosity to dive into the theoretical foundations of mapper.*
- *The interdisciplinary workshop provided a great venue for sharing knowledge and learning new mathematical techniques.*
- *With respect to knowledge in theoretical developments, I came in knowing most of the theoretical topology that was discussed, so by definition, there was no gain there. But I learned a solid framework for how to think about modeling, something that I knew very little about. I also was exposed to quite a bit of computational methods and techniques. Unfortunately, I have very little knowledge of computation to begin with, so I quickly forgot things after being exposed to them. But I know what kinds of things can be done and how to go about finding how, so that is helpful.*
- *I liked that there was a topology tutorial, but it moved too fast for me (as a novice) and used terminology I didn't understand.*

- *I learned and got hands-on experience with various computational topology packages during this workshop: R TDA, also Ripser and other Python-based packages. Also explored some visualization software for our group's problem.*

Some Workshop Participant Comments for "Describe the highlight of this workshop":

- *There were a couple talks that I really enjoyed; those by Lori Ziegelmeier and Martin Short, in particular, were great. They both provided enough background and depth to have mathematically interesting talks without diving in too deep and losing those who weren't experts in the field. They also both did a great job motivating their work. I appreciated the chance to spend time on mathematical topics that are outside of my particular expertise but which could come into play in my current research. One of the most valuable aspects of the workshop was the opportunity to network and make new research connections.*
- *The ability to network and connect with researchers with different backgrounds and areas of research.*
- *Meeting new folks, seeing old folks, and making new conversations with both. These were myriad, from professional development and social interaction to active discussion on research (both old and new). It was exhausting and enjoyable: a good sign that we are eking every drop of value out of our time together.*
- *The highlight of the workshop was by far the way that people with different backgrounds engaged in meaningful ways. I have expanded my professional network in ways that strengthen me as a mathematician and invigorates my research.*
- *The positive, productive and friendly environment bringing people from different fields together, working and talking together. Also crab cakes and bagels.*
- *the flint water crisis model provides some refreshing idea into my current research (I'm working on a combination of machine learning and agent-based dynamics right now). The topology part turns out to be not that useful. I wish that more time has been spent on constructing various topological spaces (i.e., building suitable metrics on non-Euclidean objects, e.g. opinions, trusts, emotions), instead of using TDA to talk about geometric objects.*
- *Professional session was helpful; inclusive environment was very helpful and welcoming especially for those who are working in undergraduate institutions (or liberal arts schools).*
- *I got even more than expected: good insight into new computational techniques, tools for data analysis, new collaborators and promising ways to extend my current research directions. Thank you!*
- *The working groups were a great opportunity to talk to a diverse group of folks about a new research project.*
- *I really enjoyed the diversity and inclusion breakout group during the professional development portion.*
- *The highlight of this workshop was meeting and connecting with people both within my research group and at the workshop in general. The organizers did a fantastic job of urging people to meet people they never spoke to, which offered a nice balance of reconnecting with people I knew and actually getting to know people I had never met.*

- *Working with and meeting new people with various backgrounds. I really enjoyed working in small groups where everyone could learn from each other and we could combine our skills to tackle new problems from a creative angle.*
- *--Participating in group project was really efficient way to get ideas for future research as well as making connections with other researchers. --Several 30-minute coffee breaks are very nice to talk with many people out of my project group.*
- *The ability of our group to pursue multiple topological and analytic approaches over the course of the workshop to attempt to uncover collective behaviors.*
- *I am part of a new research group. Everybody in my group connected pretty well. We plan to further the research started this week. We plan to hold virtual meetings regularly, and even apply for ICERM funding to meet once again.*
- *The overall plan for the workshop -- breaking into small groups to work on pre-assigned specific problems -- made this workshop the most successful I have had the chance to participate in with respect to building collaborations and making quick progress on a new project. I found the experience extremely inspiring and productive.*
- *I enjoyed the group projects a lot. It was productive, educational and allowed me to meet future collaborators.*

Topical Workshop 7: Numerical Methods and New Perspectives for Extended Liquid Crystalline Systems

December 9 - 13, 2019

Organizing Committee:
Jan Lagerwall, University of Luxembourg
Apala Majumdar, University of Bath/University of Strathclyde
Shawn Walker, Louisiana State University

Workshop Description:
Liquid crystals (LCs) are classic examples of partially ordered materials that combine the fluidity of liquids with the long-range order of solids, and have great potential to enable new materials and technological devices. A variety of LC phases exist, e.g. nematics, smectics, cholesterics, with a rich range of behavior when subjected to external fields, curved boundaries, mechanical strain, etc. Recently, new systems came into focus, such as bent-core LC phases, twist-bend-modulated nematics, chromonics and polymer-stabilized blue phases, with more to be discovered.

Best known for applications in displays, LCs have recently been proposed for new applications in biology, nanoscience and beyond, such as biosensors, actuators, drug delivery, and bacterial control (related to active matter). Indeed, it is believed that the LC nature of DNA once enabled the mother of all applications, namely life itself. New numerical methods and scientific computation is needed to guide new theory and models for these systems that capture the interplay of symmetry, geometry, temperature and confinement in spatio-temporal pattern formation for LCs and extended LC-like systems.

This workshop provides an interdisciplinary platform for computational and experimental research in extended LC-like systems, and how these approaches can yield new theoretical insight for novel LC systems.

Participant List Topical Workshop 7

Name	Institute
James Adler*	Tufts University
Roberta Almeida	University Thecnolgy of Paraná
Anca Andrei	Tufts University
Timothy Atherton*	Tufts University
Konark Bisht	Indian Institute of Technology Delhi
Maria-Carme Calderer*	University of Minnesota
Douglas Cleaver	Sheffield Hallam University
James Dalby	University of Strathclyde
Michael Dimitriyev	Georgia Institute of Technology
Thomas Fai	Brandeis University
Lidong Fang	Shanghai Jiao Tong University
Patrick Farrell*	University of Oxford
Zhiyuan Geng	Courant Institute of Mathematical Sciences
Helen Gleeson*	University of Leeds
Joseph Harris	University of Strathclyde
Kirsten Harth*	Otto von Guericke University
Alfa Heryudono	University of Massachusetts, Dartmouth
Andrew Hicks	Louisiana State University
Jan Lagerwall	University of Luxembourg
Dmitriy Leykekhman	University of Connecticut
Jichun Li	University of Nevada Las Vegas
Yuan Liu	Wichita State University
Scott MacLachlan	Memorial University of Newfoundland
Ruma Maity	Indian Institute of Technology Bombay
Apala Majumdar*	University of Bath/University of Strathclyde
Sabetta Matsumoto*	Georgia Institute of Technology
Lidia Mrad*	Mount Holyoke College
Ricardo Nochetto*	University of Maryland
Peter Palffy-Muhoray*	Kent University
Sourav Patranabish	Indian Institute of Technology (IIT) Delhi
Tom Powers*	Brown University
Denisse Reyes Arango	Universidad Nacional Autónoma de México
Michele Ruggeri*	TU Wien
Giusy Scalia*	Université du Luxembourg
Francesca Serra*	John Hopkins University
Jie Shen*	Purdue University
Giordano Tierra Chica	University of North Texas
Epifanio Virga*	Università di Pavia
Shawn Walker	Louisiana State University
Qi Wang*	University of South Carolina

Yiwei Wang*	Illinois Institute of Technology
SULIN WANG	Michigan State University
Jingmin Xia	University of Oxford
Yue Yu	Lehigh University
Ziyao Yu	Purdue University
Jia Zhao*	Utah State University

*Workshop speaker

Some Workshop Participant Comments for "Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.":

- *I have met theoreticians working on problems adjacent to my (experimental) field. Some of my own questions regarding numerical implementations are one step closer to an answer, and I saw parallels to other fields of research (regarding implementation), that were not obvious to me before. I have also found new potential collaborators which I would probably not have met outside this workshop.*
- *The workshop had an excellent cross-section of researchers in theoretical, experimental, and computational methodologies.*
- *The conference was attended by a wonderful mixture of experimentalists, theoreticians and numerical analysts. I gained a deeper understanding of the modelling needs of experimentalists and intend to refocus my numerical efforts on more complex models required to describe phenomena at the cutting edge of liquid crystal science.*
- *Knowledge added via the presentations, quite extended in time and by the discussions with people with different backgrounds in a relaxed environment, also during meals. A more extended use of the white/ blackboard, if clear and visible text or formulas, would be beneficial to highlight more critical steps in theoretical developments.*
- *All the talks gave in the workshop are great, and they really increased my knowledge in this area.*
- *The talks were excellent as were the questions and discussion that followed. It was a good atmosphere for sharing knowledge.*
- *Participants engaged in discussions immediately after talks and during breaks. Experimentalist, theorists, and numerical analysts had the opportunity to share their experiences and exchanged information. I learned a lot from these interactions.*
- *The talks were really good, with the top knowledge in LC.*
- *I attended this conference to build a foundational knowledge on liquid crystals and to see the up and coming research topics. It was nice to see both point of views from experimentalists and mathematicians.*
- *I have gained new contacts/collaborations through this.*
- *The workshop was really inspiring and stimulating: On the one hand, I gained theoretical knowledge (I am essentially a newcomer in the field). On the other hand, wonderful talks given by experimentalists gave me many physical insights and suggested challenges for mathematical and numerical modeling.*
- *Excellent venue and infrastructure, fantastic and supportive staff, appropriate and balanced choice of delegates, impressive diversity of attendees, conducive atmosphere, great computing facilities, well maintained.*

- *I was particularly happy with the connections I was to establish with the numerical/computational community represented at the Workshop.*
- *I gained a much deeper understanding of the subtleties of mathematical methods applied to liquid crystal theory across a wide range of topics. This is vital to me as an experimentalist as it gives me new ideas for investigations. I also gained new perspectives on some of the experimental data I've been working to understand.*
- *Very good workshop for getting knowledge about the LC community. Very good schedule for the attendees so that we can ask enough questions and understand more details.*
- *I learned a great deal about how finite element people think about their work, and also made some very valuable connections with experimentalists.*

Some Workshop Participant Comments for "Describe the highlight of this workshop":

- *The best part of the workshop for me was getting to meet other graduate students. As I've only just begun my PhD being able to speak to students who are further along than me and find out how they've found the experience so far was valuable, and most importantly being able to hear about their work through the poster session and discussions was great.*
- *I'm an early career researcher and the interest of others in my talk is probably the most I've experienced. Questions I received were interesting and the general attitude towards my work was encouraging. This workshop did help me feel visible as a researcher.*
- *Many novel models in experiments and numerical simulations may leads to some developments in the analytical issues in liquid crystals.*
- *New results in modeling and computation of which I was unaware. Organization was great; facilities were excellent.*
- *enough time to discuss and get to know new people!!! This provides room for new ideas, new collaborations and deepening / connecting theory and experiment parts of existing research. 2) the friendly, open and interested atmosphere between the participants*
- *Simply the wide range of expertise of the participants.*
- *The friendly atmosphere, the open-minded attitude of people, the broad mix of people, the relaxed and casual atmosphere that made it very easy to approach persons for discussion.*
- *The highlight was the vigour, breadth and depth of the discussions after every talk. This was aided by the very generous schedule, allowing lots of time for questions (in some cases up to twenty minutes). This was also aided by the conference attendees, with a rich mixture of interdisciplinary expertise.*
- *Talks were great, and we had enough communication times.*
- *All the talks and discussions afterward.*
- *It was a very exciting workshop with a lot of discussion about current questions and possibilities of future research. Great experience.*
- *The talks were really interesting and the organization of the workshop was really good.*
- *The highlight was the discussion sessions happening during coffee/tea breaks. The entire workshop was phenomenal and the discussion sessions really added to the positive effect of the entire workshop.*
- *The question and answer period after each talk.*
- *I enjoyed the interdisciplinary nature of the meeting: mathematical modeling, analysis, numerics, theoretical physics, experiments, applications. Looking at the problems from different perspectives opens your mind.*

- *Truly welcoming platform for three different sets of researchers from applied mathematics, computational mathematics and experimentalists. Very unique and supportive environment for new collaboration that transcend discipline boundaries.*
- *Soliton propagation in liquid crystals (M.C. Carlderer's talk). Auxetic behaviour in nematic elastomers (E. Gleeson's tank).*
- *Having the time and atmosphere to think and discuss, and to have those discussions specifically aimed to bridge the gap between experiments and computation/theory*
- *The excellent talks as well as many stimulating discussions.*
- *Discussions. Q & A sessions, and one or two talks.*
- *The workshop brought in people from different disciplines working in Liquid crystal research. It was truly interdisciplinary and the comments and feedbacks made me start looking at things from a different perspective which will help me greatly for my research. I would be very happy to have similar opportunities in future as well. Thank you.*
- *Good schedule and a lot of interesting talks.*
- *I learned new theorems and numerical implementations about ELC systems.*
- *An opportunity to meet collaborators and interact with the finite element community.*

Collaborate@ICERM (C@I)

ICERM hosted eight Collaborate@ICERM programs from May 2019 to May 2020.

Collaborate@ICERM offers teams of 3-6 researchers the opportunity to spend five days at the institute during the summer (May-August) or during the month of January. The team research project should have a computational or experimental component. ICERM provides access to a variety of software packages as well as to high performance computing through Brown's Center for Computation and Visualization.

Proposals involving research projects that continue a collaboration fostered at one of the past ICERM semester programs are encouraged. Collaborate@ICERM provides limited funding for travel to the institute and local accommodations for six nights. The majority of participants must be from U.S. institutions. The entire team should be present for the week at ICERM.

Collaborate@ICERM Process

1. Solicitation of Proposals

ICERM solicits proposals from faculty through announcements about the opportunity during welcoming remarks at other ICERM programs, and calls for proposals in quarterly newsletters.

Though it is not required, Collaborate@ICERM proposers are welcome to contact the ICERM Director prior to submitting a proposal for preliminary feedback.

The 2-3 page Collaborate@ICERM proposal should include a research title and the list of team members on the first page, as well as:

- Broad research objectives and specific goals for the week at ICERM, written for a general mathematical audience
- Members of the team (3-6)
- The case for convening at ICERM

- A list of possible dates (5 weekdays in May-August or in January)
- 2-page CVs for each team member.

During this reporting cycle the following eligibility guidelines for Collaborate@ICERM (C@I) were developed:

The majority of group participants must be from U.S. institutions. C@I groups can include self-funded participants. The entire team should be present for the week at ICERM. An individual invited to more than one accepted C@I proposal within a given review cycle will only receive funding for one of the visits. Individuals should not participate in a C@I program more than twice within three years.

2. Deadline and Review Process

Completed proposals should be submitted to the ICERM Director. Annual target deadlines are October 1st and May 1st. ICERM Directors and the Scientific Advisory Board (SAB) review all proposals. Proposers receive feedback within a month of the SAB meeting.

Collaborate@ICERM Participants and Projects

C@I 1: Widening the scope of Accuracy Enhancing Filters (May 13 - 17, 2019)

- Julia Docampo Sanchez, MIT
- Robert Haimes, MIT
- Gustaaf Jacobs, San Diego State University
- Xiaozhou Li, University of Electronic Science and Technology of China
- Jennifer Ryan, University of East Anglia and Heinrich Heine University

C@I 2: Geometry of Data and Networks (June 17 - 21, 2019)

- Joan Bruna, CIMS, NYU
- Zheng Ma, Princeton University
- Guido Montúfar, UCLA
- Nina Otter, UCLA
- Yuguang Wang, UNSW

C@I 3: Higher Dimensional Post-Critically Finite Maps on Projective Space (July 8 - 12, 2019)

- Patrick Ingram, York University
- Rohini Ramadas, Brown University
- Joseph Silverman, Brown University

C@I 4: The Geometry of Nash Blowups of Schubert Varieties, Fiber Products of Resolutions, and Peterson Translation (July 8 - 12, 2019)

- David Anderson, Ohio State University
- Laura Escobar, Washington University- St. Louis
- Edward Richmond, Oklahoma State University
- William Slofstra, University of Waterloo
- Alexander Woo, University of Idaho

C@I 5: The Tropical Convex Hull of Convex Sets (July 15 - 19, 2019)
- Cvetelina Hill, Georgia Institute of Technology
- Sara Lamboglia, Goethe-Universität Frankfurt
- Faye Pasley Simon, North Carolina State University

C@I 6: Fault Tolerant Power Domination and Zero Forcing (August 12 - 16, 2019)
- Katherine Benson, University of Wisconsin-Stout (Menomonie, WI, US)
- Daniela Ferrero, Texas State University
- Mary Flagg, University of St. Thomas
- Veronika Furst, Fort Lewis College
- Violeta Vasilevska, Utah Valley University

C@I 7: Improved Results for Root Discriminant Bounds in Towers of Number Fields and Tame Tate-Shafarevich Groups (January 6 – 10, 2019)
- Farshid Hajir, University of Massachusetts Amherst
- Christian Maire, FEMTO-ST
- Ravi Ramakrishna, Cornell University

C@I 8: Fast and Accurate Simulation of Waves in Layered Media (January 13 - 17, 2020)
- Min Hyung Cho, University of Massachusetts Lowell
- Lingyun Ding, The University of North Carolina at Chapel Hill
- Hao Gao, University of Illinois at Urbana-Champaign
- Jingfang Huang, UNC
- Djeneba Kassambara, University of Massachusetts Lowell
- Andreas Kloeckner, University of Illinois at Urbana-Champaign
- Zhuochao Tang, University of North Carolina at Chapel Hill

Note: ICERM sends exit surveys to Collaborate@ICERM participant groups 6 months after their meetings. For exit survey reports from the 2019 Collaborate@ICERM programs listed above, see Appendix C.

TRIPODS Workshops

Brown University's Data Science Initiative partners with ICERM on public events, included workshops supported by the TRIPODS grant from the National Science Foundation.

Data Science in Low-dimensional Spaces
May 13 - 17, 2019

Organizing Committee:
Vincent Cohen-Addad, CNRS & Sorbonne Université
Philip Klein, Brown University
Eli Upfal, Brown University

Program Description:
Data science in low-dimensional spaces is motivated by applications in mapping, navigation, geographic resource allocation, modeling of body shapes and chemical structures, and more. In addition to datasets that naturally reside in low-dimension spaces, dimension-reduction methods can often transform high dimensional data to lower-dimensional data while preserving properties of interest. Since many computational problems are intractable for high-dimensional data but potentially tractable for low-dimensional data, it is useful to establish the algorithmic foundations of data science on low-dimensional data, to understand the special properties of such data, and to identify computational methods that are highly effective when applied to such data.

This workshop will bring together researchers in academia and industry to explore algorithmic and data analysis technique specialized for low-dimensional data, and application areas in which such problems arise. The focus of this workshop is on algorithms with provable performance guarantees. In particular, we are interested in algorithms that scale to large datasets, and algorithms that adapts to distributed environments and to online settings.

Hot Topics Workshops

ICERM is the recipient of one of the Simons Foundation Targeted Grants to Institutes. The Simons funding, totaling nearly $1 million over 5-years (2017-2021), enhances and expands ICERM's efforts to bring top scholars to the institute to explore big questions in mathematical research.

ICERM uses the additional funding to improve financial support for the academic leaders of the institute's semester-long topical conferences and workshops.

In this reporting year, ICERM also started using these funds to launch its "Hot Topics" workshop program. Hot Topics workshops are designed to allow ICERM to move quickly in order to start the public exploration of breakthroughs and emerging mathematical areas. They run 2-3 days and are organized on a few months' notice. They can originate through suggestions from ICERM boards or the community. The Simons Foundation Targeted Grant provides financial support of around $50K for each Hot Topics workshop, including honoraria to attract key speakers and organizers.

The institute welcomes suggestions for Hot Topics Workshops and encourages researchers to contact the ICERM Director with ideas. The Director and a SAB Hot Topics subcommittee considers proposals for such workshops, which should include:

- List of potential organizers
- Description of the program area/theme (1 paragraph)
- Explanation about why it is a "Hot Topic" (1 paragraph)
- List of 8-10 high-level speakers/participants, their research areas, and how they connect to the goals of the workshop.

Hot Topics suggestions are accepted on a rolling basis. Suggestions are considered by the ICERM Directors, and a sub-committee of ICERM's Scientific Advisory Board that decides

which ideas are developed into workshops. ICERM responds to all Hot Topics suggestions within two weeks.

Hot Topics Workshop 1: Algorithms in Complex Dynamics and Mapping Class Groups
November 2 - 3, 2019

Organizing Committee:
Dan Margalit, Georgia Institute of Technology
Kevin Pilgrim, Indiana University
Rebecca Winarski, University of Michigan

Workshop Description:
Thurston maps are orientation-preserving branched covering maps of the two-sphere to itself for which the forward orbits of the branch points form a finite set. They arise in the classification of complex dynamical systems.

Recent work has shown close connections between the combinatorial, topological, and algebraic theory of Thurston maps and that of mapping class groups. The algorithmic and computational theories of mapping class groups are highly advanced and have reached the point of effective implementation via computer programs. However, such implementations for Thurston maps are significantly less advanced. The aim of the proposed Hot Topic workshop is to bring together researchers in the computational theory of mapping class groups and those in the combinatorial theory of Thurston maps in order to make headway on fundamental problems.

This workshop is fully funded by a Simons Foundation Targeted Grant to Institutes.

Hot Topics Workshop 2: Soergel Bimodules and Categorification of the Braid Group
February 28 – March 1, 2020

Organizing Committee:
Ben Elias, University of Oregon
Eugene Gorsky, UC Davis
Andrei Negut, MIT

Workshop Description:
The purpose of this workshop is to bring together experts in representation theory, categorification, low-dimensional topology, mathematical physics, and combinatorics, in other to understand how categorifications of the braid groups and Hecke algebras allow one to compute and understand link invariants. Our concrete goals are to:

(a) develop and compare various algebro-geometric models for link homology, and use them to explicitly compute Khovanov-Rozansky homology of various links

(b) categorify various structures in the Hecke algebra (center, cocenter, Kazhdan-Lusztig cells, Jones-Wenzl projectors) using Soergel bimodules

(c) compare the geometric and algebraic constructions above, and understand the connection between the (co)center of the Soergel category and the Hilbert scheme of points on the plane

This workshop is fully funded by a Simons Foundation Targeted Grant to Institutes.

Program Promotions

ICERM programs and events are marketed through a variety of outlets: its website, dedicated Facebook page, Twitter, Instagram, and LinkedIn accounts, targeted blast emails, posters mailed to purchased targeted university and college lists, placement of advertisements in mathematical journals and newsletters, Director participation in conferences and exhibits, upcoming program fliers and announcements made available to all ICERM participants, and various on-line math organization calendars (researchseminars.org, SIAM, AMS, NAM, European Mathematical Society, National Math Institutes, and Conference Service Mandl).

ICERM's email database is made up of former and upcoming participants, ICERM board members, academic and corporate sponsors, and the department managers from higher education math departments in both the US and overseas. It currently has over 4,000 contact emails. Posters for ICERM's summer undergraduate research program (Summer@ICERM) are target-mailed to institutions known to have undergraduate programs in mathematics, applied math, and computer science.

During the 2019-2020 reporting cycle, ICERM either hosted or had a speaker, a booth and/or joint representation with other institutions at the following locations and national events:

- Sponsored a booth at Modern Math Workshop at SACNAS, Fall 2019 (Honolulu, HI)
- Had a rep and marketing materials at Field of Dreams Conference, fall 2019 (St. Louis, MO)
- Hosted an ICERM Mixer, sponsored a table at NSF Math Institutes reception, and worked a shared NSF Math Institutes booth at the Joint Mathematics Meeting (JMM), Winter 2019 (Denver, CO)

All program advertising emphasizes diverse participation and uses language encouraging minority and under-represented students to apply. More details about this can be found in the "Outreach/Diversity" section of this report.

Communications Plan

ICERM's frequent social media postings, quarterly newsletters, funder acknowledgements, and presence on Brown's fundraising page have helped ICERM remain relevant and maintain contact with recent, current and upcoming program participants, board members, corporate and academic sponsors, and the general population. Brown is still committed to supporting ICERM's Provost-approved fundraising goals, and Brown's Foundation Relations continues to help ICERM build relationships with corporations and foundations.

Organization/Infrastructure

ICERM's governing body is a Board of Trustees (BOT). The Scientific Advisory Board (SAB) oversees all scientific activities of the Institute and selects the scientific programs. The Education Advisory Board, or EAB coordinates the oversight of educational activities at all levels at ICERM.

Board of Trustees (BOT)

The Board of Trustees oversees all institute activities. This includes being responsible for reviewing the budget for the coming year, developing policies and procedures, advising on the appointment of new Directors and actively recruiting for the position as needed, and taking a leadership role in fundraising and public awareness. The Board of Trustees has a face-to-face meeting at ICERM for one day each year (usually in late spring), and one or two conference-call meetings if needed.

Board of Trustee member appointments are for four years. Chairs from the Scientific Advisory Board (SAB) and the Education Advisory Board (EAB), as well as the ICERM Directors and co-PIs, are invited to sit in.

Board of Trustee Members:

Name	**Institution**
Sir John Ball	Heriot-Watt University
Jennifer Chayes	UC Berkeley
Charles Epstein	University of Pennsylvania
Bruce Hendrickson	Lawrence Livermore National Laboratory
Peter Jones (Chair)	Yale University
Julia Kempe	New York University
David Keyes	Columbia University/KAUST
Jonathan Mattingly	Duke University
Jill Mesirov	University of California, San Diego
Jill Pipher	Brown University
Karen Smith	University of Michigan

Note: The minutes from the May 29, 2019 annual Board of Trustees meeting can be found in Appendix D.

Scientific Advisory Board (SAB)

The Scientific Advisory Board (SAB) is responsible for approving the programs and scientific activities of the Institute. In addition, through direct communication with the Directors, Science Board members will be involved in shaping the direction of the scientific enterprise through specific suggestions of thematic programs, program organizers.

Terms are three years. The ICERM Directors and Brown's Director of the Data Science Initiative (Bjorn Sandstede) act as ex officio members of this committee.

Scientific Advisory Board Members:

Name	Institution
Liliana Borcea	University of Michigan
Jeffrey Brock	Yale University
Henry Cohn (Chair)	Microsoft Research
Jesús De Loera	University of California, Davis
Vanja Dukic	University of Colorado, Boulder
Anne Gelb	Dartmouth College
William Goldman	University of Maryland
Misha Kilmer	Tufts University
Rachel Kuske	Georgia Institute of Technology
Anna Lysyanskaya	Brown University
Mauro Maggioni	Johns Hopkins University
Kavita Ramanan	Brown University
Bjorn Sandstede (ex officio)	Brown University
Joseph Silverman	Brown University
Jon Wilkening	UC Berkeley
Carol Woodward	Lawrence Livermore National Laboratory

Note: The minutes from the May 15, 2019 mid-year SAB conference call and the November 17-18, 2019 SAB annual meeting can be found in Appendix E.

Education Advisory Board (EAB)

The Education Advisory Board 1) oversees the undergraduate research programs, and helps to develop and identify successful proposals, 2) helps to develop proposals for outreach programs and events that are aligned with the mission of the institute, and 3) helps to identify sources of funding for education and outreach activities.

Terms are three years. The ICERM Directors act as ex officio members of this committee.

Education Advisory Board Members:

Name	Institution
Tarik Aougab	Haverford College
John Ewing	Math for America
Karen Haberstroh	Brown University
Rachel Levy	Mathematical Association of America
Katharine A. Ott (Chair)	Bates College
Lynn Rakatansky	RI Mathematics Teachers Association Executive Board
Jessica Sidman	Mount Holyoke College
Sergei Tabachnikov	Pennsylvania State University
Ulrica Wilson	Morehouse College

Note: The minutes from the September 13, 2019 annual Education Advisory Board meeting can be found in Appendix F.

Mathematics Institute Directors Meeting (MIDs)

The April 24, 2020 MIDs meeting minutes can be found in Appendix G.

ICERM's Early Career Training and Mentorship

A special focus of the operations of the institute is the training and mentorship of younger and early career mathematicians, through specific outreach programs and directed opportunities for connections between mathematicians at different stages in their career. This includes ICERM's postdoctoral program, integration and support of graduate students in the context of semester programs, and summer research programs for undergraduates (Summer@ICERM). The addition of postdoctoral fellows (as described above) and graduate students is essential to the success of ICERM's programs.

Postdoctoral Program

ICERM's postdoctoral program brings early career mathematicians to the institute in order to support and expand their research and to create lasting career collaborations and connections. ICERM supports postdoctoral researchers in two salaried categories: "Semester" postdoctoral fellows who participate in a single semester-length program, and a smaller number of "Institute" postdoctoral fellows, who stay at ICERM for an academic year.

Recruiting and Selection of ICERM-Funded Postdocs

ICERM's postdoctoral positions are widely advertised using MathJobs.org, print and online publications of the Society for Industrial and Applied Mathematics News, Notices of the American Mathematical Society, the Association of Women in Mathematics, the Society for the Advancement of Chicanos and Native Americans in Science, and on the ICERM website. These positions are also advertised at the NSF Institute Reception at the Joint Mathematics Meeting. ICERM collects applications via Mathjobs.org, an online job application service provided by the American Mathematical Society.

In all written material sent out, it is emphasized that Brown is an EEO/AA Employer and that ICERM encourages applications from women and minority candidates.

ICERM sets an early-January deadline for postdoctoral applications. Application review begins immediately and continues until the positions are filled.

The Postdoctoral Fellow Search Committee consists of the ICERM Semester Program organizers for the upcoming programs with input for the Directorate.

The program organizers review all of the applications and provide a rank-ordered list to the ICERM Directors for each of the two types of positions (Semester and Institute postdocs). The Directorate reviews the ranked lists, and may suggest changes to ensure diversity and field balance. The Director approves all offers, and Brown University's Dean of the Faculty oversees postdoctoral offers and appointment terms.

2019-2020 ICERM Postdoctoral Cohort

ICERM Postdoctoral Fellows (4 months w/benefits; funds for travel to and from institute)

Name	Previous Institute	ICERM Semester Program
Gabriel Dorfsman-Hopkins	UC Berkeley	Fall 2019
Michael Musty	Dartmouth College	Fall 2019

Martin Skrodzki	Freie Universität Berlin	Fall 2019
Steve Trettel	Stanford University	Fall 2019
Davide Palitta	Max Planck Institute	Spring 2020
Jemima Tabeart	University of Edinburgh	Spring 2020
Michael Schneier	University of Pittsburgh	Spring 2020
Min Wang	Duke University	Spring 2020

ICERM Institute Fellows (9 months w/benefits; funds for travel to and from institute)

Name	**Previous Institute**	**ICERM Semester Program**
Alba Málaga Sabogal	Polytechnique, Paris Sud	2019-2020: focus on Fall 2019
Gregory Darnell	Princeton University	2019-2020: focus on Spring 2020

Based on available information, the ICERM stipend-supported postdocs for 2019-2020 break down as follows:

	Male		**Female**	
Black	0		0	
Hispanic	0		0	
American Indian/Alaskan Native	0		0	
Asian/Pacific Islands	0		1	
White	7		2	
Other (specify)	0	+	0	
	7		3	= 10 Total

Tracking Former Postdocs (Institute and Semester)

ICERM Research Fellows are supported with a salary for one semester. We expect that these postdoctoral fellows will be on leave from, or have deferred the start of, another position. The institute makes every effort to keep in touch with its postdoctoral alums in order to track their professional growth.

ICERM-funded postdocs ***(to date)***	**Period of Stay**	**Where are they as of Spring 2019?**
Emre Esenturk	Fall 2011	University of Warwick
Jeffrey Haack	Fall 2011	Los Alamos National Laboratory
Andong He	**Fall 2011**- Spring 2012	Passed away in 2016
Ahmed Kaffel	Fall 2011	Marquette University
Daniela Tonon	Fall 2011	Université Paris Dauphine
Dongming Wei	Fall 2011	RBC Capital Markets
Cecile Armana	Spring 2012	University of Franche-Comté
Anupam Bhatnagar	Spring 2012	Unity Technologies
Alon Levy	Fall 2011 – **Spring 2012**	Transit Writer at the Marron Institute
Bianca Viray	Spring 2012	University of Washington
Xiaoguang Wang	Spring 2012	Zhejiang University
Daniel Cargill	Fall 2012	Lockheed Martin
Arnab Ganguly	Fall 2012	Louisiana State University
Peng Hu	Fall 2012	Oxford-Man University
Hao Ni	Fall 2012	University College
Aaron Smith	**Fall 2012** - Spring 2013	University of Ottawa

Julio Andrade	Fall 2012 - **Spring 2013**	Universty of Exeter
Kwangho Choiy	Spring 2013	Southern Illinois University
Zajj Daugherty	Spring 2013	CUNY
Martina Lanini	Spring 2013	Università di Roma Tor Vergata
Ben Salisbury	Spring 2013	Central Michigan University
Ryan Greene	Fall 2013	The Ohio State University
BoGwang Jeon	Fall 2013	POSTECH
Rodolfo Rios-Zertuche	Fall 2013	Ecole Normale Supérieure
Giulio Tiozzo	**Fall 2013** – Spring 2014	University of Toronto
Anastasiia Tsvietkova	Fall 2013	Rutgers University
Kyle Fox	Spring 2014	University of Texas at Dallas
Danupon Nanongkai	Spring 2014	KTH
Amanda Redlich	Spring 2014	UMASS Lowell
Charalampos Tsourakakis	Spring 2014	Boston University
Grigory Yaroslavtsev	Fall 2013 - **Spring 2014**	Indiana University
Ali Ahmed	Fall 2014	Information Technology University (Lahore)
Ulas Ayaz	**Fall 2014** – Spring 2015	MIT
Jacqueline Davis	Fall 2014	Data Scientist at Carvana
Pawel Siedlecki	Fall 2014	Polish Academy of Science
Li Wang	Fall 2014	University of Illinois
Tyler Helmuth	Spring 2015	University of Bristol
Marcin Lis	Spring 2015	University of Cambridge
Emily Russell	Fall 2014 – **Spring 2015**	Google
Xuan Wang	Spring 2015	Data Scientist at Databricks
Samuel Watson	Spring 2015	Brown University/DSI
Olga Balkanova	Fall 2015	Russian Academy of Sciences
Sandro Bettin	Fall 2015	University of Genova
Edgar Costa	Fall 2015	MIT
Anna Medvedovsky	**Fall 2015** – Spring 2016	Boston University
James Weigandt	**Fall 2015** – Spring 2016	Purdue University
Abel Farkas	Spring 2016	Alfréd Rényi Institute of Mathematics
Marta Canadell Cano	Fall 2015 – **Spring 2016**	Wallapop
Nishant Chandgotia	Spring 2016	Einstein Institute of Mathematics
Zhiqiang Li	Spring 2016	Peking University
Polina Vytnova	Spring 2016	University of Warwick
Hannah Alpert	**Fall 2016** – Spring 2017	University of British Columbia
Chaim Even-Zohar	Fall 2016	University of California, Davis
Isaac Mabillard	Fall 2016	Google
Greg Malen	Fall 2016	Duke University
Jose Alejandro Casas	Fall 2016	MPI-MIS Leipzig
John Wiltshire-Gordon	Fall 2016	University of Wisconsin, Madison
Sergey Dyachenko	Fall 2016 – **Spring 2017**	University of Illinois, Urbana-Champaign
Seok Hyun Hong	Spring 2017	Pohang University
Cecilia Mondaini	Spring 2017	Drexel University
Olga Trichtchenko	Spring 2017	Western University
Xeucheng Wang	Spring 2017	Tsinghua University

Xiaoqian Xu	Spring 2017	Duke University
Mario Bencomo	**Fall 2017** – Spring 2018	Rice University
Wei Li	Fall 2017	Louisiana State University
Shixu Meng	Fall 2017	University of Michigan
Yimin Zhong	Fall 2017	University of California, Irvine
David de Laat	Spring 2018	Delft University of Technology
Maria Dostert	Spring 2018	EPFL
Philippe Moustrou	Spring 2018	University of Tromsø
Yuguang Wang	Spring 2018	University of New South Wales
Wei-Hsuan Yu	Fall 2017 – **Spring 2018**	National Central University in Taiwan
Daniel Bernstein	Fall 2018	MIT
Papri Dey	Fall 2018	University of Missouri
Mareike Dressler	Fall 2018	University of California - SD
Kathlén Kohn	Fall 2018	KTH/Stockholm
Sara Lamboglia	Fall 2018	Goethe-Universität
Dane Wilburne	Fall 2018	York University
Marilyn Vazquez	Fall 2018 – **Spring 2019**	Postdoc at MBI
Shubhendu Trivedi	Fall 2018 – **Spring 2019**	MIT CSAIL
Guangyao Zhou	Spring 2019	Vicarious AI
Gabriel Dorfsman	Fall 2019	UC Berkeley
Alba Málaga Sabogal	**Fall 2019** – Spring 2020	Maître de Conferences, Lorraine University
Michael Musty	Fall 2019	ERDC-CRREL
Martin Skrodzki	Fall 2019	RIKEN
Steve Trettel	Fall 2019	Stanford University
Gregory Darnell	Fall 2019 – **Spring 2020**	Brown University
Davide Palitta	Spring 2020	Max Planck Institute
Jemima Tabeart	Spring 2020	University of Edinburgh
Michael Schneier	Spring 2020	DOE lab Bettis Atomic Power Laboratory
Min Wang	Spring 2020	Duke University

Graduate Students

Support for Graduate Students

The research semester program budget includes partial support for a cohort of graduate students. A housing allowance $950/month and travel to the institute is provided to about 10-14 graduate students each of whom applies to be in residence for the entire semester. Applicants include graduate students working with visitors to the program, as well as students who intend to come without an advisor. Graduate students must arrange for a letter of recommendation from their advisor to be sent separately. The graduate student applications prioritized by the semester program organizing committee (1 - Would make a contribution to this program; 2 - Desirable for this program but not high priority; 3 - High priority, important for the success of the program). The prioritized list is subsequently reviewed by the Deputy Director overseeing the development of that particular program. Final decisions are made by the Directors. The ability to provide a mentor for each graduate student in residence is a factor in the decision.

Training and Mentoring Programs

Before an ICERM semester program starts, all postdocs and graduate students are assigned a mentor. The institute provides all senior mentors with written guidelines that spell out their responsibilities and the responsibilities of mentees. Currently, Associate Director Caroline Klivans coordinates these efforts and works with the members of the Program Organizing Committee assigned to be responsible for mentorship.

In addition, at the beginning of each semester program, Directors hold mentor/mentee introductory meetings. These meetings emphasize that mentors should help mentees start to build a research cohort and help them create contacts and resources which will persist beyond the program.

The mentoring program for the Institute Postdoctoral Fellows necessarily includes a plan for the "off semester" when these postdocs are in residence at ICERM while there is no active research program in their area. In most cases, postdocs are matched with mentors at Brown in Math, Applied Math, or Computer Science in order to continue their ICERM research. During this reporting cycle, the Fall Institute Postdocs (Alba Málaga Sabogal) continued to be mentored by Brown University Professor Richard Schwartz during spring 2020. The spring Institute Postdoc, Gregory Darnell, was mentored by ICERM Deputy Director Sigal Gottlieb and Professor Yanlai Chen (both of UMass Dartmouth), and Sohini Ramachandran (Brown University) during the fall 2019 semester.

ICERM Postdoctoral Participant and Mentor list by Semester Program

Postdoc	Mentor	Program
Diana Davis	Rich Schwartz	Fall 2019 Independent
Gabriel Dorfsman-Hopkins	Brendan Hassett	Fall 2019 ICERM Postdoctoral Fellow
Taneli Luotoniemi	Henry Segerman	Fall 2019 Independent
Alba Málaga Sabogal	Rich Schwartz	Fall 2019 ICERM Institute Postdoc
Michael Musty	Katherine Stange	Fall 2019 ICERM Postdoctoral Fellow
Martin Skrodzki	Matthias Goerner	Fall 2019 ICERM Postdoctoral Fellow
Steve Trettel	David Dumas	Fall 2019 ICERM Postdoctoral Fellow
Gregory Darnell	Yanlai Chen	Spring 2020 ICERM Institute Postdoc
Christian Himpe	Peter Benner	Spring 2020 Independent
Jeffrey Hokanson	Misha Kilmer	Spring 2020 Independent
Jiahua Jiang	Akil Naryan	Spring 2020 Independent
Davide Palitta	Petter Brenner	Spring 2020 ICERM Postdoctoral Fellow
Neerah Sarna	Peter Benner	Spring 2020 Independent
Michael Schneier	Akil Naryan	Spring 2020 ICERM Postdoctoral Fellow
Jemima Tabeart	Misha Kilmer	Spring 2020 ICERM Postdoctoral Fellow
Min Wang	Daniele Venturi	Spring 2020 ICERM Postdoctoral Fellow
Yangwen Zhang	Peter Monk	Spring 2020 Independent

Graduate Student Mentor List

Graduate Student	Mentor	Program
Sebastian Bozlee	Jonathan Wise	Fall 2019
Dina Buric	Aaron Abrams, Kelly Delp	Fall 2019
Emily Donovan	John Edmark, Kelly Delp	Fall 2019

Bernat Espigule	Edmund Harriss	Fall 2019
Max Krause	John Sullivan	Fall 2019
Daniel Lautzenheiser	Arthur Baragar	Fall 2019
Daniel Martin	Katherine Stange	Fall 2019
Tashrika Sharma	Frank Farris	Fall 2019
Farhat Arslan	Peter Kramer	Spring 2020
Muhammad Izzatullah	Yanlai Chen	Spring 2020
Lijie Ji	Yanlai Chen	Spring 2020
Petar Mlinaric	Serkan Gugercin	Spring 2020
Zhichao Peng	Fengyan Li	Spring 2020
Elizabeth Qian	Serkan Gugercin	Spring 2020

Roundtable Discussions

To prepare graduate students and postdocs better for their future careers, the institute also organizes regular roundtable discussions with long-term visitors, Brown faculty, and Directors, that in the course of each semester, cover the following topics:

- Preparing job applications
- Writing and submitting papers
- Writing grant proposals
- Ethics in research as required by NSF – mandatory, attendance is taken
- Job opportunities in industry and government labs

Peer-to-Peer Discussions

During semester programs, there are regularly scheduled postdoc-graduate student seminars, expressly limited to junior researchers. This gives participating postdocs and graduate students an opportunity to discuss research topics and any other issues openly, without senior people present. The format is completely flexible. For example, it could feature talks by postdocs or graduate students on their current research or provide an opportunity to read and report on papers, or give an introduction to upcoming talks in other seminars. The group could even ask a senior participant to give a tutorial lecture and then follow up with a discussion session afterwards.

ICERM makes all of its resource materials for its Graduate Students and Postdoctoral Fellows available to the general public on its website, which can be found at:
https://icerm.brown.edu/pds/

Summer Undergraduate Research Program

Summer@ICERM is an eight-week summer research program for 16-20 undergraduates. Students work in small groups, typically in pairs, supervised by faculty advisors and assisted by TAs. In addition to research projects, the program includes topical mini-courses and colloquium-style lectures given by invited speakers. Students present their findings at a symposium at the end of the program.

1. Solicitation of Proposals

ICERM solicits and recruits proposals from faculty nationwide. Faculty organizers and TAs are required to be in residence for a minimum of six of the eight weeks, especially the first and last week of the program.

2. Future Proposal Selection

Programs are selected from proposals submitted to ICERM in an open competition. Successful programs typically have a significant computational component. Summer research programs which pair with the semester programs are especially encouraged, but not required. A subcommittee of the EAB and an Associate Director, vet proposals. External evaluations of proposals are solicited. Preliminary decisions on summer programs are made by the Directors and must be approved by the Education Advisory Board.

3. Application Process

Undergraduates apply to the program through MathPrograms.org and participants are selected from a talented pool of students currently enrolled in U.S. universities and colleges. A small number of international participants may also be admitted.

4. Applicant Selection

Undergraduate participants are selected by the Summer@ICERM faculty organizers and the selections are finalized by ICERM Director(s). At all stages of recruitment, solicitation, and selection, the organizers are instructed about the diversity goals of the National Science Foundation, and ICERM in particular. To ensure a diverse group of applicants, ICERM advertises and recruits from minority serving organizations.

Financial Decisions for Program

Faculty and TAs receive a stipend and travel support, and faculty also get partial or full support for lodging. Undergraduate participants funded by ICERM receive a stipend, travel funds within the United States, meals, and accommodation in a Brown dormitory.

Summer 2019: Summer@ICERM – Computational Arithmetic Dynamics

June 10 – August 2, 2019

Organizing Committee:
John Doyle, Louisiana Tech University
Benjamin Hutz, Saint Louis University
Bianca Thompson, Westminster College
Adam Towsley, Rochester Institute of Technology

Program Description
The 2019 Summer@ICERM program at Brown University is an eight-week residential program designed for a select group of 18-22 undergraduate scholars.

The faculty advisers will present a variety of interdisciplinary research projects on the theme of Computational Arithmetic Dynamics. This overarching theme will allow participants to utilize

theory and computation from algebra, number theory, and algebraic geometry. Faculty will also guide the development of open-source computational tools for dynamical systems in Sage as well as work on a database of dynamical systems.

The faculty will begin the program with brief introductory talks. Throughout the eight-week program, students will work on assigned projects in groups of two to four, supervised by faculty advisors and aided by teaching assistants. Students will meet daily, give regular talks about their findings, attend mini-courses, guest talks, professional development seminars, and will acquire skill in open-source software development. Students will learn how to collaborate mathematically, working closely in their teams to write up their research into a poster and/or paper by the end of the program.

ICERM provides an excellent research environment, and the students and their faculty and TA mentors will have access to shared offices and collaborative space throughout the institute. They also will have access to ICERM's computer facilities and specialized software. ICERM staff will provide logistical support for students and will help build community through fun activities and events.

This program is partially funded by a grant from the National Security Agency.

2019 Proposed Research Project Topics

1. Classification of Preperiodic Graphs
2. Automorphisms of Rational Functions
3. Post-Critically Finite Maps
4. Randomness over Finite Fields

2019 Summer@ICERM Cohort

The "Summer@ICERM" program had a cohort of 20 students. 3 students were funded through the NSF; 17 via a combination of a grant from the Department of Defense (DOD) and the NSF.

Student Name	Institute	Funding Source
Heidi Benham*	Western Oregon University	ICERM, NSA
Talia Blum*	Massachusetts Institute of Technology	ICERM, NSA
Julia Cai	Yale University	ICERM, NSA
Jasmine Camero*	California State University, Fullerton	ICERM, NSA
Anna Chlopecki*	University of Illinois at Urbana-Champaign	ICERM, NSA
Alexander Galarraga*	Swarthmore College	ICERM, NSA
Brandon Gontmacher*	Stony Brook University	ICERM, NSA
Colby Kelln*	University of Michigan	ICERM, NSA
Juliano Levier-Gomes	Westminster College	ICERM, NSA
Chieh-mi Lu*	California State University San Marcos	ICERM, NSA
Joey Lupo	Amherst College	ICERM, NSA
Leopold Mayer	Lawrence University	ICERM, NSA
Emily Rachfal*	Kenyon College	ICERM, NSA
Olivia Schwager*	Muhlenberg College	ICERM, NSA
Alex Shearer	Pacific Lutheran University	ICERM, NSA
Srinjoy Srimani*	Brown University	ICERM

Henry Talbott*	Brown University	ICERM
Matt Torrence*	Gettysburg College	ICERM, NSA
Shuofeng Xu*	Colby College	ICERM
Eric Zhu*	Georgia Institute of Technology	ICERM, NSA

*Received ICERM support to present a poster related to S@I at JMM 2020

Here follows a sample of the most substantive comments from our Summer@ICERM participants.

Some Participant Comments for "Describe the highlight of this workshop":

- *The highlight of this program was definitely not only the research I was able to do, but also the people I was able to meet.*
- *The final presentation with my team.*
- *Having everything fall into place after figuring out a key idea in the proof of our main theorem.*
- *I loved working with my teammates to understand math or create a presentation.*
- *My highlight of this program was being surrounded by folks who share the same love of math as I do. It was insightful to be each other. I also enjoyed being around such supportive faculty and TAs that we're really so passionate about their projects and were able to translate that passion to us.*
- *Having certain things "click" or reaching a breakthrough in research*
- *It was nice to be around a group of students most of whom were interested in pursuing or at least considering graduate school as an option. Even though some people were from more prestigious schools and had more background, for the most part it felt like we were all on the same playing field because computational arithmetic dynamics was a field that the majority of us hadn't heard of/worked in before.*
- *Doing cutting edge research.*

Summer@ICERM 2019 Scientific Outcomes to Date

Final Student Presentations

- "Periodic points for Lattés maps over finite fields" by J. Camero, F. Lu, and E. Zhu
- "Dynamical statistics over finite fields break" by A. Chlopecki, J. Levier-Gomes, and A. Shearer
- "Classification of rational preperiodic structures" by M. Grip, E. Rachfal, O. Schwager, and M. Torrence
- "Automorphism groups of rational maps char 0" by J. Cai, B. Gontmacher, L. Mayer, S. Srimani, and Simon Xu
- "Automorphism groups of rational maps char p" by J. Cai, B. Gontmacher, L. Mayer, S. Srimani, and S. Xu
- "Post-critically finite rational maps" by J. Lupo, A. Galarraga, H. Benham
- "Finite orbit sets for several polynomial maps" by T. Blum, C. Kelln, and H. Talbott

Posters Presented at JMM 2020 in Denver, CO

- Unlikely Intersections and Portraits of Dynamical Semigroups (Colby Kelln, Talia Blum, and Henry Talbott)*

- Periodic Points for Latts maps over Finite Fields (Jasmine Camero, Fiona Lu, and Eric Zhu)**
- Characteristic 0 Automorphism Loci of the Moduli Space of Rational Functions (Brandon Gontmacher, Srinjoy Srimani, and Simon Xu)**
- Permutation Polynomials (Anna Chlopecki)**
- Rational Preperiodic Points of $z^d + c$ (Olivia Schwager, Emily Rachfal, and Matt Torrence)
- Explicit Description of Degree 3 Polynomials and an Algebraic Approach to a Special Case of Thurston Rigidity (Alexander Galarraga and Heidi Benham)

*Recipient of the MAA "Outstanding Poster Award" at JMM 2020
**Recipient of an MAA "Honorable Mention" at JMM 2020

Outcome highlight/Presentation at JMM 2020
Trevor Hyde, 5734 S University Ave, Chicago, IL 60637, Chicago, IL 60637, and John Doyle, Max Weinreich, Colby Kelln, Talia Blum and Henry Talbott. Portrait spaces for dynamical semigroups and unlikely intersections. Preliminary report. Given a dynamical portrait for several rational functions acting on a finite set, we initiate the study of the corresponding moduli space of realizations. In this talk we discuss the various ways in which these moduli spaces can have higher than expected dimension and present results explaining this phenomenon. Time permitting, we will also survey the findings of large exhaustive computations we conducted for portrait spaces of cubic polynomials.

The Evaluation Process: Measure to Evaluate Progress

Current Program Evaluation
ICERM continues to work with Strategic Research Group (SRG), an external evaluation company, to build upon its current survey data.

ICERM automates its survey reporting, using templates that display particular variables of interest across participants and over time. In this way, ICERM can easily recognize a pattern of program strengths in certain areas and may be able to tailor aspects of its programs to successfully equip individuals for a thriving and influential research career.

ICERM also successfully creates two and five-year follow-up surveys that are customized to a single participant instead of distributing a broad and generalized survey to all participants. An example of how customized surveys are being used at the institute is the generation of publication lists for each participant. When the survey is sent, Qualtrics reads the unique identification number of the participant stored in the panel database and generates a list of publications previously collected by ICERM staff and assigned to that specific identification number. Then, the surveyed participant is able to identify the publications that can be attributed to his or her time at ICERM. This novel incorporation of a participant-specific generated publication list has been useful in understanding how influential ICERM programs are to one's research career long-term.

Survey response rates

ICERM strives to get the highest response rate for its surveys. The Director informs participants that they will receive a survey during the welcoming remarks. In addition, the institute explains within the body of every survey how it handles responses confidentially and why it collects gender and ethnicity data. Reminders are sent one or two weeks after each survey is first sent out. This year, ICERM averaged a 66% response rate on all of its exit surveys (up from 58% last year).

Measure impact across subgroups

Qualtrics cloud-based software not only aids in creating customizable surveys for participants, but also serves as a platform for analyzing data according to different subgroups of participants e.g., gender, job title, race/ethnicity.

SRG continues to assist ICERM with using the Qualtrics data analysis tools to better understand how the institute's programs impact different subgroups of researchers in both the immediate i.e., program exit surveys and intermediate-/long-term i.e., two- and five-years after program participation. Qualtrics also provides the opportunity to analyze longitudinal data, which will be helpful in the analysis of certain programs over time. Ultimately, these analyses will provide information as to how ICERM can alter programs to benefit different types of participants who may be at various points in their research career.

Measure long-term outcomes

Since 2014, ICERM has been administering an intermediate - i.e., two-year follow-up survey to past semester program participants. Using the unique identification numbers and in-survey data analyses as described above, these surveys measure the attributable impact of participation in ICERM research programs by gathering data on published papers, invited talks, and funded or pending grant proposals. These follow-up surveys help us understand the far-reaching impact of ICERM's research programs over time. The average response rate for our two-year follow-up surveys remains steady at around 56%. The average response rate for our 5-year follow-up surveys is 36%.

In 2019, ICERM introduced a new way to display its follow-up survey highlights through an on-line summary report made available on its spring 2017 semester program website. This report makes a subset of the follow-up survey results available for public knowledge (publication list, impact on professional growth, etc.). Student interns are currently formatting all other follow-up surveys so that similar summaries can be posted on all past semester program pages with completed 2- and 5-year follow-up surveys.

A central tenet of ICERM is that networking, collaboration, and engagement with computational tools promote career growth that would not be possible without engagement with our programs.

To test this, ICERM introduced new methodology for long-term evaluation in 2018. With SRG's help, the institute developed a longitudinal comparison report using the original program exit survey, as well as the 2 and 5-year follow-up survey data for participants from its spring 2013 program. This was ICERM's first effort to connect participant data across surveys (with the use of unique IDs) and generate a more holistic narrative of ICERM's impact over a longer period of

time. The results from this report are meant to showcase ICERM's long-term impact on participant careers and their continued perceptions of their time at the institute. Notably, this report examines:

- trends in employment over time
- professional talks
- grant funding submitted and received
- collaborations

ICERM could also use this longitudinal report to track the number of ICERM spin-off programs generated. For example, semester programs leading to Collaborate@ICERM programs, or workshops leading to semester programs.

Early results suggest that ICERM needs a higher response rate to draw meaningful conclusions. Only about 36% of long-term participants respond to the five-year follow-up survey and they may not be representative of the program as a whole. At the recommendation of ICERM's SAB, the institute will enlist organizers to make their own assessments of the long-term impact of the program, share these with participants as a prompt for their own reflections, and integrate survey data with organizer comments in the SAB program reviews. This effort was stymied by the onset of the COVID-19 pandemic in 2020, so the program organizers were not involved in encouraging their past participants to respond to ICERM's follow-up surveys.

ICERM continues to play a large role in gathering and updating participant information for the two and five-year follow-up surveys. Specifically, one question provides participants with a list of their papers, pre-prints, or reports published since their participation at ICERM (or, in the case of the five-year follow-up, since their initial two-year survey). Participants then have the opportunity to include/update publications resulting from their participation in an ICERM program or event. ICERM is responsible for finding and compiling these publications for each participant. Additionally, before implementing each survey, ICERM continues to be involved in editing and testing the survey in order to have an end product that will most effectively provide data aligned with its goals.

It is important to note here that although ICERM has hired SRG as its external evaluation company to aid in reaching their evaluation goals, the institute still plays a vital role in the data collection and survey distribution process. In addition, at weekly management meetings, survey results are reviewed and discussed so that improvements can be made as appropriate.

Note: Links to exit survey summaries for core programs run during this reporting cycle (May 11, 2019 through May 1, 2020) can be found in Appendix H.

Reported Scientific Outcomes/Projects Initiated

In the past, the Director sent a request to all long-term participants asking for updates on their research projects and/or publications that arose during, or were enhanced by, participation in an ICERM program. With the advent of ICERM's 2-year and soon to be added 5-year follow-up survey for each of its semester programs, scientific outcomes have begun to be collected much more systematically and consistently; ICERM can now report scientific outcomes for past programs in a standardized report.

ICERM now can track "projects initiated" that were reported on the Fall 2019 and Spring 2020 semester program exit surveys. Participants were ased the question, "What, if any, specific projects did you initiate or continue while attending this semester program?" Using unique IDs, ICERM will be able to track the advancement of these initial projects through the subsequent standardized 2-year and 5-year follow-up surveys.

In general, the response rate for all survey types has remained steady over the past three years, when ICERM first began tracking response rates.

Note: a list of research projects (publications, code, software) initiated at ICERM during the Fall 2019 and Spring 2020 semester programs can be found in Appendix I.

Corporate and Academic Sponsorship

Several math institutes currently funded by the NSF employ corporate and university-sponsored programs with tiered memberships. ICERM launched its own unique corporate and academic sponsorship programs in 2011.

The Corporate Sponsorship program has a $5,000 annual membership fee. To date, ICERM has received $87,500 in corporate sponsorship funds.

Our current corporate sponsors are:

- Microsoft Research
- Schlumberger

The Academic Sponsorship has an annual membership fee of $1,500 for domestic memberships with small graduate student programs, $3,000 for domestic membership with large graduate student programs, and $5,000 for international membership. To date, ICERM has received $94,375 in academic sponsorship funds.

Academic sponsors include:

- Cornell University, Department of Mathematics
- Indiana University, Bloomington, Department of Mathematics
- Korea Advanced Institute of Science and Technology, Department of Mathematical Sciences
- Michigan Tech, Department of Mathematical Sciences
- Worcester Polytechnic Institute, Mathematical Sciences Department

External Support

The institute staff works to develop new sources of support for its programs. Assistant Director of Finance and Administration, Juliet Duyster, has duties which include managing both public and private grants, managing the proposal process and ensuring that follow-up reporting is completed. Assistant Director Ruth Crane manages relations with the institute's sponsoring

corporations and serves as a liaison to Brown's Division of Advancement, which unites Alumni Relations, Development, Corporate and Foundation Relations in a single, focused organization.

In addition to the funding provided by the NSF, ICERM receives substantial in-kind financial support from Brown University. The Director is released from teaching, and two Deputy Directors are released from half of their teaching responsibilities. In addition, ICERM is not charged for the use of its building or for custodial care which Brown values at $670,500. This year Brown gave ICERM $82,082.00 ($75K of which is the university operating budget).

Other Funding Support received in 2019-2020

Additional Grants	*Amount*
American Mathematical Society Epsilon Fund *(for GirlsGetMath@ICERM)*	$ 3,000.00
JetBlue Foundation *(for expanding the GirlsGetMath program nationally*	$ 50,000.00
Sloan Foundation *(for the Illustrating Mathematics fall semester program*)	$ 50,000.00
TRIPODS	$ 25,609.00
Sub-total	**$128,609.00**
University Funding Support	
University Research Committee	$75,000.00
Supplemental Administrative Costs	$ 7,084.00
Sub-total	**$82,084.00**
Sponsor Support	
Academic Sponsors	$11,000.00
Corporate Sponsors	$ 5,000.00
Individual Sponsors	$ 4,905.00
Sub-total	**$20,905.00**
TOTAL	**$231,598.00**

"Mathinstitutes.org" Supplemental Funding

ICERM handles ongoing basic maintenance for the www.mathinstitutes.org website. This entails hosting the website on Brown servers, providing technical assistance to other institutes uploading data, keeping the diversity program pages and other resources current, and adjusting the video search interface as needed.

ICERM requested this supplement because the institute had been covering the costs of this work through its core grant. The supplement allows ICERM to be more active in keeping the site current and responsive to our peers as they request changes.

The main advantages of this supplement are that: 1) the NSF can quantify the ongoing cost to maintain the site; 2) ICERM staff are able to take on larger and more complex updates to the video search interface; and 3) ICERM can facilitate improvements to the presentation and organization of the diversity program webpages.

The www.mathinstitutes.org site serves an important role for the Mathematical Institutes program as a whole. This supplement ensures that it evolves to meet the changing needs of each of the institutes and allows ICERM to be pro-active in responding to suggestions from program leadership on how institute activities may best be promoted. ICERM technical staff continues to provide routine maintenance and end user support.

From May 2019 through April 2020, $1,509.50 was spent on staff time. This time was focused on making incremental changes to page layout, such as adjusting the way upcoming events are displayed, modifying content based on feedback from the Institutes Directors, and fixing bugs to improve the accuracy of search results. During this time ICERM staff also updated the underlying software for the joint media database and the website as a whole in order to stay within vendor support parameters.

Diversity and Outreach

Ulrica Wilson, an Associate Professor of Mathematics at Morehouse College, is also ICERM's Associate Director of Diversity and Outreach. Ulrica provides leadership in meeting institutional diversity goals: ensuring diversity throughout ICERM's programs, assisting in the development of policies and procedures, participating in national meetings and conferences, and helping to identify and obtain funding for programs and activities. She chairs the overarching diversity committee of the Mathematical Sciences Institutes Diversity Initiative (MSIDI). In addition, she leads the program 'Research Experiences for Undergraduate Faculty' (REUF), a collaboration of ICERM and the American Institute of Mathematics that supports faculty at four-year institutions that would like to lead research experiences for undergraduates.

ICERM strongly supports the National Science Foundation's goals of expanding the numbers and diversity of individuals engaged in mathematical sciences through increased participation. Through its membership in the Math Institutes Diversity Committee, the institute actively seeks best practices for securing the participation of women and under-represented minorities in ICERM's governing bodies and in all scientific programs, workshops and events. Specifically, ICERM policy includes the following:

In consultation with Dr. Wilson and members of the Scientific Advisory Board (SAB), ICERM's Directors reach out to women and underrepresented minorities to encourage them to submit proposals for workshops and semester programs. When we receive program sketches and pre-proposals, Directors routinely ask organizers to consider women as organizers. When invitations are issued to speakers or long-term program participants, Directors push back if the proposed slates include few women. Similar guidance is offered as postdocs and undergraduate students are evaluated. Directors review each shortlist to ensure it takes ICERM's diversity goals into account.

Directors also promote networking opportunities within workshops and semester programs, e.g., opportunities for women to come together for lunchtime discussions. The ADVANCE program of the Association for Women in Mathematics promotes the development of networking groups and research conferences supporting these networks. ICERM has hosted (or will host) meetings for Women in the Science of Data and Mathematics (WISDM), Women in Symplectic and

Contact Geometry and Topology (WiSCon), and a developing network of women in algebraic geometry.

ICERM hosts or co-sponsors special events or conferences that serve women and under-represented minorities in the mathematical sciences, including diversity workshops, Blackwell-Tapia conferences, Society for Advancement of Chicanos and Native Americans in Science (SACNAS) conferences, Association for Women in Mathematics (AWM) workshops and events, and is building relationships with academic institutions that serve large minority populations.

ICERM states its commitment to diversity on all informational and promotional materials, and broadly advertises its activities and opportunities for funding.

Diversity Events in 2019-2020

- Modern Math Workshop at SACNAS, Fall 2019 (Honolulu, HI)
- Mathematical Field of Dreams Conference, Fall 2019 (St. Louis, MO)

Other Activities

- Continue to share funds among NSF Mathematics Institutes available for rotating programs like Modern Math Workshop and Blackwell-Tapia
- ICERM is a member of the NSF Institute-wide diversity committee
- ICERM co-supporter the AWM mentor network
- GirlsGetMath@ICERM high school math camp (outside funding)

Outreach Activities

Public Lectures

ICERM has gained a reputation for providing the Brown community and the general public with an excellent public lecture series. These lectures attract a broad audience, from high school students on up.

During this reporting cycle, two scheduled public lectures were postponed due to unforeseen circumstances (including the COVID-19 pandemic). ICERM hopes to reschedule both at some point in the future: “The nth Perspective” featuring Glen Whitney, one of the founders of the Museum of Mathematics (MoMath) in New York City and “Law and Lottery”, featuring Skip Garibaldi from the Institute for Defense Analysis.

GirlsGetMath@ICERM

For the past six years, ICERM has been able to secure funding to run its well-received GirlsGetMath@ICERM program.

GirlsGetMath is designed to address the underrepresentation of women in STEM fields, seeks to motivate young women to consider careers in mathematics, computation, and quantitative fields, and provides an affirming environment that encourages participants to explore, and invites them to excel in, the mathematical sciences.

The program inspires 20-25 participants to love math by:

- demonstrating through hands-on activities, games, and computer simulations that the study of mathematics can be exciting, fun, and useful;
- introducing the high school participants to a variety of career opportunities for which sophisticated mathematical ability plays a key role, with an emphasis on the central role mathematics plays for success in STEM careers; and
- providing the participants with a support group of like-minded peers and mentors.

GirlsGetMath Broader Impact
The mentorship provided to the participants has been specifically designed by those with experience in outreach to meet a key set of needs identified by research as being most likely to make a difference in the way the girls view mathematics and STEM disciplines. The program content is created by mathematicians who collectively have many years of experience as researchers and educators. It is crafted to be at the appropriate level for the participants, but at the same time challenging and practical. The topics are selected to showcase the beauty and depth of mathematics.

Thanks to funding from the JetBlue Foundation in 2018, ICERM developed a train-the-trainer opportunity for nine faculty who were interested in replicating a GirlsGetMath program at their home institutions. The observational training occurred during ICERM's summer 2019 GirlsGetMath program. The train-the-trainer participants were then given the opportunity to apply for start-up seed funds to run their own programs. Six out of the nine trainees applied for the four available seed grants. Through the seed grants, GirlsGetMath programs will now be developed at the University of Delaware, the University of Central Oklahoma, Boston University, and Stonehill College in summer 2020 (delayed by one year due to the COVID-19 pandemic).

ICERM has developed methodologies for tracking GirlsGetMath alumnae annually in order to follow their educational interests – specifically, how many will go on to seek a college degree and if they choose to major in a STEM field. We are already aware that two GirlsGetMath alumnae (from 2014 and 2015) are currently matriculating at Brown University. One has already declared her concentration in Computer Science.

EPSCoR

ICERM supports the National Science Foundation's EPSCoR mission: "to assist the NSF in its statutory function "to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of such research and education." EPSCoR goals are:

1. to provide strategic programs and opportunities for EPSCoR participants that stimulate sustainable improvements in their R&D capacity and competitiveness;
2. to advance science and engineering capabilities in EPSCoR jurisdictions for discovery, innovation and overall knowledge-based prosperity.

Accepted ICERM participants from EPSCoR States
(May 11, 2019 through May 1, 2020)

EPSCoR State	# of ICERM Participants
Alabama	6
Arkansas	3
Delaware	12
Hawaii	1
Idaho	3
Iowa	7
Kansas	3
Kentucky	4
Louisiana	5
Maine	7
Mississippi	1
Missouri	6
Montana	3
Nebraska	2
Nevada	4
New Hampshire	11
New Mexico	1
Oklahoma	8
Rhode Island	118
South Carolina	6
Tennessee	16
Utah	22
Vermont	5

Administration and Staff

The ICERM Directors who received funding from the NSF core grant during this reporting cycle were Carolyn Klivans, Kavita Ramanan, and Homer Walker. Brendan Hassett commits 100% time.

ICERM Staff

Finance Team

Juliet Duyster, Assistant Director of Finance and Administration, hired in August 2011: reports to the Assistant Director. Oversees all business operations such as financial management and services, including budgets, reports, contracts, stipends, human resources, and visa issues. Coordinates the development of new proposals, teaching buyouts for program leaders, and advises the Director on the resources available for specific scientific programs. Manages the finance staff.

Nina Succi, Coordinator of Finance and Administration, hired February 2016: reports to the Financial Manager. Serves as fiscal liaison and primary point of contact for ICERM staff, program organizers, visitors, postdocs, students, customers, and vendors for all financial

transactions and related issues. Processes all participant reimbursements and payments made to vendors; assists with human resources and administrative support.

Events Team

Jenna Sousa, Program Manager hired May 2014: reports to the Assistant Director. Provides project management and logistical oversight for ICERM's complex portfolio of research programs and events. This includes the oversite of all applications, invitations, housing, program schedules, special events, and exit surveys. Manages the event staff.

Teresa Fitzenry, Program Coordinator, hired October 2016: reports to Program Manager. One of two Program Coordinator positions. Coordinates all logistical aspects of the fall semester/later summer programs and workshops. Acts as the main point of contact and customer support for ICERM visitors; sends and tracks speaker invitations, coordinates visitor housing, orders office supplies, and enters participant data into ICERM's Cube database. Assist the Program Manager and Assistant Director with other activities, such as social media and other marketing, as needed.

Kellie Shaughnessy, Program Coordinator, hired February 2017: reports to Program Manager. One of two Program Coordinator positions. Coordinates all logistical aspects of the spring semester/early summer programs and workshops. Acts as the main point of contact and customer support for ICERM visitors; sends and tracks speaker invitations, coordinates visitor housing, orders office supplies, and enters participant data into ICERM's Cube database. Assist the Program Manager and Assistant Director with other activities, such as social media and other marketing, as needed.

IT Team

Brian Lavall, Senior Systems Administrator, hired April 2014: reports to the Director of IT. Oversees support and administration of all ICERM A/V technologies, hardware and software systems. Coordinates the development of ICERM's website and video database. Monitors and actively controls the Echo 360 lecture capture system and provides first level support for technical issues such as wireless connectivity and printing.

Bernadette McHugh, Web and Communications Coordinator, hired in September 2012: reports to the Director of IT. Updates and maintains website content, web-based applications, and social media used to support and promote ICERM and its activities. Provides A/V support for the institute's workshops and events.

Tori Santonil, Senior Application Developer, hired October 2017: reports to the Director of IT. One of two Application Developer positions. Performs project management, application testing, development, and maintenance, including development/coding, testing, and ongoing maintenance of the department's front-end applications, back-end applications, java application servers, and databases.

Zachary Hyman, Application Developer, hired March 2020: reports to the Director of IT. One of two Application Developer positions. Performs application testing, development, and maintenance, including development/coding, testing, and ongoing maintenance of the

department's front-end applications, back-end applications, java application servers, and databases.

ICERM PI and Director Biographies

Brendan Hassett (Director) joined the Brown faculty the summer of 2015 as a Professor of Mathematics. He assumed the directorship of ICERM in July 2016. Brendan received his Ph.D. from Harvard in 1996 and then spent four years at the University of Chicago before joining the faculty at Rice University in 2000. He was the chair of the mathematics department at Rice from 2009 to 2014. He has also held visiting positions at the Mittag-Leffler Institute in Stockholm, the Chinese University of Hong Kong, and the University of Paris. Brendan's research focus is algebraic geometry - the study of geometric objects that are defined as solutions to polynomial equations. Brendan has written more than 60 research papers and has authored or co-edited seven books. His work has been recognized with a Sloan Research Fellowship, a National Science Foundation CAREER award, and the Charles W. Duncan Award for Outstanding Faculty at Rice. He is a Fellow of the American Mathematical Society.

Mathew Borton was one of ICERM's first employees, hired in December 2010. As the IT Director, he brings big-picture, strategic development skills to the institute. He oversees all daily IT/technology related operational activities and ensures IT security and stability. He acts as the liaison to the Brown University's IT community. Besides supporting the scientific activities within the institute, his responsibilities include overseeing the support of administrative IT and A/V equipment, and the development and support of key web interfaces and databases. Mat received his BS in Information Technology and his MS in Technology – Information Security, both from Purdue University.

Ruth Crane, Assistant Director, joined ICERM in November 2010 as the institute's first employee. She has over 35 years of communications and management experience, ranging from corporate training, health care, and academia. She uses her broad range of experience in order to act as chief-of-staff and oversees the coordination and administrative aspects of all the research programs of the institute. She is the liaison for the institute's fundraising activities and coordinates grant proposals, including proposal writing. Ruth manages all ICERM marketing and oversees ICERM's web content as well as community outreach activities. She works closely with the Director and the institute's boards. Ruth received her BS from Emerson College.

Sigal Gottlieb is a Deputy Director at ICERM, and a Chancellor Professor of Mathematics and founding co-Director of the Center for Scientific Computing and Visualization Research (CSCVR) at UMass Dartmouth. She is a Fellow of the Society of Industrial and Applied Mathematics. Sigal graduated from the Division of Applied Mathematics at Brown University (ScB'93, ScM'95, PhD'98). Her research interests include numerical analysis, scientific computing, and high-performance computing. Specifically, the high-order numerical methods for simulation of hyperbolic PDEs with shocks. These methods include WENO, spectral, and pseudo spectral methods, as well as strong stability preserving time discretizations. She is best known for her contributions to the field of high order time-stepping for hyperbolic PDEs, and her research in this area has been funded by the AFOSR continually since 2006. Sigal is also interested in reduced basis methods for solving PDEs with many parameters, and on gravitational wave simulations, and is funded by the NSF for projects in this area. Recently, Sigal led a team

of computational scientists at the CSCVR to obtain a $643,899 DURIP grant from the ONR to fund a new shared cluster at UMassD.

J. Elisenda Grigsby was a Deputy Director at ICERM, and a Professor in the mathematics department at Boston College. Her background is in low-dimensional topology, and she uses categorified invariants to study braids, links, and the surfaces they bound in the three-sphere and the four-ball. Eli's work connects and unifies structures in geometric, symplectic, and contact topology, homological algebra, and representation theory. Her research has been funded by the National Science Foundation and the Simons Foundation. In 2015, she was the inaugural winner of the AWM-Birman Research Prize in Topology and Geometry, and in 2016 she was awarded the Presidential Early Career Award for Scientists and Engineers (PECASE) by President Obama. Eli received her PhD from UC, Berkeley in 2006 and has since held visiting research positions as an NSF postdoctoral scholar at Columbia from 2006-2009, a Viterbi-endowed postdoctoral scholar at MSRI (Berkeley, CA) in Spring 2010, and a Simons foundation fellow at the Newton Institute (Cambridge, UK) in Spring 2017.

Jeffrey Hoffstein is a Professor of Mathematics at Brown University, and an ICERM Consulting Director. He received his PhD in mathematics from MIT in 1978. After holding postdoctoral positions at the Institute for Advanced Study, Cambridge University, and Brown University, Jeff was an Assistant and Associate Professor at University of Rochester. He came to Brown as a full professor in 1989. His research interests are number theory, automorphic forms, and cryptography. Jeff has written over seventy papers in these fields, co-authored an undergraduate textbook in cryptography, and jointly holds 10 patents for his cryptographic inventions. He was a co-founder of Ntru Cryptosystems, Inc., which was recently acquired by Qualcomm.

Jill Pipher is the Elisha Benjamin Andrews Professor of Mathematics at Brown University and ICERM's founding Director Emerita. She is Brown University's Vice President for Research, and also serves as president of the American Mathematical Society (AMS). Jill served as Chair of the Mathematics Department 2005-2008. Jill received her Ph.D. from UCLA in 1985 and came to Brown as an Associate Professor in 1990 from the University of Chicago. Her research interests include harmonic analysis, partial differential equations and cryptography. She jointly holds four patents for the NTRU encryption and digital signature algorithms and was a co-founder of Ntru Cryptosystems, Inc., now named OnBoard Security. Her awards include an NSF Postdoctoral Fellowship, Presidential Young Investigator Award, Mathematical Sciences Research Institute Fellowship, and an Alfred P. Sloan Foundation Fellowship. She served as President of the Association for Women in Mathematics in 2011-2013 and was a National Women's History Month 2013 Honoree. She was honored to deliver the 2014 ICM lecture, and the 2016 Brown University Presidential Faculty Award lecture. Jill is a Fellow of the American Mathematical Society, a SIAM Fellow, and a member of the American Academy of Arts and Sciences.

Caroline Klivans is an Associate Professor of Applied Mathematics at Brown University, and an ICERM Associate Director. Her focus is on the Institute's mentoring and professional development programs for students and postdoctoral fellows. In particular she leads the Round-Table discussion sessions building community and career foundations. Caroline received a BA degree in mathematics from Cornell University and a PhD in applied mathematics from the

Massachusetts Institute of Technology. Before coming to Brown, she held positions at MSRI and the University of Chicago. Her research is in algebraic, geometric and topological combinatorics.

Kavita Ramanan is the Roland George Dwight Richardson University Professor of Applied Mathematics at Brown University, also serving as Associate Chair. She is a Deputy Director at ICERM. Kavita works on probability theory, stochastic processes and their applications. She is an interdisciplinary researcher who has developed novel mathematical frameworks for the analysis of stochastic networks, Markov random fields and interacting particle systems, which arise as models in a variety of fields ranging from operations research and engineering to statistical physics and neuroscience. Her work combines tools from several fields including discrete probability, stochastic analysis and partial differential equations. She has also made fundamental contributions to the study of reflected processed, large deviations theory, high-dimensional probability and links with asymptotic convex geometry. She also has four patents to her name. She was awarded the Erlang prize in 2006 for "outstanding contributions to applied probability" by the INFORMS Applied Probability Society. She was a recipient of a Simons Fellowship in 2018 and Guggenheim Fellowship in 2020.

Bjorn Sandstede is Professor of Applied Mathematics, a Royce Family Professor of Teaching Excellence, the Director of the Data Science Initiative at Brown University, and an ICERM Associate Director. He studied mathematics at the University of Heidelberg and received his PhD in 1993 from the University of Stuttgart. After holding postdoctoral positions at the Weierstrass Institute in Berlin and at Brown University, he was a faculty member at the Ohio State University from 1997-2004, before moving in 2004 to the University of Surrey in England. In 2008, he joined the Division of Applied Mathematics at Brown University. Bjorn received an Alfred P Sloan Research Fellowship in 2000, was awarded the first JD Crawford Prize of the SIAM Activity Group on Dynamical Systems in 2001, received a Royal Society Wolfson Research Merit Award in 2004, the Elsevier Jack Hale Award, and Brown's Philip Bray Award for Teaching Excellence and the Graduate School Faculty Award for Advising and Mentoring. He was selected as a Fellow of the Society for Industrial and Applied Mathematics.

Homer Walker was a Professor of Mathematics at Worcester Polytechnic Institute 1997-2018 (now emeritus) and previously held faculty appointments at Utah State University, the University of Houston, and Texas Tech University. He is currently a Consulting Associate Director for ICERM after having served as Deputy Director for several years. Homer has held visiting appointments at a number of institutions, including Cornell, Yale, and Rice Universities and Lawrence Livermore and Sandia National Laboratories. His previous administrative experience includes service as department head at WPI 1997-2002 and as program manager for the US Department of Energy Office of Science Applied Mathematics Program 2007-2008. Homer's research interests are in numerical analysis and computational mathematics, especially iterative methods for large-scale linear and nonlinear systems, implementations for high-performance computing, and applications. He was a long-term associate editor of SIAM Journal on Numerical Analysis and a guest editor for ten special sections in SIAM Journal on Scientific Computing. He has also served on program committees for a number of national and international conferences and workshops, notably the biennial Copper Mountain Conferences on Iterative Methods, as well as on many review panels and site-visit teams for funding agencies in the US and abroad.

Ulrica Wilson is an Associate Professor of Mathematics at Morehouse College. As ICERM's Director of Diversity and Outreach, she provides leadership in meeting institutional diversity goals: ensuring diversity throughout ICERM's programs, assisting in the development of policies and procedures, participating in national meetings and conferences, and helping to identify and obtain funding for programs and activities. Ulrica's primary research has been in noncommutative ring theory and combinatorial matrix theory. Throughout her career, she has integrated opportunities to address diversity issues in the mathematical workforce. A decade of experience includes directing the Enhancing Diversity in Graduate Education EDGE Program and Research Experience for Undergraduate Faculty REUF workshops at AIM and ICERM. Ulrica was recently named as a 2019 AWM Fellow for her work supporting the professional development of women pursuing careers in the mathematical sciences.

Facilities

ICERM is located on the 10th and 11th floors of 121 S. Main Street, in a Brown owned building in downtown Providence, RI. Visitors to ICERM are within a 10-minute walking distance of the Brown campus, the train station, major hotels, and a variety of restaurants and historic sites.

The space includes a 120-seat lecture hall, a 20-seat seminar room, a 20-seat conference room, an administrative suite, office space for 40-45 visitors, two kitchens, and three large collaborative areas.

IT Resources

ICERM's information technology group's mission is to provide the necessary tools for research, collaboration, and information dissemination required by the institute's participants and to support the administrative staff. This is accomplished by providing flexible systems that can be quickly reconfigured to meet research needs and efficient administrative tools that allow the institute's staff to maintain operational excellence.

Work Stations

ICERM provides virtual desktop systems to all semester program participants using a custom VNC connection to the Center for Computation and Visualization. The host operating system is Redhat Linux Server, the guests use Redhat Linux workstation, and the client machines are thin clients using a thin version of Debian. Applications are distributed based on the needs of the current program and researcher requests. Applications are distributed as needed. Application needs differ from program to program and researcher to researcher. Individuals have administrative control over their own virtual desktops. Researchers are also free to provide their own equipment or use their own laptop. The majority of the applications provided to users will leverage existing Brown license agreements.

Web Based Tools

ICERM provides an evolving suite of web-based tools for collaboration and to assist research. ICERM uses Zoom webinar to facilitate virtual workshops. Zoom Meeting is available for smaller presentations and participant working groups. Participants have access to discuss.icerm.brown.edu, a traditional forum style site that allows posting and responding to

discussion threads and limited file sharing. They also have access to a dedicated Slack workspace for text-based messaging. ICERM offers participants licensed access to Overleaf, a collaborative web based LaTeX editor. Access to Jupyter notebooks and CoCalc are available on request.

All previous talks and papers generated in the course of semester programs are archived and available for download and review via the website.

Multimedia Resources

ICERM has state of the art audio/visual capabilities. The 120-seat lecture hall features dual projection screens, a centrally controlled AV system capable of displaying multiple media types, and a lecture capture system with an auto-tracking camera for recording presentations and streaming to the web. A smaller meeting room is equipped with a video conferencing system and includes a digital media projection system. The video conferencing system can also be leveraged to communicate with the lecture hall. A seminar room on the 10th floor provides basic multimedia presentation capability. Digital signage screens throughout the institute are used to display important information to visitors and can be independently used as a peripheral display from a laptop.

Live Streaming

ICERM provides live, real-time video streaming of all Workshop talks, special events, and tutorial sessions given in the lecture hall.

Video Archives

ICERM digitally records semester and topical workshop talks and special lectures in High Definition using the Panopto lecture capture system. Presentations are then archived and made available for viewing on our website along with a PDF copy of the presenter's slides, when available.

Data Collection and Reporting

ICERM has a visitor management system called CUBE to collect and report on participant data. This system will become a central point of data management for both staff and participants as new feature sets are added.

ORCID ID

ICERM collects ORCID iDs from NSF-funded participants. The following message is conveyed: *In order for the NSF's Division of Mathematical Sciences to effectively evaluate math institutes, it requires that funded participants provide their Open Researcher and Contributor ID (ORCID) identifier. Only those participants who furnish their ID to ICERM may be supported with award funds.*

Brown Computing Resources

ICERM participants are encouraged to use other IT resources available at Brown. Chief among these is the high-performance computing cluster hosted by the Center for Computation and

Visualization. ICERM provides premium access accounts upon request to all long-term participants and to workshop participants on an as needed basis with approval from the Director.

Participants are also welcome to use the Digital Scholarship Lab at the Rockefeller Library. This room incorporates a high-definition video wall for large-scale visualization and collaboration.

CCV makes other services available to ICERM participants, including access to consultants for code creation and optimization and an immersive display environment.

APPENDIX:

Appendix A: Sample Semester Schedule & Organizer Timeline
Appendix B: Upcoming Programs and Events
Appendix C: Collaborate@ICERM Summary Reports
Appendix D: Minutes from Board of Trustees Meeting
Appendix E: Minutes from Scientific Advisory Board Meetings
Appendix F: Minutes from Education Advisory Board Meeting
Appendix G: MIDs Meeting Minutes
Appendix H: Survey Summaries May 11, 2019-May 1, 2020
Appendix I: Projects Initiated at ICERM 2019-2020
Appendix J: ICERM Income and Expenditure Report (NSF Required)