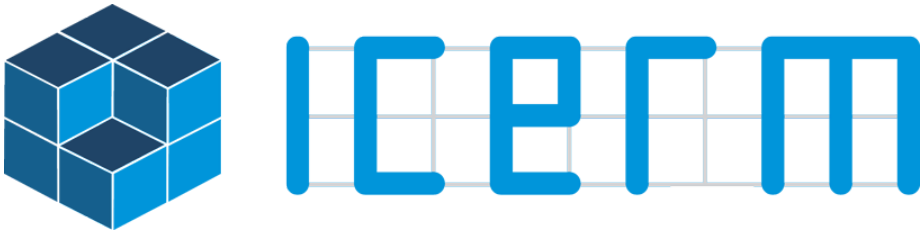

Institute for Computational and Experimental Research in Mathematics

Annual Report
May 1, 2021 – April 30, 2022

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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

The following grid lists ICERM's scheduled programs and events from May 1, 2021 through April 30, 2022 supported by the core NSF award and other grants. All programs and events were virtual. The grand total of "Unique Visits" during this timeframe was **2,061**. The "Unique Visits" total for *just ICERM's core programs* was **1,817** (not including Hot Topics – see note below the grid). As this year had a mix of in person and virtual interaction, we recorded **383** unique visitors who came in person. For reporting purposes, a visit is defined as "A contiguous period of time that a person is physically at or virtually interacting with ICERM". Based on known arrival and departure dates, without reported gaps."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. The public lectures list the number of people registered to attend.

TYPE	TITLE	START Date	END Date	# UNIQUE ATTENDED	Total Attended
Topical Workshop	VIRTUAL ONLY: Advances and Challenges in Hyperbolic Conservation Laws	17-May-21	21-May-21	161	162
Summer@ ICERM	Summer@ICERM 2021: Computational Polygonal Billiards	14-Jun-21	6-Aug-21	32	33
Topical Workshop	VIRTUAL ONLY: Computational Aspects of Discrete Subgroups of Lie Groups	14-Jun-21	18-Jun-21	57	59
Collaborate@ ICERM	Mathematical Models of Pedestrian Movement in Large Lecture Halls	21-Jun-21	25-Jun-21	6	6
TRIPODS	VIRTUAL ONLY: MAA - SIAM & TRIPODS Advanced Workshop in Data Science for Mathematical Sciences Faculty	28-Jun-21	2-Jul-21	79	79
Collaborate@ ICERM	Numerical Methods for Fokker-Planck Equation and Its Inverse	28-Jun-21	2-Jul-21	4	4
Topical Workshop	VIRTUAL ONLY: Applications of Rough Paths: Computational Signatures and Data Science	6-Jul-21	9-Jul-21	84	84
Collaborate@ ICERM	Matroids over Partial Hyperstructures	19-Jul-21	23-Jul-21	8	8

Public Lecture	A Virtual ICERM Public Lecture: Knotty Knits and Evening of Math and Crafts	28-Jul-21	28-Jul-21	132	132
Collaborate@ ICERM	Linearly and Nonlinearly Stable Space-Time Discretizations with Application to h/p/r-adaptation	2-Aug-21	6-Aug-21	5	5
Hot Topics Workshop	VIRTUAL ONLY: Workshop on Advances in Theory and Algorithms for Deep Reinforcement Learning	2-Aug-21	4-Aug-21	195	195
Topical Workshop	VIRTUAL ONLY: Research Community in Algebraic Combinatorics	5-Aug-21	6-Aug-21	48	48
Collaborate@ ICERM	Codes and Designs: Optimal Discrete Measures	9-Aug-21	13-Aug-21	6	6
Topical Workshop	VIRTUAL ONLY: D-modules, Group Actions, and Frobenius: Computing on Singularities	9-Aug-21	13-Aug-21	81	81
GirlsGetMath	GirlsGetMath@ICERM: Summer Math Camp for High Schoolers	16-Aug-21	20-Aug-21	31	31
Collaborate@ ICERM	Tropical degree two del Pezzo surfaces and their 56 lines	16-Aug-21	20-Aug-21	5	5
Public Lecture	A Virtual ICERM Public Lecture: Hidden Narratives in Mathematics - The Power of Storytelling	18-Aug-21	18-Aug-21	188	188
Topical Workshop	VIRTUAL ONLY: Spectra LGBTQ+ in Mathematics Conference	18-Aug-21	20-Aug-21	113	114
Topical Workshop	VIRTUAL ONLY: Prediction and Variability of Air-Sea Interactions: the South Asian Monsoon	23-Aug-21	27-Aug-21	76	76
Semester Program	Hamiltonian Methods in Dispersive and Wave Evolution Equations	8-Sep-21	10-Dec-21	108	108
Semester Program Workshop	Numerics, Modeling, and Experiments in Wave Phenomena	20-Sep-21	24-Sep-21	40	115
Semester Program Workshop	Generic Behavior of Dispersive Solutions and Wave Turbulence	18-Oct-21	22-Oct-21	50	130Ap
Hot Topics Workshop	Foam Evaluation	5-Nov-21	7-Nov-21	65	70
Semester Program Workshop	Hamiltonian Methods and Asymptotic Dynamics	6-Dec-21	10-Dec-21	74	149

TRIPODS	Geometric and Topological Methods in Data Science	16-Dec-21	17-Dec-21	31	31
Topical Workshop	Holistic Design of Time-Dependent PDE Discretizations	10-Jan-22	14-Jan-22	66	66
Collaborate@ ICERM	Topics in Tame Galois Theory	10-Jan-22	14-Jan-22	3	3
Collaborate@ ICERM	Numerical Algebraic Geometry and Tropical Geometry	18-Jan-22	21-Jan-22	6	6
Semester Program	Braids	1-Feb-22	6-May-22	64	64
Topical Workshop	Research Community in Algebraic Combinatorics	10-Feb-22	11-Feb-22	47	47
Semester Program Workshop	Braids in Representation Theory and Algebraic Combinatorics	14-Feb-22	18-Feb-22	54	87
Semester Program Workshop	Braids in Symplectic and Algebraic Geometry	21-Mar-22	25-Mar-22	73	109
Semester Program Workshop	Braids in Low-Dimensional Topology	25-Apr-22	29-Apr-22	119	154

Note: The Hot Topics workshops are fully funded by a Simons Foundation Targeted Grant to Institutes.

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: "funded" refers to participants who had offered funding attached to their attendance (some before COVID).

ICERM Funded Participants

	Program Type	Summer@ICERM 2022	5 Collaboration Groups	2 TRIPODS Programs	Fall Semester '21					Spring Semester '22					Topical '21 - '22										
					Semester Program	Workshop 1	Workshop 2	Workshop 3	% 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	Workshop H	Workshop I	Workshop J	% of # Reporting
	Total Participants	2	5	1	10	1	3	5		5	6	13	30		0	0	2	0	0	0	0	0	6	6	
Gender and Ethnicity	Female	1	2	0	3	0	0	0	17%	2	1	4	10	32%	0	0	1	0	0	0	0	0	1	6	62%
	Other	0	0	0	0	0	0	0	0%	0	0	0	1	1.9%	0	0	0	0	0	0	0	0	0	0	0%
	# Reporting Gender	2	5	1	10	1	3	4		5	6	13	29		0	0	1	0	0	0	0	0	6	6	
	African American	0	0	0	1	0	0	0	5%	0	0	1	1	4%	0	0	0	0	0	0	0	0	2	0	17%
	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	0%
	Asian	0	2	1	3	0	1	1	26%	2	2	5	11	38%	0	0	0	0	0	0	0	0	2	2	33%
	Hispanic	0	0	0	1	0	0	0	5%	0	1	2	3	11%	0	0	0	0	0	0	0	0	0	1	8%
	# Reporting Ethnicity	1	5	1	10	1	4	4		4	6	13	30		0	0	1	0	0	0	0	0	6	5	
Geographical Point of Origin	US - Midwest	0	0	0	1	0	0	0	5%	0	0	4	3	13%	0	0	0	0	0	0	0	0	1	1	14%
	US - Northeast	1	1	1	4	0	1	1	32%	1	3	5	9	33%	0	0	0	0	0	0	0	0	0	1	7%
	US - South	0	3	0	1	0	0	0	5%	1	0	0	5	11%	0	0	0	0	0	0	0	0	3	1	29%
	US - West	1	0	0	0	0	1	1	11%	0	1	1	2	7%	0	0	1	0	0	0	0	0	2	2	36%
	Africa	0	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	0	0	0	0	0	0	0	0	0%
	Canada	0	0	0	0	0	0	1	5%	0	0	0	4	7%	0	0	1	0	0	0	0	0	0	0	7%
	Europe	0	1	0	4	1	0	2	37%	2	0	2	6	19%	0	0	0	0	0	0	0	0	0	0	0%
	Latin & South America	0	0	0	0	0	0	0	0%	0	1	0	0	2%	0	0	0	0	0	0	0	0	0	1	7%
	Oceania	0	0	0	0	0	0	0	0%	1	1	1	1	7%	0	0	0	0	0	0	0	0	0	0	0%

All Participants (ICERM funded and Non-ICERM funded)

	Program Type	Summer@ICERM 2022	8 Collaboration Groups	2 TRIPODS Programs	Fall Semester '21					Spring Semester '22					Topical '21 - '22									
					Semester Program	Workshop 1	Workshop 2	Workshop 3	% 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	Workshop H	Workshop I	Workshop J	% of # Reporting
Gender and Ethnicity	Total Participants	32	43	110	108	40	50	74		64	54	73	119		161	57	84	48	81	113	76	3	66	47	
	Female	15	13	41	21	5	4	11	19%	27	15	22	46	39%	36	10	8	47	28	33	15	0	14	46	38%
	Other	2	1	0	0	0	0	1	0.5%	0	0	0	2	1%	0	0	0	0	0	23	0	0	0	0	4%
	# Reporting Gender	32	37	103	87	30	39	55		52	51	66	114		141	43	58	47	71	104	56	2	54	46	
	African American	1	1	3	3	2	0	0	3%	1	2	1	1	2%	1	2	0	0	0	4	0	0	7	0	2%
	American Indian	0	0	0	0	0	0	0	0%	0	0	0	1	0%	0	0	0	0	0	0	0	0	0	0	0%
	Asian	11	8	23	24	13	15	24	40%	13	14	21	35	30%	69	6	18	10	22	23	36	2	17	10	36%
	Hispanic	1	2	3	7	2	3	3	8%	3	5	2	6	6%	8	4	4	7	2	8	3	0	1	7	7%
	# Reporting Ethnicity	30	37	105	77	26	34	51		49	49	65	110		131	45	49	46	66	114	49	2	50	46	
Geographical Point of Origin	US Based	29	29	109	57	24	25	33	51%	33	34	49	77	62%	89	40	28	38	59	74	29	3	46	37	60%
	Foreign Based	3	14	1	51	16	25	41	49%	31	20	24	42	38%	72	17	56	10	22	39	47	0	20	10	40%

ICERM Funded Speakers

	Program Type	Summer@ICERM 2022	8 Collaboration Groups	2 TRIPODS Programs	Fall Semester '21					Spring Semester '22					Topical '21 - '22										
					Semester Program	Workshop 1	Workshop 2	Workshop 3	% 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	Workshop H	Workshop I	Workshop J	% of # Reporting
Gender and Ethnicity	Total Participants	0	0	10	0	12	12	19		0	13	16	18		23	20	23	0	14	0	6	0	20	0	
	Female	0	0	2	0	1	1	4	38%	0	2	5	7	35%	6	5	3	0	5	0	0	0	5	0	41%
	Other	0	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	0	7	0	5	4	7		0	11	13	16		15	13	9	0	8	0	1	0	13	0	
	African American	0	0	0	0	1	0	0	8%	0	0	0	0	0%	0	0	0	0	0	0	0	0	0	0	0%
	American Indian	0	0	0	0	0	0	0	0%	0	0	0	1	2%	0	0	0	0	0	0	0	0	0	0	0%
	Asian	0	0	2	0	1	1	1	25%	0	1	1	2	10%	3	0	0	0	1	0	1	0	2	0	15%
	Hispanic	0	0	0	0	0	0	1	8%	0	2	0	0	5%	1	0	0	0	0	0	0	0	1	0	4%
	# Reporting Ethnicity	0	0	5	0	3	2	7		0	11	14	16		12	12	5	0	7	0	1	0	11	0	
Geographical Point of Origin	US - Midwest	0	0	2	0	2	0	1	7%	0	2	2	0	9%	5	2	0	0	10	0	0	0	4	0	20%
	US - Northeast	0	0	7	0	0	1	4	12%	0	2	5	4	23%	5	7	4	0	0	0	1	0	3	0	19%
	US - South	0	0	0	0	2	3	5	23%	0	1	1	5	15%	3	1	1	0	1	0	0	0	2	0	8%
	US - West	0	0	1	0	1	2	0	7%	0	4	3	2	19%	1	4	3	0	0	0	1	0	4	0	12%
	Africa	0	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	2	4%	3	1	0	0	1	0	0	0	2	0	7%
	Canada	0	0	0	0	0	0	0	0%	0	0	0	0	0%	0	0	1	0	0	0	0	0	0	0	1%
	Europe	0	0	0	0	2	1	0	7%	0	3	5	5	28%	5	5	14	0	2	0	0	0	2	0	26%
	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	0%
	Oceania	0	0	0	0	0	0	0	0%	0	1	0	0	2%	0	0	0	0	0	0	0	0	0	0	0%

All Speakers (ICERM funded and Non-ICERM funded)

Program Type		Summer@ICERM 2022	8 Collaboration Groups	2 TRIPODS Programs	Fall Semester '21					Spring Semester '22					Topical '21 - '22										
					Semester Program	Workshop 1	Workshop 2	Workshop 3	% 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	Workshop H	Workshop I	Workshop J	% of # Reporting
Gender and Ethnicity	Total Participants	6	0	11	0	15	12	21		0	13	16	18		24	22	28	0	16	0	11	0	20	0	
	Female	5	0	2	0	2	1	4	35%	0	2	5	7	35%	7	5	4	0	5	0	2	0	5	0	41%
	Other	0	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	6	0	8	0	8	4	8		0	11	13	16		16	15	11	0	9	0	5	0	13	0	
	African American	0	0	0	0	1	0	0	7%	0	0	0	0	0%	0	0	0	0	0	0	0	0	0	0	0%
	American Indian	0	0	0	0	0	0	0	0%	0	0	0	1	2%	0	0	0	0	0	0	0	0	0	0	0%
	Asian	0	0	2	0	1	1	2	27%	0	1	1	2	10%	3	0	1	0	1	0	2	0	2	0	16%
	Hispanic	1	0	0	0	0	0	1	7%	0	2	0	0	5%	1	0	0	0	1	0	0	0	1	0	5%
	# Reporting Ethnicity	7	0	6	0	5	2	8		0	11	14	16		13	14	7	0	8	0	5	0	11	0	
Geographical Point of	US Based	4	0	11	0	8	6	11	52%	0	9	11	11	66%	15	16	8	0	11	0	5	0	14	0	57%
	Foreign Based	2	0	0	0	7	6	10	48%	0	4	5	7	34%	9	6	20	0	5	0	6	0	6	0	43%

ICERM Funded Postdocs

	Program Type	Summer@ICERM 2022	8 Collaboration Groups	2 TRIPODS Programs	Fall Semester '21					Spring Semester '22					Topical '21 - '22										
					Semester Program	Workshop 1	Workshop 2	Workshop 3	% 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	Workshop H	Workshop I	Workshop J	% of # Reporting
Gender and Ethnicity	Total Participants	3	7	6	23	5	6	10		22	11	9	21		0	2	7	0	0	0	1	3	4	6	
	Female	1	2	1	7	1	1	2	26%	16	4	3	9	52%	0	2	0	0	0	0	0	0	1	6	56%
	Other	0	1	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	6	6	23	4	6	9		21	10	9	21		0	2	1	0	0	0	1	2	4	6	
	African American	0	0	0	1	0	0	0	3%	1	0	0	0	2%	0	0	0	0	0	0	0	0	2	0	13%
	American Indian	0	0	0	0	0	0	0	0%	0	0	0	1	2%	0	0	0	0	0	0	0	0	0	0	0%
	Asian	2	0	2	7	3	2	4	41%	6	0	3	7	29%	0	0	0	0	0	0	1	2	2	3	53%
	Hispanic	0	0	0	1	0	1	1	8%	3	4	0	0	13%	0	0	0	0	0	0	0	0	0	0	0%
	# Reporting Ethnicity	3	6	3	21	4	5	9		21	8	8	19		0	2	1	0	0	0	1	2	4	5	
Geographical Point of Origin	US - Midwest	1	1	1	0	0	1	0	2%	0	1	1	2	6%	0	0	0	0	0	0	0	0	2	0	9%
	US - Northeast	2	2	5	10	2	3	3	41%	5	1	3	6	24%	0	1	0	0	0	0	1	2	1	1	26%
	US - South	0	0	0	1	1	1	3	14%	6	2	2	3	21%	0	0	0	0	0	0	0	1	0	0	4%
	US - West	0	0	0	4	0	0	0	9%	2	2	0	4	13%	0	1	0	0	0	0	0	0	1	3	22%
	Africa	0	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	1	2%	0	0	0	0	0	0	0	0	0	0	0%
	Canada	0	0	0	1	1	1	1	9%	1	0	0	0	2%	0	0	0	0	0	0	0	0	0	0	0%
	Europe	0	2	0	7	0	0	2	20%	7	3	2	5	27%	0	0	7	0	0	0	0	0	0	2	39%
	Latin & South America	0	0	0	0	0	0	0	0%	0	1	0	0	2%	0	0	0	0	0	0	0	0	0	0	0%
	Oceania	0	0	0	0	0	0	0	0%	1	1	1	0	5%	0	0	0	0	0	0	0	0	0	0	0%

All Postdocs (ICERM funded and Non-ICERM funded)

Program Type		Summer@ICERM 2022	8 Collaboration Groups	2 TRIPODS Programs	Fall Semester '21					Spring Semester '22					Topical '21 - '22										
					Semester Program	Workshop 1	Workshop 2	Workshop 3	% 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	Workshop H	Workshop I	Workshop J	% of # Reporting
Gender and Ethnicity	Total Participants	6	0	11	0	15	12	21		0	13	16	18		24	22	28	0	16	0	11	0	20	0	
	Female	5	0	2	0	2	1	4	35%	0	2	5	7	35%	7	5	4	0	5	0	2	0	5	0	41%
	Other	0	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	6	0	8	0	8	4	8		0	11	13	16		16	15	11	0	9	0	5	0	13	0	
	African American	0	0	0	0	1	0	0	7%	0	0	0	0	0%	0	0	0	0	0	0	0	0	0	0	0%
	American Indian	0	0	0	0	0	0	0	0%	0	0	0	1	2%	0	0	0	0	0	0	0	0	0	0	0%
	Asian	0	0	2	0	1	1	2	27%	0	1	1	2	10%	3	0	1	0	1	0	2	0	2	0	16%
	Hispanic	1	0	0	0	0	0	1	7%	0	2	0	0	5%	1	0	0	0	1	0	0	0	1	0	5%
	# Reporting Ethnicity	7	0	6	0	5	2	8		0	11	14	16		13	14	7	0	8	0	5	0	11	0	
Geographical Point of	US Based	4	0	11	0	8	6	11	52%	0	9	11	11	66%	15	16	8	0	11	0	5	0	14	0	57%
	Foreign Based	2	0	0	0	7	6	10	48%	0	4	5	7	34%	9	6	20	0	5	0	6	0	6	0	43%

ICERM Funded Graduate Students

Program Type		Summer@ICERM 2022	8 Collaboration Groups	2 TRIPODS Programs	Fall Semester '21					Spring Semester '22					Topical '21 - '22										
					Semester Program	Workshop 1	Workshop 2	Workshop 3	% 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	Workshop H	Workshop I	Workshop J	% of # Reporting
Gender and Ethnicity	Total Participants	2	5	1	10	1	3	5		5	6	13	30		0	0	2	0	0	0	0	0	6	6	
	Female	1	2	0	3	0	0	0	17%	2	1	4	10	32%	0	0	1	0	0	0	0	0	1	6	62%
	Other	0	0	0	0	0	0	0	0%	0	0	0	1	1.9%	0	0	0	0	0	0	0	0	0	0	0%
	# Reporting Gender	2	5	1	10	1	3	4		5	6	13	29		0	0	1	0	0	0	0	0	6	6	
	African American	0	0	0	1	0	0	0	5%	0	0	1	1	4%	0	0	0	0	0	0	0	0	2	0	17%
	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	0%
	Asian	0	2	1	3	0	1	1	26%	2	2	5	11	38%	0	0	0	0	0	0	0	0	2	2	33%
	Hispanic	0	0	0	1	0	0	0	5%	0	1	2	3	11%	0	0	0	0	0	0	0	0	0	1	8%
	# Reporting Ethnicity	1	5	1	10	1	4	4		4	6	13	30		0	0	1	0	0	0	0	0	6	5	
Geographical Point of Origin	US - Midwest	0	0	0	1	0	0	0	5%	0	0	4	3	13%	0	0	0	0	0	0	0	0	1	1	14%
	US - Northeast	1	1	1	4	0	1	1	32%	1	3	5	9	33%	0	0	0	0	0	0	0	0	0	1	7%
	US - South	0	3	0	1	0	0	0	5%	1	0	0	5	11%	0	0	0	0	0	0	0	0	3	1	29%
	US - West	1	0	0	0	0	1	1	11%	0	1	1	2	7%	0	0	1	0	0	0	0	0	2	2	36%
	Africa	0	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	0	0	0	0	0	0	0	0	0%
	Canada	0	0	0	0	0	0	1	5%	0	0	0	4	7%	0	0	1	0	0	0	0	0	0	0	7%
	Europe	0	1	0	4	1	0	2	37%	2	0	2	6	19%	0	0	0	0	0	0	0	0	0	0	0%
	Latin & South America	0	0	0	0	0	0	0	0%	0	1	0	0	2%	0	0	0	0	0	0	0	0	0	1	7%
	Oceania	0	0	0	0	0	0	0	0%	1	1	1	1	7%	0	0	0	0	0	0	0	0	0	0	0%

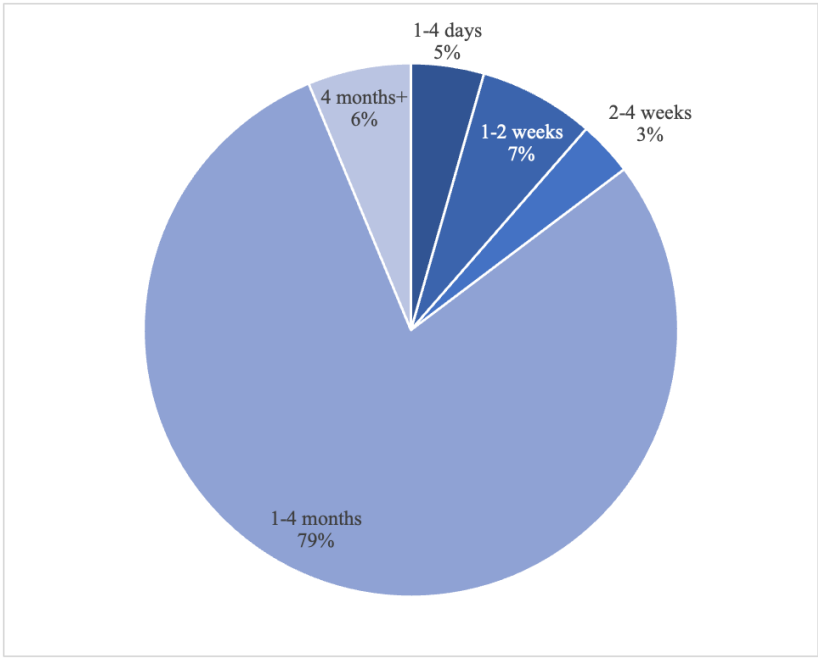
All Graduate Students (ICERM funded and Non-ICERM funded)

	Program Type	Summer@ICERM 2022	8 Collaboration Groups	2 TRIPODS Programs	Fall Semester '21					Spring Semester '22					Topical '21 - '22										
					Semester Program	Workshop 1	Workshop 2	Workshop 3	% 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	Workshop H	Workshop I	Workshop J	% of # Reporting
Gender and Ethnicity	Total Participants	2	6	8	19	4	9	15		7	13	21	40		33	13	20	6	26	32	13	0	9	6	
	Female	1	2	2	4	1	0	1	14%	3	2	8	13	33%	8	0	3	6	8	7	3	0	3	6	30%
	Other	0	0	0	0	0	0	0	0%	0	0	0	2	3%	0	0	0	0	0	7	0	0	0	0	5%
	# Reporting Gender	2	5	7	19	4	8	11		7	13	20	38		32	11	16	6	25	30	13	0	9	6	
	African American	0	0	1	1	0	0	0	3%	0	2	1	1	5%	0	2	0	0	0	1	0	0	2	0	3%
	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	0%
	Asian	0	2	4	5	3	3	6	44%	2	5	9	13	37%	19	4	6	2	11	9	9	0	4	2	46%
	Hispanic	0	0	0	3	0	1	0	10%	0	1	2	5	10%	2	2	0	1	0	1	1	0	0	1	6%
	# Reporting Ethnicity	1	5	9	18	4	8	9		6	13	20	40		29	16	16	5	23	32	10	0	8	5	
Geographical Point of	US Based	2	4	8	13	3	5	6	57%	3	8	17	26	67%	23	10	6	5	25	20	2	0	7	5	65%
	Foreign Based	0	2	0	6	1	4	9	43%	4	5	4	14	33%	10	3	14	1	1	12	11	0	2	1	35%

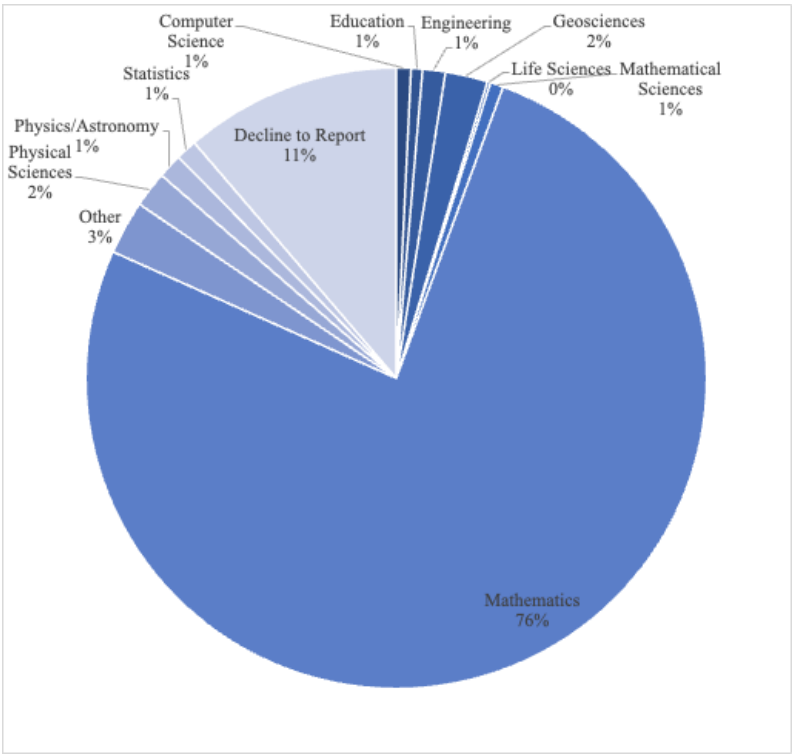
Additional Participant Data

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.

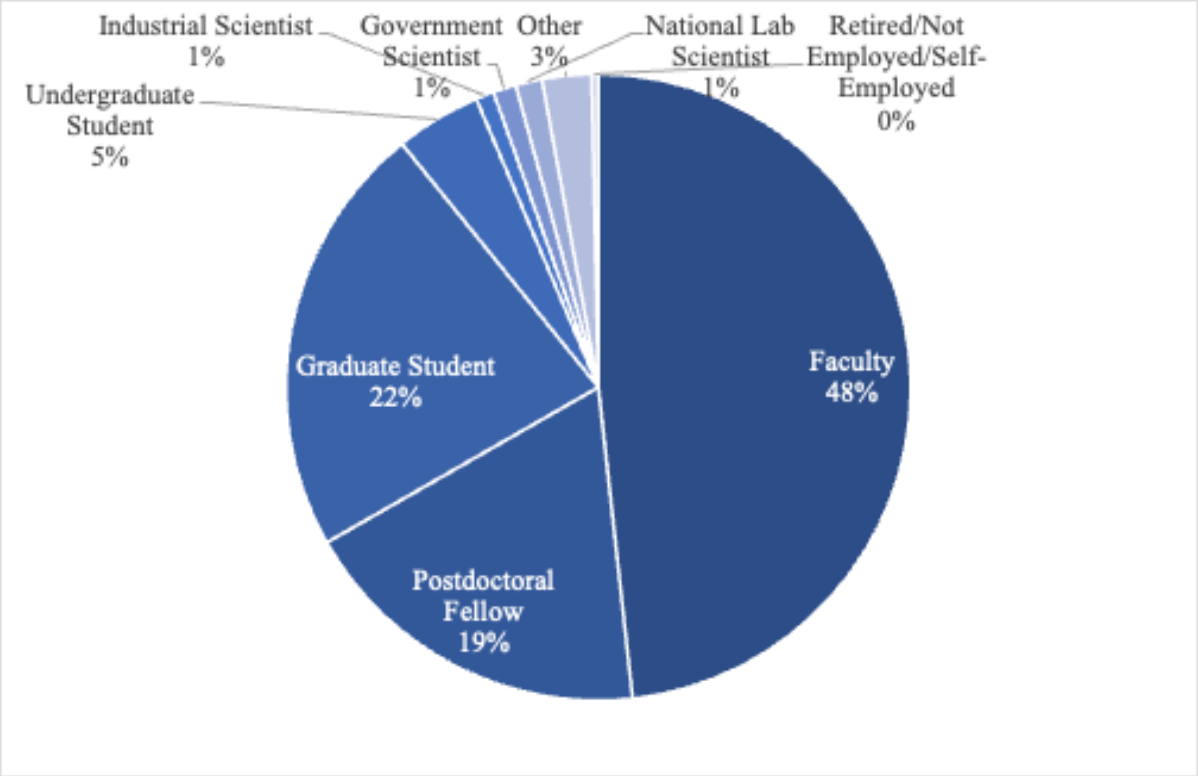
Semester Program Length of Stay



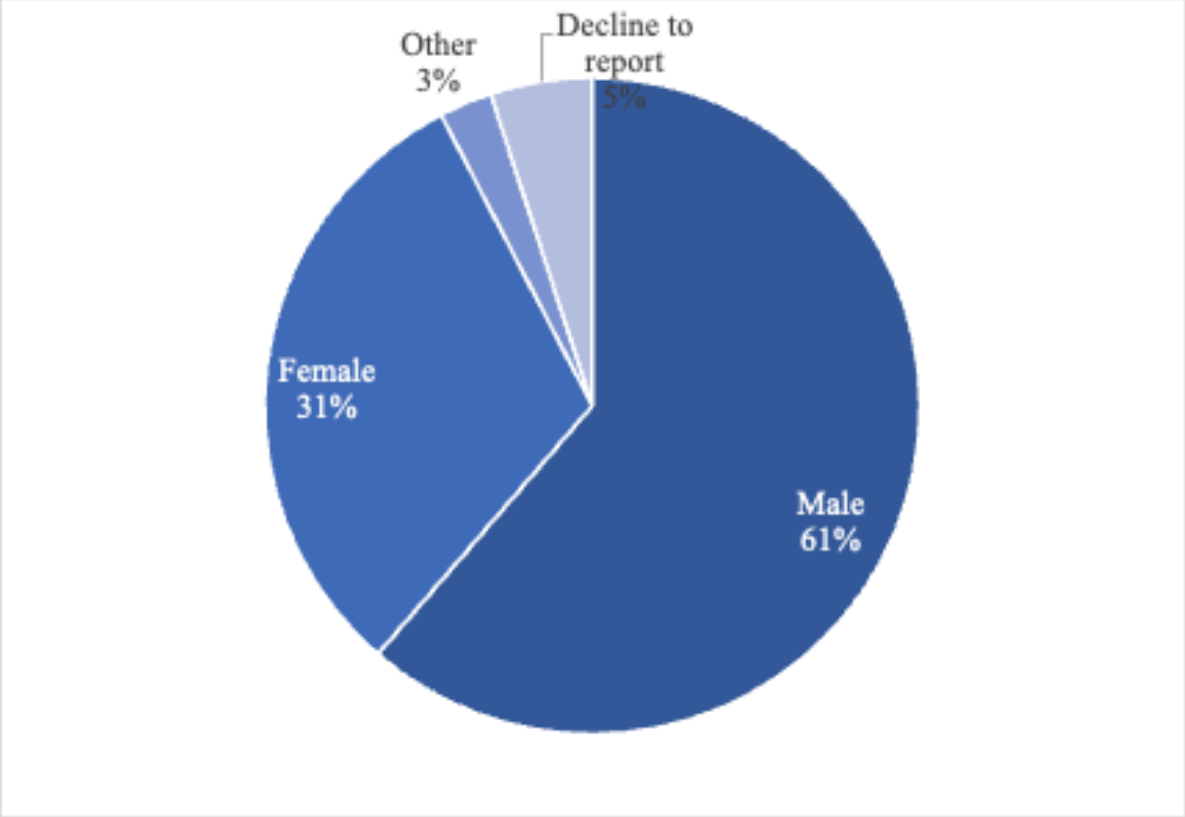
Primary Field of Interest



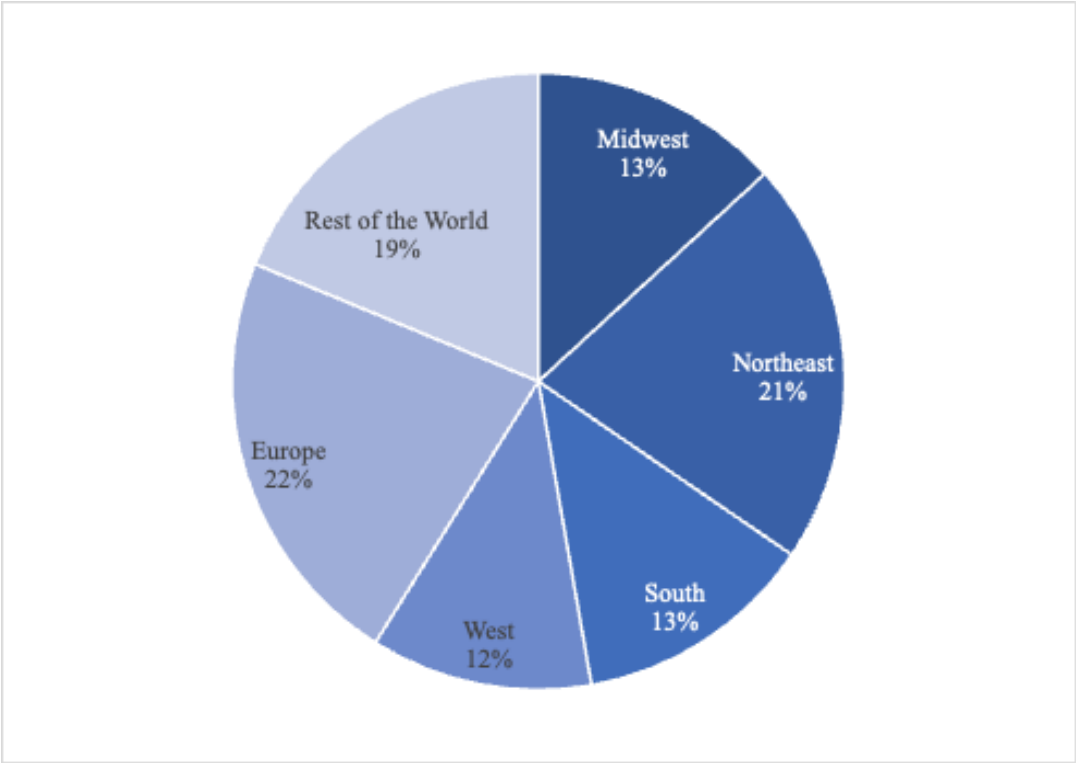
Position



Gender

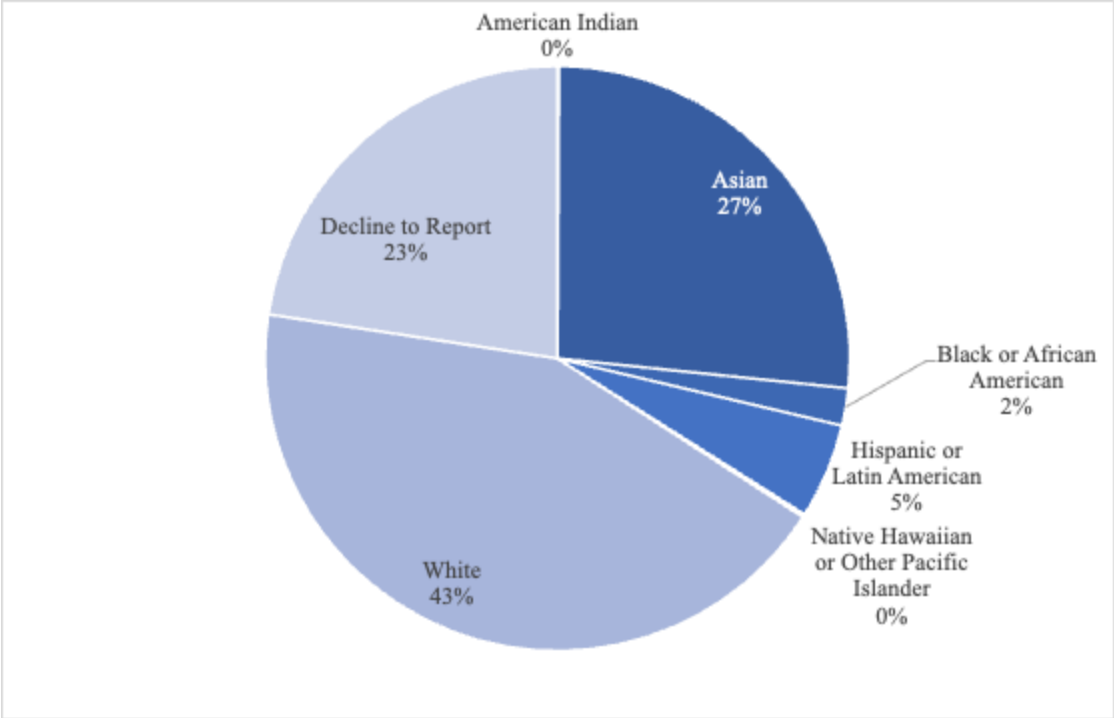


US vs Foreign Based Participants



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.

Notable Accomplishments

Fall 2020 Semester Program outcomes

The Advances in Computational Relativity program has generated highly-visible research.

Brendan Keith, a postdoc in this program, was profiled in phys.org based on a press release from LLNL, his employer this past year:

> https://www.llnl.gov/news/llnl-led-team-uses-machine-learning-derive-black-hole-motion-gravitational-waves

The underlying publication is

> Learning orbital dynamics of binary black hole systems from gravitational wave measurements
> Brendan Keith, Akshay Khadse, and Scott E. Field
> Phys. Rev. Research 3, 043101 – Published 9 November 2021
> https://journals.aps.org/prresearch/abstract/10.1103/PhysRevResearch.043101

Keith will assume a faculty position at Brown next fall.

Jacob Lange, another postdoc in the program, was profiled in

> https://www.universetoday.com/154281/a-highly-eccentric-black-hole-merger-detected-for-the-first-time/

The underlying publication is:

> Nature Astronomy
> Published: 20 January 2022
> Eccentricity estimate for black hole mergers with numerical relativity simulations
> V. Gayathri, J. Healy, J. Lange, B. O'Brien, M. Szczepańczyk, Imre Bartos, M. Campanelli, S. Klimenko, C. O. Lousto & R. O'Shaughnessy
> https://www.nature.com/articles/s41550-021-01568-w

Other authors participated more briefly in the program.

Fall 2021 Semester Program

Program organizer Andrew Nahmod (with Bjoern Bringmann, Yu Deng and Haitian Yue) posted *Invariant Gibbs measures for the three dimensional cubic nonlinear wave equation* arXiv:2205.03893.

> This paper resolves the problem of establishing that the 3D Gibbs measure is invariant under the flow of the cubic nonlinear wave equation, and proves that its solutions are globally well-posed for almost all initial conditions. In other words this is the hyperbolic counterpart to the result establishing the same for the parabolic dynamical Φ^4_3-model (by Hairer '14 and by Hairer-Matetski '17).
>
> To prove this result, we need to overcome two known challenges, which are more pronounced in the context of dispersive and wave equations: 1) the measure lives in a

space of very rough regularity, namely s = -1/2- and 2) the Gibbs measure is singular with respect to the Gaussian free field. In particular, samples of the Gibbs measure have probabilistically dependent Fourier coefficients.

To address the singularity issue, we need to find a suitable representation of the statistical ensemble of the Gibbs measure. This is achieved by relying on the associated cubic stochastic heat equation and studying the interplay between the parabolic and hyperbolic theories.

To establish the necessary local theory, we first find a suitable para-controlled Ansatz that allows us to correctly exploit the randomness of the solutions to the NLW. In closing the estimates we rely on the following four ingredients: the analytical framework of the random tensor theory, the combinatorial molecule estimates, a hidden cancellation between sextic stochastic objects and a new bilinear random tensor estimate.

Work of program participant Javier Gomez-Serrano was profiled in Quanta Magazine in the article "Deep Learning Poised to 'Blow Up' Famed Fluid Equations". The underlying research was posted as *Asymptotic self-similar blow up profile for 3-D Euler via physics-informed neural networks* by Yongji Wang, Ching-Yao Lai, Javier Gómez-Serrano, Tristan Buckmaster, arXiv:2201.06780.

Spring 2022 Semester Program

Two people affiliated with the Spring 2022 program received Mathematical and Physical Sciences Ascending Postdoctoral Research Fellowship (MPS-Ascend) program awards during the program. Jonathan Johnson was an ICERM Spring 2022 Semester Postdoctoral Fellow. Biji Wong was a visiting postdoc from the Max Planck Institute for Mathematics.

Work of semester workshop three (Braids in Low-Dimensional Topology) participants, Maggie Miller, Kyle Hayden, and Isaac Sundberg, was profiled in Quanta Magazine in the article "Surfaces So Different Even a Fourth Dimension Can't Make Them the Same". This research has been posted as *Seifert surfaces in the 4-ball* by Kyle Hayden, Seungwon Kim, Maggie Miller, JungHwan Park, Isaac Sundberg arXiv:2205.15283.

In April, we had a special series of presentations on applications of machine learning to problems in knot theory and classification. This included talks by András Juhász (Oxford) and Alex Davies (DeepMind), two authors of the recent breakthrough Nature paper "Advancing mathematics by guiding human intuition with AI".

Workshops

The June workshop "Computational Aspects of Discrete Subgroups of Lie Groups" featured lectures by Moon Duchin, Simion Filip, Curt McMullen, and Anna Weinhard. There were also tutorials on computing hyperbolic structures (Dunfield), finitely-presented groups (Rees), algebraic groups (de Graaf), sentences in random groups (Kharlampovich), and subgroups of Lie

groups (Kapovich). One nice feature of virtual programs is that tutorial leaders can walk the audience through installing a piece of software in real time.

The topical workshop “Applications of Rough Paths: Computational Signatures and Data Science” ran virtually in July. It is grounded in the work of K.S. Chen from the 1950's using iterated integrals to analyze paths and filtrations of the fundamental group. Lyons, one of the organizers, applied this framework to stochastic analysis; Hairer used related structures in his Fields-medal winning work. Recently, these ideas have found applications to a vast array of data science questions. Our workshop offered hands-on tutorials introducing participants to software and notebooks supporting these applications.

We experimented with a new format with “Research Community in Algebraic Combinatorics”. It was developed in response to concerns that the pandemic is stifling productivity in early career researchers. It was a two-step program. The first part, held August 5-6, kicked off 11 collaborative research projects involving small groups of researchers selected by organizers and group leaders from applicants. The second part, a hybrid meeting in February, gave the groups the chance to present what they've accomplished over the intervening six months.

Another two-step workshop was “Prediction and Variability of Air-Sea Interactions: the South Asian Monsoon” held in collaboration with several international research projects modeling monsoons. One of the organizers (Baylor Fox-Kemper) is a lead author on a chapter on sea-level rise in the recently-released report of the Intergovernmental Panel on Climate Change; Rhode Island has long boasted a very active research community on ocean science. We saw this as a great opportunity to involve more members of the mathematical sciences community in this important work. This group reconvened in person in May 2022.

ICERM also virtually hosted Spectra LGBTQ+ in Mathematics Conference, the first meeting of the Spectra Association, celebrating research achievements and promoting discussions of how to create better working environments. The program included extended plenary talks, short presentations, and several panel discussions of issues facing the community.

Another virtual workshop late in the summer, partly funded by the Simons Foundation, was “Advances in Theory and Algorithms for Deep Reinforcement Learning”. Speakers included prominent experts in mathematics (Caroline Uhler, Andrea Montanari) and computer science, and focused on questions in non-convex optimization, convergence of gradient algorithms, and stochastic approximation.

Despite the Omicron surge, ICERM continued to hold its workshops and semester programs as scheduled, but was flexible about remote participation. “Holistic Design of Time-Dependent PDE Discretizations”, held January 10-14, had 18 virtual and two in-person speakers. There were a significant number of people listening to presentations on site, with lots of interaction between talks. However, since most organizers could not travel they arranged a robust online program of mentoring and networking opportunities.

Non-program Specific

Just in time for Mathematics and Statistics Awareness Month, ICERM and the American Mathematical Society unveiled a joint advertisement in Rhode Island's airport touting mathematics in Rhode Island.

Stefan Czimek, a 2020-2021 Institute Postdoc who was extended for the 2021-2022 academic year due to the pandemic, recently accepted a position for a tenured professorship at the University of Leipzig. He has credited the NSF's and ICERM's support during this uncertain period with making this possible. Additionally, Dr. Czimek was slated to receive support from the NSF Division of Mathematical Sciences Analysis program but his position in Europe did not allow him to receive this award.

Report on ICERM operations

Impact of the Pandemic on 2021-2022 Programming

Due to the COVID-19 pandemic, most programming in the previous reporting cycle was converted to a virtual platform. In this cycle, we resumed our normal in-person activities with protocols - vaccination attestations, mask requirements, and ready access to testing - to ensure everyone's safety. The Summer@ICERM undergraduate research program hosted students in 2021, although one program leader was forced to work remotely due to visa restrictions. ICERM workshops began accepting in-person participants in September 2021. However, we continued to allow speakers and participants complete flexibility to choose whether to travel through May 2022. In January 2022, during the height of the Omicron surge, 80-90% of speakers chose to deliver presentations via Zoom. By April, a similar proportion delivers their talks in person.

Since moving programs and workshops to a virtual format, ICERM has made some changes to its application, selection, and offer processes. For applications, a checkbox indicating "I wish to attend this program virtually" has been added to all applications. This option removes some of the previously required uploads such as statements of support for graduate students, making virtual participation more accessible. As in past years, ICERM continues to rely on the input of program and workshop organizers for participant selection. ICERM also streamlined its invitations, removing travel funding offers and highlighting code of conduct and export control guidelines.

Outside of these processes, ICERM also made great strides in creating opportunities for virtual collaborations and mentoring. The institute has worked with organizers to ensure that time is scheduled so that participants can juggle various time zones and the myriad of competing priorities that come with participating from home.

It is important to note that the institute's applicant pool increased significantly since there were fewer barriers to participating with the availability of virtual programming. Where ICERM

previously accepted 70-80 applicants per program, it accepted up to 300+ virtual applications. Many participants were selective in the talks they attended, so attendance was quite variable.

ICERM took advantage of a planned system upgrade to incorporate Zoom capability into the lecture hall. Since Fall of 2021 workshops have been hosted in a hybrid format, with speakers and participants attending in person or over Zoom, as circumstances permit.

Program Management Team

May 2021 through May 2022 was a challenge for ICERM's program staff, as the institute moved from fully-virtual to fully-in-person with wildly varying hybrid experiences in between. These experiences tested our agility in responding to not only university, state, and federal regulations, but also to the needs of our organizers, speakers, postdocs, and participants.

Through fall 2021, all of ICERM's workshops were delivered in a virtual format The one exception to this was from June 14 - August 6, 2021, our "Summer@ICERM: Computational Polygonal Billiards" undergraduate research program was entirely in person. This program had the run of ICERM's facilities with students getting a peek into what it might be like to have a private office for mathematical research.

All ICERM staff returned to the office in September 2021 after working remotely since March 2020.

The start of our fall 2021 semester program brought with it more hope of coming together for research amidst continued struggles with travel not only for international researchers who were unable to obtain visas or were under a travel ban but also for domestic researchers whose organizations were not allowing research travel yet. Despite this, "Hamiltonian Methods in Dispersive Wave Evolution Equations" ran a successful hybrid program from September 8 - December 10, 2021. This was extremely challenging for staff and participants. Scheduling with international time constraints, juggling last-minute cancellations, and communicating covid policy on a regular basis taught everyone some important crisis management skills. The organizers of this program were very engaged and committed to working with ICERM to reach the scientific goals of the program.

In January 2022, after moving forward with in-person planning for our programs starting in January and February, ICERM was reminded of the need for continued flexibility as variants of Covid surged. Again, our processes were tested as large numbers of participants canceled travel. ICERM did support on-site visits for those able to travel - for which many were grateful.

Our spring 2022 semester program "Braids" had some late arrivals due to travel restrictions. ICERM staff supported them through changes to visas, housing, and travel arrangements, and most were able to arrive by the second week. By the end of this program, we were almost 100% in person, and while we continued to juggle changing policies and guidelines, we were able to provide a "normal" ICERM research experience to those that were able to visit. We regularly heard how exciting it was to work together in the same physical environment again from more

senior researchers. Our graduate students and postdocs were especially appreciative of the experience.

Information Technology

AV and Video Conferencing

In the summer of 2021 ICERM took advantage of a planned system update to incorporate Zoom capability into the lecture hall. Since Fall of 2021 workshops have been hosted in a hybrid format, with speakers and participants attending in person or over Zoom, as circumstances permit.

A follow up project is underway to add similar capabilities to the 10th floor seminar room, and is scheduled to be completed late summer of 2022. Additionally, ICERM's IT staff assembled a portable Zoom capable presentation system for use in areas without integrated AV resources. These enhancements allow ICERM to maximize use of the physical space we have.

Endpoint Computing

Historically ICERM has provided thin client systems to access virtual desktops on all desks in participant offices. These devices have a five year life cycle and are currently due for replacement. Actual usage has been low (below 5%) as researchers increasingly arrive with their own computing devices and prefer to work in an environment with which they are familiar. Going forward, rather than provide a desktop system for every seat, ICERM will maintain a small pool of laptops that will be made available to participants upon request. ICERM will continue to provide high resolution displays for the offices, and standard peripherals such as keyboards and mice will be readily available. This strategy optimizes resource allocation by reducing hardware expenditures and maintenance overhead.

Compute and Software Resources

ICERM continues to leverage Brown's resources for software licensing and delivery and for high performance computing. ICERM also provides access to commonly used Software as a Service (SaaS) offerings such as Overleaf and CoCalc. ICERM is augmenting our technology portfolio by supporting commercially available cloud compute resources. These systems will provide the institute with a high level of flexibility and allow us to better support a broader range of programs and participants.

Web Services and Application Development

ICERM developed a system to collect and display program related publications on the institute's website. This system can also be used to efficiently report these outcomes to the NSF and other funding agencies.

In the summer of 2021 ICERM rolled out a fully redesigned mathinstitutes.org website. The new site completely integrates the informational content driven portions of the site with the joint media database. The new site structure provides the institutes with an easy to use interface to manage their updates as well as API access for automating data transfer.

ICERM continues to iteratively develop Cube, our institute management application, in an effort to minimize administrative overhead for staff, improve the user experience for participants, and enhance reporting capabilities.

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 fall 2021 annual meeting and a subsequent conference call in June resulted in the selection of semester programs and topical workshops through Spring 2024.

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

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 revised proposals is a week prior to the annual November SAB meeting. Once a proposal is accepted, a member of the ICERM Directorate 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. 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. ICERM research fellow invitations 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 for 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 one 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
- Early Career 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

2021-2022 Semester Programs

Hamiltonian Methods in Dispersive and Wave Evolution Equations

September 8 – December 10, 2021

Organizing Committee:
Diego Cordoba, ICMAT
Erwan Faou, INRIA Rennes
Patrick Gerard, Paris-Sud University, Orsay
Pierre Germain, NYU - Courant Institute
Alexandru Ionescu, Princeton University
Alex Kiselev, Duke University
Andrea Nahmod, University of Massachusetts Amherst
Kenji Nakanishi, Research Institute for Mathematical Sciences, Kyoto University
Benoit Pausader, Brown University
Themistoklis Sapsis, MIT
Gigliola Staffilani, Massachusetts Institute of Technology

Program Description:
Dispersive equations are ubiquitous in nature. They govern the motion of waves in plasmas, ferromagnets, and elastic bodies, the propagation of light in optical fibers and of water in canals. They are relevant from the ocean scale down to atom condensates. There has been much recent progress in different directions, in particular in the exploration of the phase space of solutions of semilinear equations, advances towards a soliton resolution conjecture, the study of asymptotic stability of physical systems, the theoretical and numerical study of weak turbulence and transfer of energy in systems out of equilibrium, the introduction of tools from probability and the recent incorporation of computer assisted proofs. This semester aims to bring together these new developments and to explore their possible interconnection.

Dispersive phenomena appear in physical situations, where some energy is conserved, and are naturally related to Hamiltonian systems. This semester proposes to explore this link further by bringing together experimentalists, scientists, computational scientists and mathematicians with a common interest in exploring the various aspects of dispersive equations, from their analysis to their applications, and developing tools to facilitate experimentation. One key focus will be on

global approaches, either in the sense of analyzing the overall landscape of the phase space, or in the study of generic solutions (e.g. of properties "almost surely true" in an appropriate sense). Another key focus will be experimental, in the sense of developing and analyzing instructive toy-models, implementing numerical experiments, and in some cases, simply of looking at interesting special cases.

The main events will be centered around three workshops

- one workshop on numerics, modeling and experiments in wave phenomena
- one workshop on generic behavior of dispersive solutions and wave turbulence
- one workshop on Hamiltonian methods and asymptotic dynamics

One of the main objectives of this semester will be to integrate researchers from different horizons, and therefore special attention will be devoted to foster interdisciplinary interactions. There will be an additional introductory workshop at the beginning of the semester, and various events held in preparation of each workshop as well as in-depth follow-up discussions.

The list of all long-term visitors to the fall 2021 Semester program as well as the participant list for the affiliated workshops can be found in Appendix A.

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.":

- *This was the biggest congress I have ever attended. On the one hand, it was a congress dedicated to the specific area in which I work (which is not that easy to find), but also the number of well-known experts and leaders in each of the topics discussed was incredible. Personally, I consider that one of the best parts of the semester was the weeks without workshops since in these weeks there was a lot of time to meet other professors, PhD students and postdocs. Thanks to this, I shared many ideas and learned a lot by talking with other people. Of course, these weeks without being accompanied by the workshops would be nothing, so the combination of both types of weeks during the semester is what makes them incredible. Also, during the semester we were allowed to give small talks to show our work (and to learn about others' work). I also think that the long coffee breaks helped to meet and discuss with many people, together with all the very interesting talks. It was definitely an extremely rewarding semester within my PhD.*
- *I learnt a lot from discussions with various participants. I had some really nice interaction with Debbie Eeltink about some experiment she ran last year and there may be something to pursue there. I learnt a lot from E. Dormy and C. Lacave, but admittedly, this is from an ongoing collaboration that we have and that existed prior to ICERM (although being able to meet allowed to accelerate it to some extent). For the theoretical developments, I learnt more by exposure to the young postdocs and their works and interest (I had some interesting discussions with Matt Rosenzweig (his extensive knowledge of the many-body problem really clarified some aspect about the relevance of various mean-field equations) and Louise Gassot (use and applications of complete integrability, especially as illustrated by her nice work on weak dispersion less limit for*

BO)). I also enjoyed the introduction to so many new directions, and being updated on some of the more dramatic developments in the field, especially those brought about by Yu Deng and his collaborators.

- *We discovered that an important part of the recent research I have been doing with V. Banica fitted perfectly well with some of the approaches proposed along the program in Wave Turbulence. A collaboration of the two of us with D. Eceizabarrena and A. Nahmod has been started and look very promising.*
- *I am especially interested in work on magnetized Vlasov systems with applications to tokamaks. I learned a lot on wave turbulence theory and numerics. I got up to date on stability theory and computation for dispersive equations.*
- *Although I was only able to attend online, the ICERM conference featured many talks by major experts in a several field of interest for my current and future research. The workshop stimulated the exchange of several important ideas, gave me the opportunity to discuss recent developments with other colleagues, and sparked ideas for new collaborations.*

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

- *As a woman, it was very nice to meet and discuss with many women researchers, especially because this is not the case in some other work places that I have been too. I learned a lot both during and between the workshops thanks to the lot of extra lectures and the time for discussion. The professional development sessions for graduate students and postdocs were very useful and instructive, thank you !*
- *First of all, I will mention the efforts the organizers and senior members of the program have made to establish since the very beginning a positive and collaborative environment. I appreciated very much that a series of lectures were organized at the beginning of the program. These allowed me to learn about new problems on which I worked on throughout the semester. I also enjoyed that the main math seminars took place only 1 day per week, giving me enough time during the rest of the week to effectively work on my research.*
- *The program has been exceptionally well-organized, both in terms of scientific content and basic administration. To finally get the chance to interact with scientific peers again over a prolonged period has given me a real boost in confidence, excitement and optimism about the field of research and its future.*
- *It was essential to meet junior participants and see their energy to do research. It was also interesting to catch up on new developments in the field especially because interactions were very limited during the pandemic.*

Workshop 1: Numerics, Modeling, and Experiments in Wave Phenomena

September 20 - 24, 2021

Organizing Committee:
Diego Cordoba, ICMAT
Emmanuel Dormy, ENS
Erwan Faou, INRIA Rennes

Themistoklis Sapsis, MIT
Luis Vega, Basque Center for Applied Mathematics (BCAM)

Program Description:
The workshop will be devoted to the analysis of wave phenomena from different perspectives: mathematical modeling and analysis, experimental physics, and numerical analysis. One of the goals of this event is to gather scientists coming from a priori distant communities but sharing a common interest in wave propagation phenomena in a broad sense (fluid mechanics, quantum mechanics, plasma physics, rigorous analysis). We plan to focus on various themes representing topical problems in these fields, from experimental reproduction of physical phenomena, numerical issues, to the most recent rigorous mathematical results.

In experimental physics, several topics will be addressed, from rogues waves and wave breaking phenomena, vortex filaments, to wave turbulence in fluids or in acoustics. The analysis of observational and experimental data, combined with PDE physical models also yields the question of data assimilation and machine learning technics in the context of wave propagation. The workshop will address some of these questions in particular in oceanography, turbulence modeling and stochastic forcing, and statistical analysis of waves.

The notion of formation of singularities will also be an important topic of this workshop, from the theoretical point of view (blow-up phenomena, filament reconnexion) and by using computer-assisted proof techniques or high-performance numerical simulation.

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 a very interesting conversation with D. Eeltink about uses of experimental data she mentioned she had generated and we started an interesting discussion. It is too early to know where it will go, but it was very interesting. The talk of G. Karniadakis was very interesting in gaining some perspective and insight into applications of big data to PDEs. It was also very inspirational to see how fundamental equations are used routinely as test cases by experimental engineers and physicists.*
- *ICERM facilitates communication with researchers from other fields. This communication enriched my understanding and equipped me with new insight into my field, demonstrating the potential application of my theoretical tools. This also provides new insights concerning possible research projects which could be useful in other computational fields.*
- *I was not aware of the recent research on the Vortex Patch problem. After the workshop, I am willing to talk to the people participating in the program that are experts on the field.*
- *I learned about several projects that were related to my current research interests and will help with either literature review or future directions.*

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

- *The lightning talks were splendid: a good opportunity for young researcher and an excellent occasion for senior participants to have a global view of the activities of the*

other teams in the world. I also greatly appreciated the mix between theoretical results, numerical and expérimental result. It is a kind of unique event with such a gathering.

- *It brought the intersection of theory, experiments and computation of wave phenomena to great light. This is very important to better understand each part.*
- *Finally meeting people in person again and having low-threshold discussions. Questions that are too basic or specific to ask right after the talk online - I would never ask in a 'chat' online - but I was able to ask in person now.*
- *I really enjoyed the talk by Yao Yao on small scale formation in the IPM equations. As a result, I plan to read the associated paper in detail and explore related collaborations in the future (one of her collaborators is at my current institution)*

Workshop 2: Generic Behavior of Dispersive Solutions and Wave Turbulence

October 18 - 22, 2021

Organizing Committee:
Patrick Gerard, Paris-Sud University, Orsay
Pierre Germain, NYU - Courant Institute
Alex Kiselev, Duke University

Program Description:
The large-time behavior of (generic) solutions of nonlinear dispersive equations set on bounded domains is almost completely open as far as rigorous analysis goes, and fairly mysterious, even from a less rigorous viewpoint. Under the assumption of weak nonlinearity, physicists and applied mathematicians have devised a theory to approach this question, known as weak turbulence, a branch of statistical physics. Weak turbulence theory predicts that the equation will enter a chaotic regime, where the exchange of energy in phase space is governed by the so-called kinetic wave equation. Justifying the derivation of the kinetic wave equation is a fascinating mathematical task, for which some results are already known, but whose solution will likely require input from nonlinear PDEs, but also probability theory. Intimately related questions are the question of Sobolev growth (how much can or does, the Sobolev norm of a nonlinear dispersive equation grow over time), as well as the analysis of nonlinear dispersive equations with random data. These questions have already generated a lot of interest, but much remains to be discovered: our understanding is extremely lacunar.

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 in this program about some computational work that is being done to verify some physical conjectures, as well as learned about major theoretical breakthroughs that proved other longstanding conjectures.*
- *During my short visit to ICERM, I had the chance to attend enlightening talks in various areas of my field and interact with top tier researchers from around the world. I made connections that might initiate collaborations towards new research directions.*

- *The speakers were very well chosen, having representation researchers at different stages of their careers. It provided different perspectives on the problems.*
- *First it has been very useful for showing my recent research to some of the PI's of the Simons program in turbulence. I got the impression that they were not aware of the multiple connections of that research and the several of the main questions of the program. Secondly the interaction with young researches have been very gratifying.*
- *It strengthened my theoretical knowledge and gave a great overview over interesting topics.*
- *It was great to be exposed to the newest developments in the derivation and study of weak turbulence. It was great to see some related open questions.*

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

- *To get up to date with the current state of the art on issues related to the derivation of the kinetic wave equation*
- *Great opportunity to see current developments in this very active field. This workshop was very much needed as researchers are exploring simultaneously many directions right now.*
- *It has become super clear how important it is to attend workshops in person. Conversations in between talks are invaluable.*
- *The speakers were very well chosen. They were at different stages in their careers, providing different perspectives.*
- *The great talks and also getting to exchange ideas freely with other participants.*

Workshop 3: Hamiltonian Methods and Asymptotic Dynamics

December 6 - 10, 2021

Organizing Committee:
Alexandru Ionescu, Princeton University
Yvan Martel, École Polytechnique
Kenji Nakanishi, Research Institute for Mathematical Sciences, Kyoto University
Monica Visan, University of California, Los Angeles

Program Description:
Recent progress in the analysis of dispersive PDE's has revealed various aspects of long-time dynamics or behavior of solutions, from the basic three types (scattering, blow-up, and solitons) to more complicated combinations, transitions, and oscillations among them, and so on. The goal of this workshop is for the participants to draw integrated landscapes of those diverse phenomena, aiming towards a more complete description, classification, and prediction of global dynamics, as well as new phenomena and methods.

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 program had a mixed of theoretical and computational component and it was great to see the interactions.*
- *I have learn from discussions with participants about relations between solutions to equations and functional inequalities which I would like to investigate in the future*
- *The various talks on the dynamics of Klein-Gordon equations with a potential were very interesting and follow-up discussions with one of the speaker (F. Pusateri) may lead to a common project.*

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

- *The quality of the talks was extremely high and the knowledge gain was way over average. The schedule well-balanced and the relatively small size and the breaks enabled to make contact with many of the participants. Overall a great and important experience.*
- *The diverse mixture of lectures on the topic of long term dynamics expanded my knowledge of the current research questions in the area. The discussions at the coffee breaks were very helpful in this regard also.*
- *Conversations with experts regarding the possibility to expand the study of dispersive equations to less standard underlying domains*
- *Bring together leading experts as well as junior researchers and postdoctoral researchers discussing some of the very important and impactful topics in the field. Such progressional multi-scale workshops or conference are welcome in the community of a very broad range of participants. Especially it is encouraged to continue to invite more junior researchers, new PhD or postdoctoral mathematicians by providing more opportunities and venues for them and their career cultivation and development.*

Spring 2022 Semester Program: Braids

February 1 - May 6, 2022

Organizing Committee:
Marc Culler, University of Illinois at Chicago
Ben Elias, University of Oregon
John Etnyre, Georgia Institute of Technology
Benson Farb, University of Chicago
Juan González-Meneses, Universidad de Sevilla
Matthew Hedden, Michigan State University
Keiko Kawamuro, University of Iowa
Anthony Licata, Australian National University
Joan Licata, Australian National University

Program Description:
Braid groups were introduced by Emil Artin almost a century ago. Since then, braid groups, mapping class groups, and their generalizations have come to occupy a significant place in parts of both pure and applied mathematics. In the last 15 years, fields with an interest in braids have independently undergone rapid development; these fields include representation theory, low-dimensional topology, complex and symplectic geometry, and geometric group theory. Braid

and mapping class groups are prominent players in current mathematics not only because these groups are rich objects of study in their own right, but also because they provide organizing structures for a variety of different areas. For example, in modern representation theory, important equivalences of categories are organized into 2-representations of braid groups, and these same 2-representations appear prominently in parts of geometry and mathematical physics concerned with mirror dualities; in low-dimensional topology, manifolds are presented and related to each other via braids and mapping classes.

Computational applications and questions about braid groups have also emerged in disparate mathematical contexts; in some cases, these coalesce around the same computational problem. For example, developing fast machine-based calculations of link homology invariants is a goal shared by representation theorists, low-dimensional topologists, symplectic and algebraic geometers, and string theorists. The proposed semester program aims to bring together researchers working in diverse areas through the common thread of their interaction with braid and mapping class groups. The overarching goals of the program are to establish and clarify the key questions driving each field, and to improve each group's understanding of the tools, techniques, and perspectives of the others.

The list of all long-term visitors to the spring 2022 Semester program as well as the participant list for the affiliated workshops can be found in Appendix B.

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.":

- *The weekly computational seminar has opened up the use of software tools such as Snappy, klo, and Braiding. Discussions with other participants and visitors added greatly to my knowledge of theoretical developments.*
- *The program at ICERM really inspired me to learn some of the basics of coding. Given that there were so many people who had knowledge of this at the program, I was able to gain these skills quite quickly. Currently, I am working on a project where hopefully the code we have written will help us to prove some new results. I also learned a lot of new math while at this program. I really appreciated learning where my area of research fits into a larger mathematical context, and this new knowledge will inform exactly which directions of research I will choose to pursue.*
- *The Computational Seminar was a practical introduction to several important topological software packages. I do not have direct applications in mind for these in my own research, but I would be much more likely to recognize opportunities to use these in the future.*
- *ICERM facilitated the exchange of ideas among all participants, in particular they provided us with a space in which people were encouraged to specifically talk about computational issues in the field. This meant that many programs that I was not familiar with were introduced and I now feel less intimidated to approach and use these programs in my own research. Furthermore the machine learning mini workshop gave many of the participants an idea of how neural networks may be used in pure mathematics research.*

- *I have been thinking a lot about about group actions on triangulated categories this semester. The computational tools required to study this subject are essentially linear-algebraic in nature, although most of the basic linear algebra packages available aren't really set up to be directly useable by me and others in this area. This semester I became aware of better software that is closer to what I need in order to be able to run some of the computations that are just too large to be done correctly, with confidence, by hand. Theoretically, I have a better understanding as to how the part of representation theory I currently work in should fit as a relatively new part of geometric group theory. Getting a picture of that was one of my goals for the semester, and in some sense that is the major theoretical upside for me.*

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

- *The program as a whole was somewhat more broad than a typical, say MSRI semester; the long-term visitors were also somewhat more junior than might be the case at other semester programs. This had positives and negatives, which I would be interested to discuss at more length with ICERM. But whatever the ups and downs of the semester long aspects of the program, the conferences themselves were uniformly very successful. This is something ICERM should be proud of. The subject matters of the conference were somewhat ambitious, insomuch as most conference participants were in unfamiliar mathematical territory for at least half of whatever conference they were attending (this is perhaps a slight overstatement for the third conference, but for the first two it is definitely true.) There was a less silo-ing than I worried there would be, and there was enough genuine interaction between people from different disciplines to regard the realistic hopes of the conferences as being realized. The second conference in particular was both a breath of fresh air and a massive success, in my view.*
- *The program as a whole was somewhat more broad than a typical, say MSRI semester; the long-term visitors were also somewhat more junior than might be the case at other semester programs. This had positives and negatives, which I would be interested to discuss at more length with ICERM. But whatever the ups and downs of the semester long aspects of the program, the conferences themselves were uniformly very successful. This is something ICERM should be proud of. The subject matters of the conference were somewhat ambitious, insomuch as most conference participants were in unfamiliar mathematical territory for at least half of whatever conference they were attending (this is perhaps a slight overstatement for the third conference, but for the first two it is definitely true.) There was a less silo-ing than I worried there would be, and there was enough genuine interaction between people from different disciplines to regard the realistic hopes of the conferences as being realized. The second conference in particular was both a breath of fresh air and a massive success, in my view.*
- *I have been experiencing a lot of research isolation -- I graduated with my PhD in Spring 2020, and have been a postdoc during the most severe parts of the pandemic. The semester program at ICERM has really helped me get back on my feet, research-wise -- it's added some life and excitement back into my professional life, and has provided a very necessary jump start to my research program. While it's probably not helpful to think that this "undid" the professional damage caused by the pandemic, I think it was a very welcome antidote! (In 5 years, I'll probably be able to say "yes, this was the thing that*

helped save my research career"; but, it's a bit early to say that now!) In particular, starting up two collaborations, and meeting new people (that I probably wouldn't have met otherwise) was a huge highlight for me.

- *I would say that the ability to (re)connect with people was the highlight of the semester and its workshops. Getting to talk with people in person was extremely enjoyable and productive after two years living in the internet, and having the opportunity to make connections with graduate students and other early career mathematicians was wonderful and something that the pandemic had robbed me of. I feel better connected to my mathematical community, and also that I've made connections with folks outside of my primary research areas.*

Workshop 1: Braids in Representation Theory and Algebraic Combinatorics

February 14 - 18, 2022

Organizing Committee:
Anna Beliakova, Universität Zürich
Ben Elias, University of Oregon
Juan González-Meneses, Universidad de Sevilla
Anthony Licata, Australian National University

Program Description:
Braid groups and their generalizations play a central role in a number of places in 21st-century mathematics. In modern representation theory, braid groups have come to play an important organizing role, somewhat analogous to the role played by Weyl groups in classical representation theory. Recent advances have established strong connections between homological algebra (t-structures and stability conditions), geometric representation theory (Hilbert schemes, the Hecke category, and link homologies), and algebraic combinatorics (shuffle algebras, symmetric functions, and also Garside theory). Braid groups appear prominently in many of these connections. The goal of this workshop will be to bring experts in these different areas together to both communicate recent advances and also to formulate important questions for future work.

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 allowed me to connect with other researchers at this workshop. I learned of new computational methods that I can potentially incorporate in my research. I had fruitful discussions that allowed me to gain a new perspective and understand how different people are trying to approach similar problems.*
- *I learned a lot about current problems in geometric group theory and the study of braid group actions on triangulated categories and their associated moduli spaces of stability conditions. Both were illuminating, and seeing them in parallel raised a bunch of intesting questions that I'd consider pursuing.*

- *During this conference I met a number of graduate students and postdocs working on an interesting question (related to the boundary of the space of stability conditions, which I previously knew nothing about) which I believe I am able to contribute to. We've started thinking about the problem together. I also started a new project with an existing collaborator, based on some ideas we had during a lecture.*

Some Workshop Participant Comments for "Briefly describe workshop highlights"

- *Seeing people in person and interacting informally after and in between talks. This was a breath of fresh air.*
- *This was my first in-person conference since the beginning of the pandemic. It's been really great to attend talks in-person, but more importantly it was my first real opportunity to have extended discussions with colleagues I hadn't seen in years. This has been extremely useful to my research (and motivation).*
- *Very different perspectives of the same topic. Some talks were really good, and most of them really interesting. There was also enough time to discuss.*

Workshop 2: Braids in Symplectic and Algebraic Geometry

March 21 - 25, 2022

Organizing Committee:
Inanc Baykur, University of Massachusetts Amherst
Anand Deopurkar, Australian National University
Benson Farb, University of Chicago
Ailsa Keating, University of Cambridge
Anthony Licata, Australian National University

Program Description:
Incarnations of braid groups, or generalizations thereof, naturally arise in a range of active research areas in symplectic and algebraic geometry. This is a rich and diverse ecosystem, and the workshop will aim to bring together speakers from all corners of it. A unifying theme is monodromy: on the one hand, generalized braid groups arise in symplectic and algebraic geometry as fundamental groups of moduli spaces, loosely construed -- for instance, of complements of discriminant loci of singularities or of hyperplane arrangements, or moduli spaces of deformations of complex or symplectic structures. On the other hand, monodromy ideas motivate representations of generalized braid groups as various flavors of geometric automorphisms -- for instance, as (framed) mapping class group elements, symplectic Dehn twists, spherical twists in derived categories, or flop functors for 3-folds. These perspectives lead in turn to a wide array of further geometric applications, from classifications of Stein fillings to the study of spaces of Bridgeland stability conditions.

From a community perspective, one aim of the workshop is to bring together mathematicians from adjacent research communities with a shared interest in braids as they arise in symplectic or algebraic geometry. We hope the conference will accelerate the cross-pollination of ideas, and help foster collaborations, at what is a very exciting time for the field. Much of this research also

lies at an interface with other aspects of the thematic semester -- for instance, braids in representation theory (e.g. in connection with cluster algebras or Bridgeland stability conditions), or in low-dimensional topology (e.g. in connection with monodromies of open books) -- and many of the talks should be of interest to a broader set of semester participants.

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.":

- *By interacting with the participants of the conference I learned about new techniques in Birational Geometry and non-commutative Geometry. Also, I had a chance to interact with the community of scholars who study braid groups. They showed me various computational tools for working with braids. I am using these tools in my research now. In general, this workshop was fantastically useful for expanding my research program and for finding unexpected connections with the other fields.*
- *A very nice synthesis of different research groups who encounter the same object -- the braid group. I will be honest and say that some of the symplectic geometry talks were hard going for me, an algebraic geometer, and I'm sure the same was true on the other side, but there were a lot of junior participants and I think those are the exact people who will find it natural to acquire and master both sets of technique.*

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

- *I appreciated the range of speakers, which was broader than many conferences I have attended. I was able to speak to people closer to my field about specific questions in my own research while also gaining exposure to new topics.*
- *The workshop did a great job of balancing content-based talks with unstructured time to collaborate with fellow attendees. My favorite parts were learning new topics from talks (which I'd like to learn more about independently), and getting to know people in related research areas at different universities that I otherwise probably wouldn't have met.*
- *I really liked interaction outside of the lecture room. The open problem session provided me with an overview of the key problems of the fields that were featured during the conference. The conference had a perfect mixture of young participants with senior participants. I also learnt about the computational tools for working with braid groups and I will use these tools in my research.*
- *Definitely the problem session will stay the longest on my mind. I was amazed by the scope and depth of questions I could relate to. Everybody was able to share and had something to contribute.*

Workshop 3: Braids in Low-Dimensional Topology

April 25 - 29, 2022

Organizing Committee:
John Etnyre, Georgia Institute of Technology
Matthew Hedden, Michigan State University
Keiko Kawamuro, University of Iowa

Joan Licata, Australian National University
Vera Vertesi, University of Vienna

Program Description:
Braids are deeply entwined with low-dimensional topology. Closed braids are knots and links, while viewing braid groups as surface mapping class groups connects the topic to fundamental constructions of three- and four-manifolds. The question of how properties of braids or mapping classes reflect the associated manifolds arises in Dehn surgery, link invariants, and contact and symplectic geometry. The workshop will highlight recent advances in these and other areas of low-dimensional topology where braids and mapping classes play a significant role. The workshop will also explore related algorithms, with an eye towards their (efficient) implementation.

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.":

- *It was great to see some of the computational approaches to braid theory highlighted. I don't directly see how I'll incorporate them in my work, but I do think my awareness of the options has increased.*
- *I was very interested to learn about uses of quasimorphisms and homogenization when studying braid invariants, as well as developments in using Khovanov homology for detecting exotic surfaces.*
- *Throughout the talks at this conference, I was able to see how my own research fits into the broader mathematical community. I think this information will help me inform the directions in which I want to take my research program since some of the problems I'm interested in seem to have a larger scope than others.*

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

- *The fact that we spend much time together, made natural that interactions and new collaborations appear. For me that was the best part about the semester: having the chance to talk to new people about Maths which, eventually, lead to the starting of two joint projects.*
- *The getting together of a community of brilliant mathematicians and their welcoming nature makes this field of research a happy place to be in. ICERM has had an incredible effect on my career as a researcher in Low dimensional topology. I have met my one of my current collaborators in ICERM in 2019 and has been writing papers with him (1 arxived and submitted, 1 to be submitted soon) since then. This time around, getting to talk to people about their (mind blowing) research ideas and mine has been a highlight. I am sure that this conference will go long way in my career as a budding low dimensional topologist. This is the happiest conference that I have been in my short (~9 years) Mathematics career so far.*
- *The whole thing was amazing, it was the best time of my (academic) life.*
- *The quality of talks and the general atmosphere were outstanding. The organiser did an excellent job at selecting speakers and at orienting the workshop in several different, but*

related, directions. Personnel at ICERM have been a discrete, cheerful, and efficient presence throughout.

- *I am a faculty member at a smaller institution that doesn't carry the weight of an R1. Faculty at such institutions are often overlooked when it comes to funding and invite lists, and I was very happy to see that that was not the case at this workshop. There were several others in my category here as well.*

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).

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 2021-2022

ICERM hosted seven topical workshops from May 1, 2021 to April 30, 2022. These workshops focus on topics of current interest in the mathematical sciences.

The list of participants for each of ICERM's 2021-2022 Topical Workshops can be found in Appendix C.

Topical Workshop 1: Advances and Challenges in Hyperbolic Conservation Laws

May 17 - 21, 2021

Organizing Committee:
Alberto Bressan, The Pennsylvania State University
Gui-Qiang Chen, University of Oxford
Constantine Dafermos, Brown University
Fengyan Li, Rensselaer Polytechnic Institute
Chi-Wang Shu, Brown University
Eitan Tadmor, University of Maryland
Konstantina Trivisa, University of Maryland
Dehua Wang, University of Pittsburgh

Workshop Description:
In the field of hyperbolic conservation laws, theory, computation, and applications are deeply connected, with each one providing to the other two technical support as well as insights. Major

progress has been achieved, over the past 40 years, on the theory and computation of solutions in one space dimension. By contrast, the multi-space dimensional case is still covered by mist, which is now gradually lifting, revealing new vistas. For instance, in two space dimensions, significant progress has been achieved in the study of transonic gas flow, of central importance to aerodynamics. Parallel progress has been reported on the numerical side, with the design of high-order accurate discontinuous Galerkin and finite volume computational schemes, even for multidimensional systems. Finally, we are witnessing an explosion in the applications, not only on the traditional turf of fluid dynamics but also in new directions, in materials science, biology, traffic theory, etc.

Nevertheless, the theory and the numerics of hyperbolic conservation laws are currently facing major challenges. The recent construction of infinitely many solutions to the Cauchy problem for the Euler equations of gas dynamics and the emergence, in theory, and computation, of very weak, measure-valued, solutions raises the issue of whether the setting of nonlinear systems of conservation laws is autonomous and self-sufficient, or whether it should be enriched with new principles of mathematical and/or physical provenance. All three constituents, theory, numerics and modeling, should have an input for clarifying these issues.

This workshop brings together researchers in hyperbolic conservation laws to present the most significant theoretical and computational advances and discuss applications as well as challenges. The aim of the workshop is to explore the connections among theoretical, numerical, and applied aspects related to hyperbolic conservation laws, and stimulate discussions and collaborations among these areas. The face-to-face communication of the participants in the workshop will be a catalyst for scientific progress in theory, numerics, and applications.

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.”:

- *All speakers, including the free discussion part for young researchers, have gave a very clear, rigorous talk on the relative topics on Hyperbolic conservation laws. Prof Dafermos's book and papers also give us a basic and important understanding for this research area.*
- *ICERM is very innovative in how it helps me and my colleagues with our research agenda and I am very strong proponent of its approach to how it introduces mathematics to me and my community.*
- *Hyperbolic conservation laws is a hard topic to approach through individual study - this program was extremely helpful for getting oriented as to how the field works!*
- *I have learned about some new models with their theoretical properties, which I can potentially work on; during the discussion break, I also learned about some new computational work by another participant/organizer - the idea seems to be very promising and likely can contribute to my ongoing effects.*
- *"Advances and Challenges in Hyperbolic Conservation Laws" workshop has enlightened me about the recent development in the area of Hyperbolic Conservation Laws in particular computational aspect of it and I thank ICERM for this.*

- *I found some problems that can be used in my research. I learned new numerical methods that can be used in my research. I learned some approaches in finding the stability regions.*
- *My attention turned to theoretical contributions. Clearly, I can now manifest some intention to conduct research that aims to apply the theory to problems related to bubble dynamics in a phase transition scenario, for example. Obviously, this does not exhaust the possibilities.*

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

- *Gathering together very important people specialists in the Theory and/or practical aspects of Hyperbolic Systems of Conservation Laws, with many other interested and/or more novice people.*
- *Talks by Liu, Slemrod, Canic, Tzavaras, Dafermos, and others. The overall atmosphere of the event in this inspirig and supportuve community, with Constantine Dafermos as a leading figure.*
- *There were few out of the box ideas. The field is technically 50+ year old. Nevertheless, people are actively putting efforts and attempting to push the field a little further ... which in turns motivates others in the community to contribute and stay engaged.*
- *Principal Research Highlight: Marshal Slemrod presented a theoretical reframing of Action Potentials in terms of phase-change conservation laws, which is a dramatic change of paradigm from the classical Hodgkin-Huxley theory. To learn of such a change of paradigm, and recognise the scale of future insights/discoveries this might precipitate was a singular moment, and worthy of an event which also honoured the great contributions and achievements of Constantine Dafermos to the field of conservation laws.*
- *Some really new results on the uniqueness theory of hyperbolic conservation laws were presented. Recent work on traffic flow models were discussed, with open questions. The state of the art on non-uniqueness and admissibility conditions for multidimensional Euler flow was presented.*
- *This workshop was well administrated. Everything was smooth. The talks are great with well selected speakers. I learned a lot from this workshop about the state-of -the-art of the research in conservation laws and related applications. The workshop stimulated new connections and collaborations. In fact one of my students has been talking to one of the speakers after the talk and just started a new project to work together.*

Topical Workshop 2: Computational Aspects of Discrete Subgroups of Lie Groups

June 14 - 18, 2021

Organizing Committee:

Alla Detinko, University of Huddersfield
Michael Kapovich, UC Davis
Alex Kontorovich, Rutgers University
Peter Sarnak, Institute for Advanced Study and Princeton University
Richard Schwartz, Brown University

Workshop Description:
This workshop is at the interface of algebra, geometry, and computer science. The major theme deals with a novel domain of computational algebra: the design, implementation, and application of algorithms based on matrix representations of groups and their geometric properties. The setting of linear Lie groups is amenable to calculation and modeling transformations, thus providing a bridge between algebra and its applications.

The main goal of the proposed workshop is to synergize and synthesize the independent strands in the area of computational aspects of discrete subgroups of Lie groups. We aim to facilitate solutions of theoretical problems by means of recent advances in computational algebra and additionally stimulate development of computational algebra oriented to other mathematical disciplines and applications.

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 served as a critical foundation for me on the topic of discrete subgroups of Lie groups; while I had experience with Lie groups, I did not have a sharp view of their discrete subgroups until this workshop.*
- *I gained knowledge in state-of-the-art in several subjects complementary to my area of expertise (geometry, computational topology, number theory). I also learnt functionality of SnapPea and its application to computer experimentation.*
- *I learned a lot from (1) Marc Culler's demonstration of SnapPy (which I now have downloaed onto my laptop and (2) a number of talks by low dimensional topologists talking about the computations they have successfully implemented for their own research.*
- *This conference provided me with information on how to use SnapPy and also introduced me to many mathematicians in my area of interests. I am very grateful to ICERM for allowing me to attend.*

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

- *- Extremely high level of speakers; a number of outstanding participants. - Interdisciplinary aspects (interface of several areas of mathematics and computer science); uniqueness of the event when experts from those different areas met on one platform. - Software demonstration: several different computer algebra systems. - Intensive research discussions.*
- *This workshop is really useful and engaging. The audiences asked a lot of questions. The presentation from the speakers are also extraordinary.*
- *Meeting mathematicians outside my immediate network. Also I really liked the lightning talks, the presenters were really amazing.*
- *The opportunity for cross-disciplinary conversations in a very relaxed environment. The extremely high level of talks and profiles of participants.*
- *Enjoyed very much a number of talks, SnapPy tutorial was very useful, very good inclusive atmosphere*

Topical Workshop 3: Applications of Rough Paths: Computational Signatures and Data Science
July 6 - 9, 2021

Organizing Committee:
Thomas Cass, Imperial College London
Terry Lyons, University of Oxford
Hao Ni, University College London and Alan Turing Institute
Harald Oberhauser, University of Oxford
Mihaela van der Schaar, University of Cambridge

Workshop Description:
Rough path theory emerged as a branch of stochastic analysis to give an improved approach to dealing with the interactions of complex random systems. In that context, it continues to resolve important questions, but its broader theoretical footprint has been substantial. Most notable is its contribution to Hairer's Fields-Medal-winning work on regularity structures. At the core of rough path theory is the so-called signature transform which, while being simple to define, has rich mathematical properties bringing in aspects of analysis, geometry, and algebra. Hambly and Lyons (Annals of Math, 2010) built upon earlier work of Chen, showing how the signature represents the path uniquely up to generalized reparameterizations. This turns out to have practical implications allowing one to summarise the space of functions on unparameterized paths and data streams in a very economical way.

Over the past five years, a significant strand of applied work has been undertaken to exploit the mathematical richness of this object in diverse data science challenges from healthcare, to computer vision to gesture recognition. The log signature is becoming a powerful way to summarise the fine structure of a data stream in a neural net. The emergence of neural differential equations as an important tool in data science further deepens the connections with rough paths.

This four-day workshop will bring together key expertise across disciplines to advance understanding of some of the most pressing and exciting challenges. The week will start with structured, tutorial-style lectures on the foundational aspects of signatures their use in data science, and topics of broad appeal. These will include:

- Mathematical foundations
- Neural rough differential equations
- Signature-based kernel methods
- Expected signatures
- Applications of signatures to action recognition and healthcare

There will also be an extended interactive practical session on computing with signatures. This session will be directed by leaders with participants working in groups with others of a similar

level of previous experience. The aim of this session will be for participants to develop skills using the latest packages to implement data-focused tasks involving signatures.
The rest of the workshop will consist of technical talks and contributed talks from participants. There will be both organized discussions as well as opportunities for informal interaction.

Due to a miscommunication while transitioning roles, a follow up survey was not sent for this group.

Topical Workshop 4: Research Community in Algebraic Combinatorics

August 5 - 6, 2021 & February 10 - 11, 2022

Organizing Committee:
Susanna Fishel, Arizona State University
Pamela E. Harris, Williams College
Rosa Orellana, Dartmouth College
Stephanie van Willigenburg, University of British Columbia

Workshop Description:
The Women in Algebraic Combinatorics Research Community will bring together researchers at all stages of their careers in algebraic combinatorics, from both research and teaching-focused institutions, to work in groups of 4-6, each directed by a leading mathematician. The goals of this program are: to advance the frontiers of cutting-edge algebraic combinatorics, including through explicit computations and experimentation, and to strengthen the community of women working in algebraic combinatorics.

Successful applicants will be assigned to a group based on their research interests. The groups will work on open problems in algebraic combinatorics and closely related areas, including representation theory, special functions, and discrete geometry. Several of the proposed projects will extensively involve experimentation and computation, which will increase the likelihood that concrete progress is made over the course of the initial workshop and following 6 months, and provide useful training in computational mathematics.

In their personal statements, applicants should rank in order their top three choices of projects. They should also address their familiarity with the suggested prerequisites. Applicants are expected to attend the opening and closing workshops and meet regularly with their research group for the 6 months in between.

As this program is split into two parts, it was decided to delay the survey until after the second part.

Topical Workshop 5: D-modules, Group Actions, and Frobenius: Computing on Singularities

August 9 - 13, 2021

Organizing Committee:

Christine Berkesch, University of Minnesota
Linquan Ma, Purdue University
Claudia Miller, Syracuse University
Claudiu Raicu, University of Notre Dame
Uli Walther, Purdue University

Workshop Description:
The adoption of D-module techniques has transformed the interface between commutative algebra and algebraic geometry over the last two decades. The discovery of interactions and parallels with the Frobenius morphism has been an impetus for many new results, including new invariants attached to singularities but also D- and F-module based algorithms for computing quantities that used to be unattainable.

Our goal for this workshop is to discuss computational aspects and new challenges in singularity theory, focusing on special varieties that arise from group actions, canonical maps, or universal constructions. By bringing together geometers, algebraists, and invariant theorists, we will address problems from multiple perspectives. These will include comparisons of composition chains for D- and F-modules, the impact of group actions on singularity invariants, and the structure of differential operators on singularities in varying characteristics.

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 got a chance to learn new techniques. Moreover, the discussions with the experts in the field proved beneficial to me.*
- *Learned more about certain subtle homological properties (theoretical) and certain Macaulay2 packages as well impressive resultant theorems (experimental/computational).*
- *I learned about prime characteristic techniques that apply to rings of differential operators. There has been a lot of progress in this area in the last decade and this workshop helped me keep up with current developments!*

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

- *Talks with theoretical ideas, many examples, etc. were most helpful. Also, it's been awhile since I studied singularities and D-modules so it's been a breath of fresh air whenever I could attend these talks. But I plan to watch these lecture/conference videos later when I have time.*
- *Karen Smith's presentation on the "most extreme singularity" has already started me thinking about related projects!*
- *Hearing new ideas, seeing new examples, learning new computational techniques.*

Topical Workshop 6: Spectra LGBTQ+ in Mathematics Conference
August 18 - 20, 2021

Organizing Committee:

Rustum Choksi, McGill University
David Crombecque, University of Southern California
Alexander Hoover, The University of Akron
Brian Katz, California State University, Long Beach
Freda Li, United States Military Academy, West Point
Claire Plunkett, University of Utah
Konstantina Trivisa, University of Maryland
Alexander Wiedemann, Randolph-Macon College

Workshop Description:
Spectra, the Association for LGBTQ+ Mathematicians, was conceived in the last ten years with its first official event in 2015 -- a panel discussion at the JMM in San Antonio. Since then, Spectra has organized events at various conferences to bring together people of the LGBTQ+ community.

Spectra is organizing this conference to provide opportunities for LGBTQ+ mathematicians both to celebrate achievements and to spark conversations of challenges in our community. This will be a space for attendees to share their research across all areas of mathematics (theoretical, applied, and math education) and to interact and create support networks within and across their research communities.

Spectra is proud to organize its first official conference and create an intentional space for LGBTQ+ mathematicians. This will be an event where LGBTQ+ mathematicians at all career stages can interact and network with their peers. Further, it will facilitate discussions for creating better environments and promoting mathematics in our community.

For this conference, which will be virtual, we aim for a simple format: three days consisting of: one plenary speaker per day (one in theoretical math, one in applied math, and one in math education); contributed short talk sessions on each of the three days; several social events geared towards networking; a concluding panel discussion.

This will be the first in a series of general mathematics conferences showcasing the achievements of LGBTQ+ mathematicians.

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.”:

- *It was a perfect conference to expose young mathematicians to lots of different research that is going on across mathematics. I found a great survey of what methodologies and theoretical developments are going on in a broader scope of research*
- *I am familiar with research on teaching practices for improving inclusivity of instruction, strategies for simulating stochastic distributions of Bitcoin mining, and basics of chasing games on graphs. All of these workshops gave me a solid foundational knowledge I can expand on with further research, with the Bitcoin workshop being closely related to my*

field of specialization in math and the workshops on inclusive teaching being important for future work when I teach classes as a professor.
- *[I]n the area of supports and presence of LGBT mathematicians, the workshop contributed greatly to my knowledge about what kind of math LGBT folks are doing--and that was interesting.*
- *It seems to me that this workshop was more about building community….It accomplished that goal so well*

Some Workshop Participant Comments for "Describe the highlight of this workshop":
- *Building connections with LGBTQ+ mathematicians is priceless. Congratulations to ICERM for Giving to the LGBTQ+ mathematicians the platform to present their research. Workshops like this enhance diversity and inclusion. Excellent job!*
- *Inclusive, approachable environment. Networking was fun and people were very open to connecting with me even as an undergrad.*
- *The time spent socializing and getting to know other queer mathematicians, and the opportunity to hear their stories*
- *I gained a sense of community that I had previously not felt within mathematics. I feel validated as my whole self now.*
- *Being able to connect with other queer mathematicians and hear their stories. I feel more like I belong in mathematics after conferences like these*
- *It was wonderful to meet young people from various parts of the LGBTQ+ community and seeing them successfully integrated into the mathematical community, even at young ages. The things I lost by having no possibility of being out when I was young are irreplaceable, so it's great to see that kind of cost not being exacted in this generation.*
- *I really enjoyed the first two keynote speakers, about swimming through goo and about disrupting the white cisheteropatriarchy influences in math ed. The overall atmosphere of the conference was extremely encouraging!*

Topical Workshop 7: Prediction and Variability of Air-Sea Interactions: the South Asian Monsoon

August 23 - 27, 2021

Organizing Committee:
Baylor Fox-Kemper, Brown University
Jennifer MacKinnon, UCSD - Scripps Institution of Oceanography
Hyodae Seo, Woods Hole Oceanographic Institution
Emily Shroyer, Oregon State University
Aneesh Subramanian, University of Colorado Boulder
Amit Tandon, UMass Dartmouth

Workshop Description:
A challenge for mathematical modeling, from toy dynamical system models to full weather and climate models, is applying data assimilation and dynamical systems techniques to models that exhibit chaos and stochastic variability in the presence of coupled slow and fast modes of variability. Recent collaborations between universities and government agencies in India and the

United States have resulted in detailed observations of oceanic and atmospheric processes in the Bay of Bengal, the Arabian Sea, and the Indian Ocean, collectively observing many coupled modes of variability. One key target identified by these groups was the improvement of forecasts of variability of the summer monsoon, which significantly affects agriculture and water management practices throughout South Asia. The Monsoon Intraseasonal Oscillation is a northward propagating mode of precipitation variability and is one of the most conspicuous examples of coupled atmosphere-ocean processes during the summer monsoon. Simulating coupled atmosphere-ocean processes present mathematical challenges spanning numerical methods, data assimilation, stochastic modeling, dynamical systems and chaos, and uncertainty quantification. Predicting monsoon variability is one of the hardest, most important forecasting problems on earth due to its impact on billions of people, a key aspect of the desire to push weather forecasts into the management-actionable "medium-range" horizon of weeks to seasons. Addressing this challenge requires an interdisciplinary effort to combine observations, computation, and theory. A better understanding of these processes and how they can be represented in a variety of coupled ocean-atmosphere simulations and models (including statistical and dynamical approaches) and forecast systems (including data assimilation techniques and uncertainty quantification) is the primary topic of this workshop. While the set of observations to be discussed will emphasize this region, the mathematical and computational aspects of the program will be significantly broader, covering: coupled ocean-atmosphere modeling for weather models, climate models and idealized models; theory of the atmospheric and oceanic boundary layers, and waves on the interface; data assimilation in coupled modeling systems; and numerical methods for coupled systems.

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 am new in research ground. The all ideas I have heard enhanced my knowledge of people that they are working on the same topic on how many diverse directions. I am from mathematics background but now working in physical oceanography. So the discussions will be very helpful for my research plan.*

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

- *Recent research advancements of air sea interaction in northern Indian ocean. Recent technologies in the ocean measurements. Also what direction the future research should focus on.*
- *Awesome talks with a great opportunities to make collaborations*
- *The lectures were cross-disciplinary and the breadth of the lectures impressed me.*
- *Some of the talks were highly illuminating as to the thought processes of the presenters. Some presenters from outside of the MISO-BoB group shed light on the wider scope of issues surrounding the Indian Monsoon and prediction modeling in general. I was happy to find a few new references to consult in those talks.*
- *It was an exciting and knowledgeable experience. I have been exposed to a lot of new research ideas and techniques which would be helpful for my future research plans and possible collaboration*

Topical Workshop 8: Holistic Design of Time-Dependent PDE Discretizations
January 10 - 14, 2022

Organizing Committee:
David Ketcheson, King Abdullah University of Science & Technology
David Keyes, King Abdullah University of Science and Technology
Michael Minion, Lawrence Berkeley National Laboratory
Jingmei Qiu, University of Delaware
Benjamin Seibold, Temple University
Carol Woodward, Lawrence Livermore National Laboratory

Workshop Description:
The workshop aims to spur a holistic approach to the design of time-dependent PDE discretizations, particularly in terms of developing time integration techniques that are intertwined with spatial discretization techniques, focusing on: generalized ImEx methods, asymptotic-preserving and structure-preserving methods, methods that exploit low-rank dynamics, analysis of order reduction, parallel in time methods, and performant, maintainable, extensible software implementations.

Recent decades have seen increasing use of first-principles-based simulations via time-dependent partial differential equations (PDE), with applications in astrophysics, climate science, weather prediction, marine science, geosciences, life science research, defense, and more. Growing computational capabilities have augmented the importance of sophisticated high-order and adaptive methods over "naive'" low-order methods. However, there are fundamental challenges to achieving truly high order and full efficiency in space-time that are yet to be overcome.

Many advances in temporal and spatial discretization methods have been made independently, by employing techniques in which each part can be developed and analyzed in isolation. However, as spatial discretization methods have become more sophisticated, accurate, efficient, and specialized, computational scientists are finding that temporal integration, in particular, the interface between temporal and spatial discretization, is a source of bottlenecks that limit practical applications. As a response, myriad problem-specific time-stepping approaches have been devised in recent years, but with little feedback to or from the time integration community. This isolated development has led to a "bag of tricks" situation that will benefit from a more systematic perspective. The workshop will address these challenges by bringing together time integration specialists with numerical PDE specialists and experts in high-performance numerical computing.

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 quality of the speakers and the panel discussions provided many new ideas for future research directions and opportunities for collaboration within the time integration*

community. I was exposed to new approaches and application needs that guide my current and future work in the field.

- *The community of people who solve differential equations computationally is split into two: The people who know about spatial discretization methods (finite element/volume/difference methods) and those who know about temporal discretization methods (the ODE solver community). Few are experts in both, and as a consequence the numerical solution of time-dependent partial differential equations -- that is, many many equations of great practical interest -- is often approached in a rather hap-hazard way from either one or the other direction. This workshop was designed to bring these two communities together, and I think it did this very well. It has certainly given me a perspective of the time-discretization approaches that can be used, and I hope that the ODE-solver community has also gotten a broader appreciation for the challenges imposed on spatial discretization.*
- *I found a lot of presentations really close to my research area, and I started a lot of discussions with several speakers to connect my research with some interesting collaboration*
- *I really got to know new ideas that I haven't known that they are exist! Thank you for accepting my request to attend this workshop.*

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

- *This was, by far, the best workshop (or conference) I have attended. It was well organized and expertly run. All of the speakers were fantastic and the panel discussions were excellent. I can safely saw the new ideas and connections made at this workshop will significantly influence the direction of my research going forward. I hope this workshop could become are regular occurrence.*
- *This was a fantastic workshop for me. I was able to get a direct sense of what is cutting edge in time-marching methods as well as exposition to production level codes and infrastructure at leading labs. Moreover, I made a number of connections that will be important in future research endeavors.*
- *The excellent organization and the variety of activities scheduled (talks, panel, lighting talks,..). The active participation of attendees. The level of the talks. The diversity of talks topics. Evethough the workshop has been online, thanks to gather-town and slack, it has been possible to exchange ideas and contact with other attendees.*
- *The two talks that made me think "huh, I really learned something here!" are: * @Sigal Gottlieb's talk on how one can dramatically improve accuracy with very minimal changes to existing codes. I really liked the starting point of these ideas: People have codes that are difficult to change, what can one do to improve things -- such a practical, pragmatic approach. * @Benjamin Seibold's description of precisely what causes order reduction and that one can (of course one can!) add conditions to the construction of RK methods that avoid this. I am perpetually surprised how many things one can ask from RK methods if one just allows for sufficiently many stages.*

Collaborate@ICERM (C@I)

ICERM hosted eight Collaborate@ICERM programs from May 2021 to May 2022.

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.

3. Evaluation

We recently revised our evaluation process, which will apply to all groups meeting since the pandemic. Now ICERM surveys group members one year after their meeting, asking about publications, research products, grant proposals, and other outcomes resonating with ICERM's computational missions.

Collaborate@ICERM Participants and Projects

C@I 1: Mathematical Models of Pedestrian Movement in Large Lecture Halls (June 21 - 25, 2021)

- Mariya Bessonov, CUNY NYC College of Technology
- Korana Burke, UC Davis
- Simone Cassani, University at Buffalo, SUNY
- Veronica Ciocanel, Duke University
- Daniel Cooney, University of Pennsylvania
- Alexandria Volkening, Northwestern University

C@I 2: Numerical Methods for Fokker-Planck Equation and Its Inverse (June 28 - July 2, 2021)

- Weitao Chen, University of California, Irvine
- Yat Tin Chow, UCLA
- Huijing Du, University of Nebraska-Lincoln
- Yuan Liu, Wichita State University

C@I 3: Matroids over Partial Hyperstructures (July 19 - 23, 2021)

- Laura Anderson, Binghamton University
- Matthew Baker, Georgia Institute of Technology
- Nathan Bowler, Universität Hamburg
- Justin Chen, Georgia Institute of Technology
- Christopher Eppolito, Binghamton University
- Oliver Lorscheid, IMPA
- Rudi Pendavingh, Eindhoven University of Technology
- Ting Su, Binghamton University
- Tianyi Zhang, Georgia Institute of Technology

C@I 4: Linearly and Nonlinearly Stable Space-Time Discretizations with Application to h/p/r-adaptation (August 2 - 6, 2021)

- Mark Carpenter, NASA Langley Research Center
- Lisandro Dalcin, King Abdullah University of Science and Technology
- David Del Rey Fernádez, National Institute of Aerospace contracted to NASA
- Ayaboe Edoh, ERC, Inc. (AFRL Edwards)
- Matteo Parsani, King Abdullah University of Science and Technology

C@I 5: Codes and Designs: Optimal Discrete Measures (August 9 - 13, 2021)

- Dmitriy Bilyk, University of Minnesota

- Damir Ferizovic, Graz University of Technology
- Alexey Glazyrin, University of Texas Rio Grande Valley
- Ryan Matzke, TU Graz
- Josiah Park, Georgia Tech
- Oleksandr Vlasiuk, Vanderbilt University

C@I 6: Tropical degree two del Pezzo surfaces and their 56 lines (August 16 - 20, 2021)

- María Angélica Cueto, Ohio State University
- Amanda Knecht, Villanova University
- Kalina Mincheva, Tulane University
- Aleksandra Sobieska, Texas A&M University
- Claudia Yun, Brown University

C@I 7: Topics in Tame Galois Theory (January 10 – 14, 2022)

- Farshid Hajir, University of Massachusetts Amherst
- Christian Maire, University of Franche-Comté, FEMTO-ST Institute
- Ravi Ramakrishna, Cornell University

C@I 8: Numerical Algebraic Geometry and Tropical Geometry (January 18 - 21, 2022)

- Tianran Chen, Auburn University at Montgomery
- Paul Helminck, Swansea University
- Anders Jensen, Aarhus Universitet
- Anton Leykin, Georgia Tech
- Yue Ren, Swansea University
- Sascha Timme, Technische Universität Berlin
- Josephine Yu, Georgia Institute of Technology

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.

MAA - SIAM & TRIPODS Advanced Workshop in Data Science for Mathematical Sciences Faculty
June 28 - July 2, 2021

Organizing Committee:
Michael Dorff, Brigham Young University
Deirdre L. Smeltzer, MAA
Randy Paffenroth, WPI
Suzanne Weekes, SIAM

Program Description:
The MAA – SIAM & TRIPODS Advanced Workshop in Data Science for Mathematical Sciences Faculty is a 5-day hands-on workshop for mathematical sciences faculty who have had some exposure to and experience with data science but who are not themselves data science

experts. Participants of the 2017 or 2019 PIC Math Data Science Workshops that were held at BYU qualify and those who have experience coding in Python and applying basic statistical techniques to a large data set. The goal of the workshop is to bring together faculty from a range of institutions and expand the knowledge of the participants so that they are better armed to prepare students for the data science workforce.

Participants will learn more advanced techniques in the fields of data science, statistical learning, and machine learning. They will collaborate on data science projects that will involve accessing and cleaning large data sets and analyzing the data using data science methods. The majority of the technical content of the workshop will be delivered by experts in data science such as Prof. Randy Paffenroth of Worcester Polytechnic Institute and there will also be presentations by data science practitioners from industry.

Geometric and Topological Methods in Data Science
December 16 - 17, 2021

Organizing Committee:
Ian Adelstein, Yale University
Jeffrey Brock, Yale University
Smita Krishnaswamy, Yale University
Bjorn Sandstede, Brown University

Program Description:
The goal of this meeting is to bring together researchers using geometric and topological methods to study data. Fields of interest include manifold learning, topological data analysis, neural networks, and machine learning. While this plan is to focus on the mathematics, applications to neuroscience and quantitative biology will also be explored.

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.

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: Workshop on Advances in Theory and Algorithms for Deep Reinforcement Learning

August 2 - 4, 2021

Organizing Committee:
Nan Jiang, University of Illinois Urbana-Champaign
Sanjay Shakkottai, University of Texas Austin
R. Srikant, University of Illinois at Urbana-Champaign
Mengdi Wang, Princeton

Workshop Description:
There has been significant progress over the last few years in the theory and applications of Reinforcement Learning (RL). While RL theory and applications have had a rich history going back several decades, the major recent successes have occurred due to a successful marriage between deep learning approaches for function approximation embedded within a reinforcement learning framework for decision-making (Deep RL). On one hand, there has been a richer understanding of Stochastic Gradient Descent (SGD) for non-convex optimization, its impact in driving training error to zero in deep neural networks, and on the generalization ability of such networks for inference. On the other hand, there has been an explosion of research on iterative learning algorithms with strong statistical guarantees in the settings of reinforcement learning, stochastic approximation and multi-armed bandits.

This workshop aims to bring leading researchers from these two threads, with the goal of understanding and advancing research at their intersection. We will also explore other potential connections between deep learning and deep RL, including but not limited to: Understanding generalization in deep RL and how it is related to and/or different from generalization in deep learning; Connections between adversarial training in deep learning (e.g., Generative Adversarial Networks) and the optimization aspects of recent deep RL algorithms based on generalized moment matching in off-policy RL and imitation learning.

Hot Topics Workshop 2: Foam Evaluation
November 5 - 7, 2021

Organizing Committee:
Mikhail Khovanov, Columbia University
Aaron Lauda, University of Southern California
Louis-Hadrien Robert, University of Luxembourg

Workshop Description:
The purpose of this workshop is to bring together mathematicians interested in foams and their use in low-dimensional topology, representation theory, categorification, mathematical physics, and combinatorics. The workshop will focus on the foam evaluation formula and its applications. More concretely, we aim to:

(a) Give a more intrinsic definition of the foam evaluation, in order, for instance, to find similar formulas for the other Lie types;

(b) Understand the interplay between foams and matrix factorizations and further use foams for a unified and comprehensive approach to Khovanov-Rozansky link homology theories;

(c) Compare combinatorial foam evaluation with the geometric structures and invariants coming from gauge theory and symplectic geometry;

(d) Study potential applications of the foamy definition of link homology theories.

Program Promotions
ICERM programs and events are typically 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, ICERM directorate 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). During the pandemic posters were not distributed yet attendance to our programming was still strong both in person and virtually. ICERM's use of posters is being reconsidered as alternative advertising methods are more cost effective and environmentally friendly.

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 5,000 contact emails.

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, 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. While Brown is committed to supporting ICERM's Provost-approved fundraising goals, Brown's Advancement department has seen some turnover and as a result efforts to help ICERM build relationships with corporations and foundations have not progressed as much as desired. There was little-to-no fundraising activity during this reporting cycle. Additionally due to ICERM's own staffing changes, the quarterly newsletter was suspended this year. ICERM is evaluating what form this newsletter should take in the post-pandemic world.

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
Ron Buckmire	Occidental College
Charles Epstein (Chair)	University of Pennsylvania
Anna Gilbert	Yale University
Leslie Greengard	Flatiron Institute & NYU Courant Institute of Mathematical Sciences
Bruce Hendrickson	Lawrence Livermore National Laboratory
Julia Kempe	New York University
Rachel Kuske	Georgia Tech
Mark Lewis	Cornell University
Stéphane Mallat	Collège de France

Jonathan Mattingly	Duke University
Karen Smith	University of Michigan

The following people rotated off the BOT at the end of June 2021: Jill Mesirov.

Note: The minutes from the May 27, 2021 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 act as ex officio members of this committee.

Scientific Advisory Board Members:

Name	**Institution**
Jennifer Balakrishnan	Boston University
Fioralba Cakoni	Rutgers University
Ivan Corwin	Columbia University
Anne Gelb	Dartmouth College
William Goldman	University of Maryland
Michael Holst	University of California, San Diego
Yael Tauman Kalai	Microsoft Research
Daniel Krashen	University of Pennsylvania
Nathan Kutz	University of Washington
Sven Leyffer (Chair)	Argonne National Laboratory
Mauro Maggioni	Johns Hopkins University
Rosa Orellana	Dartmouth College
Rachel Ward	University of Texas
Jon Wilkening	UC Berkeley

The following people rotated off the SAB at the end of June 2021: Jesús De Loera, Misha Kilmer, Anna Lysyanskaya, and Joseph Silverman.

Upcoming Programs

ICERM already has a number of programs scheduled to take place in the coming years. The below listings have already been approved by the Scientific Advisory Board and are in the process of being developed.

Semester Programs (each with 3-4 associated workshops)

Fall 2022

Harmonic Analysis and Convexity

J. Gomez-Serrano, I. Holmes, B. Klartag, A. Koldobsky, S. Treil, A. Volberg, A. Zvavitch

Spring 2023

Modern Discrete Optimization: Mathematics, Algorithms, and Computation
J. De Loera, A. Deza, V. Kaibel, J. Lee, L. Sainta

Fall 2023

Math+Neuroscience: Strengthening the interplay between theory and mathematics
C. Curto, B. Doiron, R. Ghrist, K. Hess, Z. Kilpatrick, M. Marcolli, K. Mischaikow, K. Morrison, T. Sharpee, E. Schneidman

Spring 2024

Numerical PDEs: Analysis, Algorithms, and Data Challenges
M. D'Elia, B. Froese Hamfeldt, J. Guzman, M. Neilan, M. Olshanskii, S. Pollock, A.J. Salgado, V. Simoncini

Topical Workshops

2022

1. **Advances Chern-Simons Classical and Quantum Gravity**
   S. Alexander, N. Yunes
2. **Prediction and Variability of Air-Sea Interactions: the South Asian Monsoon**
   B. Fox-Kemper, J. MacKinnon, E. Shroyer, H. Seo, A. Subramanian, A. Tandon
3. **Lean for the Curious Mathematician 2022**
   J. Avigad, K. Buzzard, J. Commelin, Y. Kudryashov, H. Macbeth, S. Morrison

2023

1. **Mathematical and Scientific Machine Learning**
   M. D'Elia, G. Karniadakis, S. Mishra, T. Sapsis, J. Xu, Z. Zhang
2. **Dynamics, Rigidity AND Arithmetic in Hyperbolic Geometry**
   D. Fisher, D. Kelmer, H. Oh, A. Reid
3. **Mathematical and Computational Biology**
   W. Hao, P. Kevrekidis, M. Kuijjer, O. Prosper, L. Shahriyari, N. Whitaker
4. **Modern Applied and Computational Analysis**
   A. Gilbert, R. Lederman, G. Lerman, P.G. Martinsson, A. Nahmod, K. Serkh, C. Thiele, S. Wu
5. **Acceleration and Extrapolation Methods**
   H. De Sterck, D.Gardner, A. Miedlar, S. Pollock

Hot Topics Workshops

2022

1. **Topological and dynamical analysis of brain connectomes**
   D. Chklovskii, D. Lipshutz

Collaborate@ICERM

2022

1. **The Energy Strip for Codes in Polynomial Metric Spaces**
   P. Boyvalenkov, P. Dragnev, D. Hardin, E. Saff, M. Stoyanova
2. **Higher Fano Manifolds**
   C. Araujo, R. Beheshti, A-M. Castravet, K. Jabbusch, S. Makarova, E. Mazzon, N. Viswanathan
3. **Stochastic theory for data-driven paleoecosystem models**
   W. Cui, C. Myers, S. Petrovskii M. Pound, I. Sudakow
4. **Explicit Galois Representations of Genus 2 Curves**
   B. Banwait, A. Brumer, H. J. Kim, Z. Klagsbrun, J. Mayle, P. Srinivasan, I. Vogt
5. **Moduli of I-Surfaces Via Wall Crossing**
   K. Ascher, K. DeVleming,Y. Liu, J. Rana, F. Si
6. **Improvements to Algorithms Around S-Unit Equations**
   A. Alvarado, A. Koutsianas, B. Malmskog, C. Rasmussen, C. Vincent, M. West
7. **Algebraic Combinatorics of Weighted Oriented Graphs**
   J. Biermann, S. Kara, K-N. Lin, A. O'Keefe
8. **Arithmetical Structures on Graphs**
   K. Archer, A. Diaz-Lopez, D. Glass, J. Louwsma
9. **Practical Computation with Infinite Linear Groups**
   A. Detinko, D. Flannery, A. Hulpke, M. Kapovich, A. Kontorovich
10. **PSL(2; F) Representations of Homology Spheres**
    N. Hoffman, K. Petersen, E. Samperton
11. **Impartial Achievement and Avoidance Games for Generating Finite Groups**
    B. Benesh, D. Ernst, M. Meyer, S. Salmon, N. Sieben
12. **Configuration spaces of graphs and moduli spaces of tropical curves**
    C. Bibby, M. Chan, N. Gadish, C. Yun
13. **Experimental Validation of Observed Principles of Optimal Deep Networks**
    K. Leonard, J. Jenny Li, F. P. Medina, L. Ness
14. **Topological Applications of Khovanov Homology and Related Link Homologies**
    C. Caprau, N. Gonzalez, C. R. S. Lee, R. Sazdanovic, M. Zhang
15. **Optimal Pots for Tile-Based Self-Assembly of DNA Complexes**
    L. Almodovar Velazquez, A. Harsy, C. Johnson, J. Sorrells
16. **Modeling Dynamic Behavior in Evolving Networks**
    C. Domeniconi, E. Evans, W. Guo, E. Purvine, S. Tari
17. **Quantum Error Correction**

S. Anderson, H. López, G. Matthews, F. Revson, D. Ruano, I. Soprunov

2023

1. **Point Configurations on Projective Varieties**
   A. Caminata, N. Giansiracusa, H-B. Moon, L. Schaffler
2. **Bridging Modeling Modalities and Experimental Data with Equation Learning**
   T. Jackson, H. Jain, K-A. Norton

Summer@ICERM

2022

1. **Computational Combinatorics**
   S. Fishel, P. Harris, G. Rojas Kirby

2023

2. **Mathematical Modeling of DNA Self-Assembly**
   L. Almodovar, A. Harsy, C. Johnson, J Sorrells

Reunion Events - these programs are designed to bring together as many of the attendees originally scheduled to attend programs which were switched to virtual due to the pandemic.

2022

1. **Spring 2020 Reunion Event**
   Y. Chen, S. Gugercin, M. Kilmer, Y. Maday, S. Moskow, A. Narayan, D. Venturi
2. **Summer@ICERM 2020**
   Y. Chen, A. Narayan, M. Oh
3. **Fall 2020 Reunion Event**
   S. Aretakis, S. Field, G. Khanna, S. Lau, S. Liebling, D. Shoemaker, J. Speck

2023

1. **Spring 2021 Reunion Event**
   A. Buch, M. Chan, J. Huh, T. Lam, L. Mihalcea, S. Payne, L. Williams

Extended Program - this program takes place in summer 2022 and summer 2023 with work being carried out in between the sessions virtually.

2022 & 2023

Data Science and Social Justice: Networks, Policy, and Education
C. Diaz Eaton, J. Hibdon, D. Lewis, J. Libertini, M. Manes, O. Ortega, V. Piercey, B. Sandstede, T. Washington, T. A. Wong, H. Zinn Brooks

Note: The minutes from the May 12, 2021 mid-year SAB conference call and the November 14-15, 2021 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
Cathy Boutin	West Warwick School Department (Math)
John Ewing	Math for America
Thomas Garrity (Chair)	Williams College
Ryan Hand	University of Pennsylvania
Rachel Levy	AMS/AAAS Congressional Policy Fellow
Katharine A. Ott	Bates College
Javier Rojo	Oregon State University
Jessica Sidman	Mount Holyoke College
Ulrica Wilson	Morehouse College

Note: The minutes from the September 10, 2021 annual Education Advisory Board meeting can be found in Appendix F.

Mathematics Institute Directors Meeting (MIDs)

The April 24, 2021 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.

2021-2022 ICERM Postdoctoral Cohort

ICERM Postdoctoral Fellows (4 months w/benefits; funds for research travel)

Name	Previous Institute	ICERM Semester Program
Amirali Hannani	CEREMADE- Universite Paris Dauphine-PSL	Fall 2021
Kyle Liss	University of Maryland	Fall 2021
Annalaura Stingo	Mathematical Sciences Research Institute	Fall 2021
Antonio Alfieri	University of British Columbia	Spring 2022
Lei Chen	University of Maryland	Spring 2022
Jonathan Johnson	University of Texas at Austin	Spring 2022
Hannah Turner	University of Texas at Austin,	Spring 2022
Yvon Verberne	Georgia Institute of Technology	Spring 2022

ICERM Institute Postdoctoral Fellows (9 months w/benefits; funds for research travel)

Name	Previous Institute	ICERM Semester Program
Louise Gassot	Université Paris-Saclay	2021-2022: focus on Fall 2021
Anastassiya Semenova	University of New Mexico	2021-2022: focus on Fall 2021
Jiaqi Yang	Georgia Institute of Technology	2021-2022: focus on Fall 2021

Sudipta Kolay	Georgia Institute of Technology	2021-2022: focus on Spring 2022
Nancy Scherich	U. of California, Santa Barbara	2021-2022: focus on Spring 2022
Stefan Czimek	ICERM	2021-2022: extension from 20-21

ICERM Bridge Postdoctoral Fellows (9 months w/ benefits; funds for research travel)

Name	**Previous Institute**	**ICERM Semester Program**
Ian Alevy	University of Rochester	Fall 2021
Steven Amelotte	University of Rochester	2021-2022
Justin (Yi-Chang) Chen	Georgia Institute of Technology	2021-2022
Jayan Mukherjee	University of Kansas	2021-2022
Rahul Singh	Virginia Tech	2021-2022

Based on available information, the ICERM stipend-supported postdocs for 2021-2022 breakdown as follows:

	Male	**Female**
American Indian/Alaskan Native	0	0
Asian/Pacific Islands	3	2
Black or African American	1	0
Hispanic or Latino	0	0
White	6	4
Decline to report	1	1
Other (specify)	0	0
	11 +	7 = 18 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 2022?**
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	Università degli Studi di Padova
Dongming Wei	Fall 2011	RBC Capital Markets
Cecile Armana	Spring 2012	University of Franche-Comté
Anupam Bhatnagar	Spring 2012	Meta
Alon Levy	Fall 2011 – **Spring 2012**	NYU | The Marron Institute

Bianca Viray	Spring 2012	University of Washington
Xiaoguang Wang	Spring 2012	Virginia Tech
Daniel Cargill	Fall 2012	Lockheed Martin
Arnab Ganguly	Fall 2012	Louisiana State University
Peng Hu	Fall 2012	Oxford University
Hao Ni	Fall 2012	University College
Aaron Smith	**Fall 2012** - Spring 2013	University of Ottawa
Julio Andrade	Fall 2012 - **Spring 2013**	University 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	Toulouse 1 Capitole University
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	University of Copenhagen
Amanda Redlich	Spring 2014	UMASS Lowell
Charalampos Tsourakakis	Spring 2014	Boston University
Grigory Yaroslavtsev	Fall 2013 - **Spring 2014**	George Mason University
Ali Ahmed	Fall 2014	Information Technology University (Lahore)
Ulas Ayaz	**Fall 2014** – Spring 2015	JPMorgan Chase
Jacqueline Davis	Fall 2014	
Pawel Siedlecki	Fall 2014	University of Warsaw
Li Wang	Fall 2014	University of Illinois
Tyler Helmuth	Spring 2015	Durham University
Marcin Lis	Spring 2015	Vienna Institute of Technology
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	Università degli studi di Genova
Edgar Costa	Fall 2015	MIT
Anna Medvedovsky	**Fall 2015** – Spring 2016	Boston University
James Weigandt	**Fall 2015** – Spring 2016	Freelance
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	Auburn University
Chaim Even-Zohar	Fall 2016	Alan Turing Institute
Isaac Mabillard	Fall 2016	Google
Greg Malen	Fall 2016	Union College
Jose Alejandro Casas	Fall 2016	University of Miami
John Wiltshire-Gordon	Fall 2016	Zagaran Inc.
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	DePaul 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	KTH
Philippe Moustrou	Spring 2018	Université Toulouse Jean Jaures
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	Tulane University
Papri Dey	Fall 2018	University of Missouri
Mareike Dressler	Fall 2018	University of New South Wales
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
Guangyao Zhou	Spring 2019	Vicarious AI
Gabriel Dorfsman	Fall 2019	UC Berkeley
Alba Málaga Sabogal	**Fall 2019** – Spring 2020	Université de Lorraine
Michael Musty	Fall 2019	ERDC-CRREL
Martin Skrodzki	Fall 2019	TU Delft
Steve Trettel	Fall 2019	Stanford University
Gregory Darnell	Fall 2019 – **Spring 2020**	Apple
Davide Palitta	Spring 2020	Università di Bologna
Jemima Tabeart	Spring 2020	University of Edinburgh
Michael Schneier	Spring 2020	Naval Nuclear Laboratory
Min Wang	Spring 2020	Duke University
Stefan Czimek	**Fall 2020** – Spring 2022	University of Leipzig
Martin Licht	Fall 2020	EPFL
Jacob Lange	Fall 2020	Rochester Institute of Technology
Caroline Mallary	Fall 2020	UMass Dartmouth
Zachary Nasipak	Fall 2020	NASA Goddard Space Flight Center
Brendan Keith	Fall 2020	Lawrence Livermore National Lab
Sunita Chepuri	Spring 2021	University of Michigan
Netanel Friedenberg	Spring 2021	Tulane University
Sean Griffin	Spring 2021	UC Davis
Daoji Huang	Fall 2020 – **Spring 2021**	University of Minnesota
Gleb Nenashev	Spring 2021	Brandeis University

Louise Gassot	**Fall 2021** - Spring 2022	University of Basel
Amirali Hannani	Fall 2021	PSL Research University
Kyle Liss	Fall 2021	Duke University
Anastassiya Semenova	**Fall 2021** - Spring 2022	University of Washington
Annalaura Stingo	Fall 2021	UC Berkeley
Jiaqi Yang	**Fall 2021** - Spring 2022	Clarkson University
Antonio Alfieri	Spring 2022	University of Montreal
Lei Chen	Spring 2022	University of Maryland
Jonathan Johnson	Spring 2022	University of Texas
Sudipta Kolay	Fall 2021 - **Spring 2022**	Pursuing Industry Positions
Nancy Scherick	Fall 2021 - **Spring 2022**	Elon University
Hannah Turner	Spring 2022	Georgia Tech
Yvon Verberne	Spring 2022	Georgia Tech
Steven Amelotte	ICERM Bridge Postdoc	University of Western Ontario
Justin (Yi-Chang) Chen	ICERM Bridge Postdoc	
Jayan Mukherjee	ICERM Bridge Postdoc	University of California, Riverside
Rahul Singh	ICERM Bridge Postdoc	Pursuing Industry Positions

Graduate Students

Support for Graduate Students

The research semester program budget typically includes partial support for a cohort of graduate students. Applicants include graduate students working with visitors to the program, as well as students who intend to attend without an advisor. Graduate students must arrange for a letter of recommendation from their advisor to be sent separately. The graduate student applications are 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 a semester program starts, ICERM attempts to assign a mentor to all postdocs and graduate students. The institute provides all senior mentors with written guidelines that spell out their responsibilities and the responsibilities of mentees. Currently, the assigned ICERM Deputy Director coordinates these efforts and works with the members of the Program Organizing Committee assigned to be responsible for mentorship.

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.

ICERM Postdoctoral Participant and Mentor list by Semester Program

Postdoc	Mentor	Program/How Supported
Louise Gassot	Patrick Gerard	Fall 2021 Institute Postdoc (NSF Funds)
Amirali Hannani	Gigliola Staffilani	Fall 2021 Semester Postdoc (NSF Funds)
Kyle Liss	Alex Kielselev	Fall 2021 Semester Postdoc (NSF Funds)
Anastassiya Semenova	Themistoklis Sapsis	Fall 2021 Institute Postdoc (NSF Funds)
Annalaura Stingo	Luis Vega	Fall 2021 Semester Postdoc (NSF Funds)
Jiaqi Yang	Benoit Pausader	Fall 2021 Institute Postdoc (NSF Funds)
Antonio Alfieri	Matthew Hedden	Spring 2022 Semester Postdoc (NSF Funds)
Lei Chen	Brendan Hassett	Spring 2022 Semester Postdoc (NSF Funds)
Jonathan Johnson	Brendan Owens	Spring 2022 Semester Postdoc (NSF Funds)
Sudipta Kolay	John Baldwin	Spring 2022 Institute Postdoc (NSF Funds)
Nancy Scherick	Juan González-Meneses	Spring 2022 Institute Postdoc (NSF Funds)
Hannah Turner	Ina Petkova	Spring 2022 Semester Postdoc (NSF Funds)
Yvon Verberne	Tara Brendle	Spring 2022 Semester Postdoc (NSF Funds)
Ian Alevy	Richard Schwartz	ICERM Bridge Postdoc
Steven Amelotte	Fred Cohen	ICERM Bridge Postdoc
Justin (Yi-Chang) Chen	Anton Leykin	ICERM Bridge Postdoc
Jayan Mukherjee	Hal Schenck	ICERM Bridge Postdoc
Rahul Singh	Ben Elias/ Leonardo Mihalcea	ICERM Bridge Postdoc

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 2021: Summer@ICERM – Computational Polygonal Billiards

June 14 - August 6, 2021

Organizing Committee:
Paul Apisa, University of Michigan
Diana Davis, Phillips Exeter Academy
Samuel Lelièvre, Université Paris-Saclay
Jane Wang, Indiana University

Program Description
The 2021 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 research projects on the theme of computational polygonal billiards and flat surfaces. This overarching theme will allow participants to use the theory of flat surfaces, along with the computational tools of pre-existing free software including Sage packages, to work on open problems in the field. Faculty will also guide the development of free software for flat surfaces. Students will be assigned to one or more research groups before the program begins and will be expected to do background reading before the program starts. During the program, students will work with faculty advisors to ensure they have the background understanding necessary to work on the problems. Students will also learn programming skills and computational techniques, including using Sage.

Throughout the eight-week program, students will work on their 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, and professional development seminars, and will acquire skills in free software development. Students will learn how to collaborate mathematically, working closely in their teams to write up their research into a paper.

2021 Proposed Research Project Topics

1. The Finite Blocking Problem
2. Square-Tiled Surfaces
3. Periodic Points on Veech Surfaces
4. Periodic Billiard Paths

2021 Summer@ICERM Cohort

The Summer@ICERM 2021 program had a cohort of 19 students. All of them were funded through the NSF.

Student Name	Institute	Funding Source
Jessica Bennett	Brown University	ICERM, NSA
Kelly Chen	MIT	ICERM, NSA
Ahmed Zawad Chowdhury	MIT	ICERM

Mei Rose Connor	Stony Brook University	NSA
Catherine Cui	Harvard	NSA
Elaine Danielson	University of Florida	NSA
Samuel Everett	University of Colorado, Boulder	NSA
Victor Ginsburg	Pennsylvania State University	NSA
Brin Harper	Massachusetts Institute of Technology	ICERM, NSA
Paul Kielstra	Harvard University	NSA
Veronica Kirgios	Notre Dame	NSA
Destine Lee	Columbia University	ICERM, NSA
Vanessa Lin	UNC	ICERM, NSA
Aidan Mager	University of Washington	ICERM, NSA
Zachary Steinberg	Amherst College	ICERM, NSA
Chenyan Sun	Williams College	ICERM
Cameron Thomas	Morehouse College	ICERM, NSA
Hamilton Wan	Yale	ICERM, NSA
Hanna Yang	MIT	ICERM, NSA

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

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

- Other than being able to work with everyone in-person, I appreciated the sense of community and the prioritization of enjoying the work we were doing.
- Doing math in an environment where people actively were trying to make others feel as included as possible
- Meeting so many wonderful people. Math-wise, I thought there was a strong spirit of collaboration, and I learned a lot just by chatting with the other participants.
- "The" highlight seems to assume uniqueness, which is an unsupported assumption. I will instead list a few highlights, in no particular order: Interacting with people with diverse mathematical backgrounds A culture of kindness and good humor Air conditioning Related but kind of off-topic discussions and memes Camaraderie from doing research together
- The people! I feel very fortunate to have met the people I did, and in particular, my fellow undergraduates. It was enlightening meeting people coming from other institutions with different mathematical backgrounds. I learned a lot from them, and these learning experiences defined the program for me.
- Everyone was willing to collaborate and share math freely. There was no competition, and everyone was able to learn at their own pace.

Summer@ICERM 2021 Scientific Outcomes to Date

Final Student Presentations and Published Papers

- "Hecke Eigenforms to Flat Atlases" by Zawad Chowdhury, Elaine Danielson, Aidan Mager, HamiltonWan
- "Closed Geodesics on Dilation Surfaces" by Catherine Cui, Victor Ginsburg, Veronica Kirgios, Vanessa Lin

- "Hyperbolic Staircases: Periodic paths on (2n + 1)-gons" by Mei Rose Connor, Michael Kielstra, Zachary Steinberg, Chenyang Sun
- "Periodic Orbits of Affine Interval Exchange Transformations" by Kelly Chen, Zachary Steinberg, Cameron Thomas
- "Language Complexity of Billiards" by Jessica Bennett1, Catherine Cui, Elaine Danielson, Veronica Kirgios
- "The J-invariant as a tool for detecting Veech Surfaces and the Combinatorics of Lattice Hexagons" by Mei Rose Connor, Brin Harper, Hamilton Wan, Hanna Yang
- "Long and Short Trajectories in the Double Pentagon" by Sam Everett, Vanessa Lin, Aidan Mager
- "Blocking and Periodic Points on Veech Surfaces" by Jessica Bennett, Zawad Chowdhury, Sam Everett, Destine Lee
- "Towards the Asymptotic Language Complexity of the Regular Hexagon" by Michael Kielstra, Chenyang Sun, Cameron Thomas

Posters Presented at JMM 2022

- Computing periodic points on Veech surfaces (Zawad Chowdhury, Samuel Everett, and Destine Lee)
- Constructing Translation Surfaces from Hecke Eigenforms (Paul Apisa, Zawad Chowdhury, Elaine Danielson, Paige Helms, Aidan Mager, and Hamilton Ji Wan)
- Hyperbolic Staircases: Periodic Paths on 2g + 1-gons (Mei Rose Connor, Diana Davis, Paige Helms, Michael Kielstra, Samuel Lelievre, Chenyang Sun, and Zachary Steinberg)
- Periodic Orbits of Affine Interval Exchange Transformations (Kelly Chen, Zachary Steinberg, Cameron Thomas, and Jane Wang)
- The Finite Blocking Problem on Cyclic Covers of the Regular Octagon (Jessica Bennett, and Destine Lee)
- Towards a Classification of Veech 12-Gons and Trapezoidal Unfoldings (Paul Apisa, Brin Harper, Hamilton Ji Wan, and Hanna Yang)
- Towards the Language Complexity of the Regular Hexagon (Diana Davis, Michael Kielstra, Samuel Lelievre, Sunrose Thapa Shrestha, Chenyang Sun, Cameron Thomas, and Jane Wang)

Papers

- Z. Chowdhury, S. Everett, S. Freedman, and D.Lee. Computing Periodic Points on Veech Surfaces. arXiv:2112.02698
- S. Everett, V. Lin, and A. Mager. Long and Short Periodic Billiard Trajectories in the Regular Pentagon. arXiv:2111.09856

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.

COVID-19 and its impact on 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.

During this reporting cycle, the institute's applicant pool increased significantly since there were fewer barriers to participating with everything being available virtually. Where ICERM previously accepted 70-80 applicants per program, it often accepted 300+ applications. Many participants were selective in the talks they attended, and many more did not respond to the exit surveys. Therefore, ICERM's average response rate of 66% for all exit surveys was lower this year, averaging only 49%. Although this is an improvement compared to last year's 28% average response rate.

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.

To boost survey response rates during this reporting cycle, the SAB suggested the program organizers send a "heads up/please respond" email to their program's long-term participants prior to putting the follow-up surveys in the field. This request resulted in an increased response rate (from our average of 50% for the two-year-follow-up and 36% for the five-year-follow-up to 52% and 55%, respectively.

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.

With SRG's help, the institute developed a longitudinal comparison report using a program's exit survey, as well as its 2 and 5-year follow-up survey. In this way, ICERM can 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

The challenge, of course, is having high enough response rates for the collected data to draw meaningful conclusions.

The SAB is interested in seeing details about a program's long-term impact. The challenge in the coming year is to pare down the massive quantity of information we collect to something more concise. ICERM will endeavor to simplify and streamline our survey instruments, with a view toward what we need for formative evaluation (in our director-manager meetings) and summative evaluation (led by our boards).

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, 2021 through May 1, 2022) 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 5-year follow-up survey for each of its semester programs, scientific outcomes have begun to be collected much more systematically and consistently. In general, the response rate for all survey types has remained steady over the past four years, when ICERM first began tracking response rates.

During ICERM's 2021 Board of Trustees Meeting, the idea came up to present the publication information collected in these surveys somewhere to highlight accomplishments of ICERM programs and participants. Over the past year a project was carried out which resulted in publications being added to the program's website that the author(s) attended. Our semester programs now include listings as soon as ICERM is made aware of an attributable publication to the program and a database has been made to manage the information. So far over 600 publications have been added to the related program pages. In the coming year the goal is to have similar upgrades to the Summer@ICERM and Collaborate@ICERM pages.

Note: a list of publications initiated at ICERM since ICERM's years 6-10 final report can be found in Appendix I.

Future Plans for Evaluations

Based on the feedback from ICERM's Scientific Advisory Board, ICERM has started to take steps to modify the current evaluation summary format. The goal is to provide quickly comprehensible data points and highlight standout responses from the open ended questions. This would effectively streamline the summary from the current format which can quickly grow to several pages. Further we hope that by having this done in-house will allow for more flexible responsiveness to the needs of the SAB and the participants taking the surveys. The 2 and 5 year follow up surveys were used as a test and the initial responses were good. With some additional staffing, plans are in development to expand upon this momentum to manage more aspects in-house and survey more of the groups.

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 $92,500 in corporate sponsorship funds.

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 $99,375 in academic sponsorship funds. Academic sponsors have included:

- Cornell University, Department of Mathematics
- Indiana University, Bloomington, Department of Mathematics
- Korea Advanced Institute of Science and Technology, Dept. 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. Director Brendan Hassett and Assistant Director Juliet Duyster manage 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 $75,000.

Other Funding Support received in 2021-2022

Additional Grants	*Amount*
American Mathematical Society Epsilon Fund *(for GirlsGetMath@ICERM)*	$ 6,000.00
JetBlue Foundation *(for expanding the GirlsGetMath program nationally)*	$ 50,000.00
Math *f*or America *(for GirlsGetMath@ICERM)*	$ 7,458.00
Sub-total	**$ 63,458.00**

University Funding Support	
University Research Committee	$ 44,962.00
Sub-total	**$ 44,962.00**
Sponsor Support	
Academic Sponsors	$ 0.00
Corporate Sponsors	$ 0.00
Individual Sponsors	$ 1,650.00
Sub-total	**$ 1,650.00**
TOTAL	**$ 110,070.00**

Diversity and Outreach

Ulrica Wilson, 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.

ICERM's Directors present demographic data each year to its Board of Trustees, indicating progress toward its diversity goals and soliciting advice on how to improve our efforts.

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. During this reporting cycle ICERM hosted the "Research Communities in Algebraic Combinatorics" workshop.

ICERM typically 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. None of these events were held, or ICERM chose not to participate, during this reporting cycle due to the pandemic.

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

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)
- ICERM has a subcommittee to support Brown University's diversity and inclusion action plan

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, three virtual public lectures were held:

- Knotty Knits and Evening of Math and Crafts with Sabetta Matsumoto (July 2021)
- Hidden Narratives in Mathematics - The Power of Storytelling with Ranthony Edmonds (August 2021)
- More Data, More Problems - Double Dipping in Statistics (September 2022)

GirlsGetMath@ICERM

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

Because GirlsGetMath incorporates so many interactive, hands-on experiences, and the participants benefit from meeting peers with shared interests, we determined that a virtual version of the program this summer would lose its impact.

We worked with the founding program organizers (Katharine Ott and Amanda Tucker) to come up with an alternate plan that provided meaningful and engaging content in keeping with the spirit of the program. A very abbreviated, asynchronous version of GirlsGetMath was made available to every applicant as well as the general public. Two-to-three videos of Katy and Amanda presenting a selection of modules related to the GirlsGetMath curriculum (as well as some downloadable activities) are still posted on ICERM's GirlsGetMath website.

GirlsGetMath was 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, and Boston University in summer 2022 (delayed by two years due to the COVID-19 pandemic). The program at Stonehill College was able to be held in summer 2021 and had a great turnout.

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.

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 1, 2021 through April 30, 2022)

EPSCoR State	# of ICERM Participants
Alabama	7
Arkansas	4
Delaware	3
Idaho	2
Iowa	14
Kansas	6
Kentucky	4
Louisiana	8
Maine	1
Mississippi	3
Missouri	8
Montana	1
Nebraska	6
Nevada	2
New Hampshire	15
New Mexico	4
North Dakota	4
Oklahoma	13
Rhode Island	91
South Carolina	5

Tennessee	9
Utah	10
Vermont	4
West Virginia	2

Administration and Staff

The ICERM Directors who received funding from the NSF core grant during this reporting cycle were Carolyn Klivans, Benoit Pausader, Jill Pipher, Kavita Ramanan, Bjorn Sandstede. Brendan Hassett commits 100% time.

ICERM Staff

Events Team

Teresa Fitzsenry, 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.

Shadira Presbot, Program Assistant, hired March 2022: reports to the Program Manager. Is the first point of contact for ICERM visitors. Acts as receptionist/concierge. Assists with updating and posting schedules, tracking invitations, visitor data entry, all event prep and set-up.

Finance Team

Carly Seaman, Financial Coordinator, hired March 2022: reports to the Manager of Finance and Administration. Serves as primary point of contact for ICERM staff, program organizers, visitors, postdocs, students, vendors, and sponsor agencies for all financial transactions and related issues; reconciles the day-to-day financial activity for expenses supported by sponsored projects and University appropriated budgets.

Nina Succi, Manager of Finance and Administration, hired February 2016: reports to the Assistant Director of Finance and Administration. Supports grant proposal submissions, general grant management, and reporting. Provides human resources guidance and support to the department. Engages with intercampus departments to resolve issues that arise within financial, human resources, and grant domains.

IT Team

Andy Alter, A/V Support Technician, hired April 22: reports to the Senior Systems Administrator. Provides A/V support for the institute's programs and events. Assists with technical support for program participants.

Christopher Cate, Senior Systems Administrator, hired April 2022: reports to the Director of IT. Manages and Maintains software, systems, servers, and infrastructure necessary to support ICERM programs, and oversees technical support.

João Dos Santos, Application Developer, hired March 2022: reports to the Senior Application Developer. 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.

Bernadette McHugh, IT Customer Experience Manager, hired in September 2012: reports to the Senior Systems Administrator. 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. Assists with technical support for program participants.

Tori Santonil, Senior Application Developer, hired October 2017: reports to the Director of IT. Performs project management. Leads 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 70 research papers and has authored or co-edited eight 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 Director of Information Technology, 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.

Juliet Duyster, Assistant Director of Finance and Administration, was hired in August 2011. She has 15+ years experience in higher education. She is responsible for directing the long-range and day-to-day financial and administrative activities that support ICERM's 18-20 mathematical

conferences and 1,000+ international scientific researchers annually. She supervises the financial staff, works closely with the Directorate, is involved in management planning sessions for the Institute, and serves as the primary financial advisor and administrative risk manager. Juliet received both her BS and her MBA from Nova Southeastern University.

Sigal Gottlieb is a Chancellor Professor of Mathematics and founding co-Director of the Center for Scientific Computing and Visualization Research (CSCVR) at UMass Dartmouth and Consulting Associate Director at ICERM. She is a Fellow of the Society of Industrial and Applied Mathematics (SIAM, 2019) and the Association for Women in Mathematics (AWM, 2021). 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 UMass Dartmouth.

Jeffrey Hoffstein is a Department Chair and Professor of Mathematics at Brown University as well as an ICERM Consulting Associate 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 the 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.

Misha Kilmer is a William Walker Professor of Mathematics at Tufts University and an ICERM Deputy Director. She has a secondary appointment in the Department of Computer Science at Tufts University and a co-PI of Tufts TRIPODS Institute. She has been a Tufts Data Intensive Studies Center (DISC) Faculty Fellow since January 2021. In 2019, Prof. Kilmer was named a Fellow of the Society for Industrial and Applied Mathematics (SIAM) "for her fundamental contributions to numerical linear algebra and scientific computing, including ill-posed problems, tensor decompositions, and iterative methods." She served as Chair of the Tufts Department of Mathematics from 2013 to 2019. She is a 2001 recipient of the Tufts Undergraduate Initiative in Teaching Award and was promoted directly from Assistant to Full Professor in 2005.

Caroline Klivans is an Associate Professor of Applied Mathematics at Brown University and an ICERM Deputy Director. As Deputy Director, her responsibilities include: overseeing semester programs and other institute activities such as summer programming and special events, assisting in solicitation and development of programs and workshops and with grant proposals to support

institute activity. Previously she served as an ICERM Associate Director from 2015-2020, where her focus was on the Institute's mentoring and professional development programs for students and postdoctoral fellows. 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.

Benoit Pausader is a Professor of Mathematics at Brown University and a co-PI on the ICERM grant. Benoit received his Ph.D. from the University of Cergy-Pontoise. He has held appointments at New York University, the Centre National de la Recherche Scientifique in France, and at Princeton. His current position at Brown marks his second appointment to the Brown faculty; from 2008-2011 he was appointed as a Tamarkin Assistant Professor. Benoit studies partial differential equations, especially equations coming from physics such as the nonlinear Schrodinger equation, the Euler-Maxwell system, the Water Wave system. He has been the recipient of two grants from the National Science Foundation, was named a Sloan Research Fellow in Mathematics in 2014 and a Simons Fellow in 2021.

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. 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, was a National Women's History Month 2013 Honoree, and also served as president of the American Mathematical Society from 2019-2020. 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.

Kavita Ramanan is the Roland George Dwight Richardson University Professor of Applied Mathematics at Brown University. She served as Deputy Director of ICERM in 2020, and is currently an Associate Director. Kavita works on probability theory, stochastic processes and their applications. She has made fundamental contributions to the study of reflected processes, large deviations theory, high-dimensional probability and applications to asymptotic convex geometry. She has also 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 also has four patents to her name. Kavita is an elected fellow of multiple societies including the AMS, SIAM and AAAS. She has received several honors for her research. She was awarded the Erlang prize in 2006 for "outstanding contributions to applied probability" by the INFORMS Applied Probability Society,

and a Medallion from the Institute of Mathematical Sciences in 2015. She was a recipient of a Simons Fellowship in 2018, a Guggenheim Fellowship in 2020, a Distinguished Alumna Award from IIT Bombay in 2020, the Newton award in 2020 from the Department of Defense for "transformative ideas" during the COVID-19 pandemic, and a Distinguished Research Achievement Award from Brown University in 2021. She was also named a member of the American Academy of Arts and Sciences in 2021.

Bjorn Sandstede is Professor of Applied Mathematics, the Department Chair of the Division of Applied Mathematics, 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.

Jenna Sousa, Assistant Director of Programs and Operations, hired May 2014: reports to the Director. Jenna has 15+ years experience in higher education and was in student affairs before coming to ICERM. Provides project management and logistical oversight for ICERM's complex portfolio of research programs and events. This includes the oversight of all applications, invitations, housing, program schedules, special events, and exit surveys. Manages the event staff. She also is responsible for working closely with Brown University for upkeep/maintenance of the physical space at ICERM.

Ulrica Wilson is a Professor of Mathematics at Morehouse College. As ICERM's Associate Director for 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 Meeting to facilitate virtual workshops and the software is available for smaller presentations and participant working groups. 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. The room is Zoom-capable to facilitate hybrid in-person/remote activities. A smaller meeting room is equipped with a Zoom video conferencing system and includes a digital media projection system. 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 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. It collects demographic, financial, and scheduling data for all ICERM visitors. External-facing features include our application and organizer information systems. ICERM public calendars, webpages, video archives, and publication listings refer to data held in Cube.

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 invited 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.

APPENDICES

Appendix A: Fall 2021 Semester Program and Workshop Participant Lists
Appendix B: Spring 2022 Semester Program and Workshop Participant Lists
Appendix C: 2021-2022 Topical Workshops: Participant Lists
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 1, 2021-April 30, 2022
Appendix I: Publications since last ICERM report
Appendix J: ICERM Participant Data Report (NSF Required)