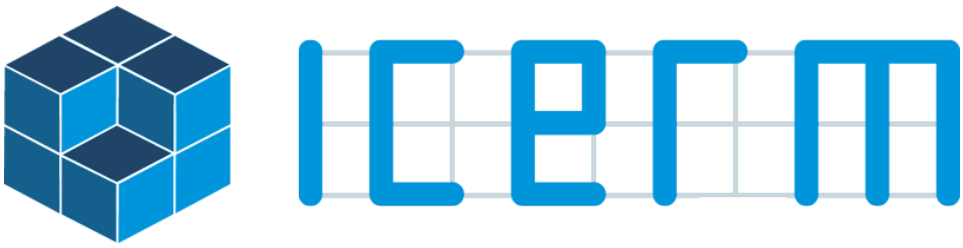

Institute for Computational and Experimental Research in Mathematics

Annual/Final Report
DMS-0931908 (VI-MSS)
May 1, 2016 – July 31, 2017

Brendan Hassett, Director
Jeff Brock, Associate Director
Jeffrey Hoffstein, Consulting Associate Director
Caroline Klivans, Associate Director
Jill Pipher, Consulting Associate Director
Sinai Robins, Deputy Director
Bjorn Sandstede, Associate Director
Homer Walker, Deputy Director
Ulrica Wilson, Associate Director for Diversity and Outreach

Table of Contents

This is the final report for ICERM's DMS-0931908 grant (VI-MSS), and reflects all of the close-out data collected during the final reporting cycle of May 1, 2016 through July 31, 2017.

Virtual Institute of Mathematical and Statistical Sciences (VI-MSS)

ICERM's supplemental proposal for the two-year pilot program "Virtual Institute of Mathematical and Statistical Sciences (VI-MSS)" was awarded in August 2011, creating a partnership that formally connected ICERM with several mathematics and statistics institutes in India. ICERM was granted no-cost extensions which allowed the program to expand to additional sites.

During the life of the grant, ICERM jointly funded international collaborations with institutes and institutions in Brazil, China, Germany, Israel, Japan, and South Africa. These collaborations created a "virtual" institute in the mathematical and statistical sciences.

VI-MSS Goals

1. Collaborative workshops held in US and other contributing international Institutes
2. Research visits by international faculty, postdocs and students to ICERM semester programs and workshops funded by their home institution.
3. Satellite workshops funded by international institutions associated with semester programs at ICERM.
4. Graduate/postdoc joint training events.
5. Research visits abroad to participating international institutions.

Participating Institutions and Organizations

In US

- Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, RI

In Brazil

- Instituto Nacional de Matemática Pura e Aplicada (IMPA)

In China

- Hong Kong University of Science and Technology (HKUST)

In Germany

- Freiburg Institute of Advanced Studies (FRIAS)

In India

- Chennai Mathematical Institute (CMI), Chennai
- Indian Institute of Science (IISc), Bangalore
- Indian Institute of Science Education and Research (IISER), Pune
- Institute of Mathematical Sciences (IMSc), Chennai
- Indian Statistical Institute (ISI), Kolkata, Delhi, Bangalore
- Tata Institute of Fundamental Research (TIFR), Mumbai
- University of Delhi (DU), Delhi

ICERM also collaborated with the International Centre for Theoretical Sciences (ICTS)

In Israel

- School of Mathematical Sciences at the Tel Aviv University

In Japan

- Kobe University

In South Africa

- University of the Witwaterstrand, Johannesburg (WITS) and the African Institute for Mathematical Sciences (AIMS)

VI-MSS Programs

During this reporting period, ICERM utilized the VI-MSS grant to fund two international undergraduate students for the Summer@ICERM undergraduate research program (Surabhi Desai and Tharathep Sangsawang); two programs were co-hosted with the Hong Kong University of Science and Technology (HKUST); one topical workshop was held at ICERM in collaboration with colleagues from Freiburg; and one month's summer salary was paid to Professor Jeff Brock for his work as faculty organizer during the 2017 Summer@ICERM program.

PROGRAM TYPE	NAME	DATES	ATTENDEES
Summer Undergraduate Research Experience	Summer@ICERM 2016: Dynamics and Stochastics	June 20 – August 12, 2016	2 funded by VI-MSS
HKUST-ICERM VI-MSS Program	Integral Equation Methods, Fast Algorithms and Their Applications to Fluid Dynamics and Materials Science	At HKUST: Jan 2-13, 2017; At ICERM: May 30-June 9, 2017	18 (17 funded by VI-MSS)
HKUST-ICERM VI-MSS Program	Phase Retrieval: Theory, Application and Algorithms	At HKUST: Jan 9-23, 2017; At ICERM: June 5-18, 2017	20 (16 funded by VI-MSS)
Topical Workshop	Robust Methods in Probability & Finance	June 19 - 23, 2017	32 (all funded by VI-MSS)

Gender/Ethnicity Breakdown

During this reporting period, 30 of the participants funded by the DMS-0931908 grant were male, 11 were female, and 31 declined to report. The ethnic breakdown for the same participant pool is as follows: 21 were Asian, 1 was Black, 1 was Hispanic/White, 21 were White, and 28 declined to respond.

Description of Programs Funded by VI-MISS

Integral Equation Methods, Fast Algorithms and Their Applications to Fluid Dynamics and Materials Science

At HKUST: Jan 2-13, 2017; at ICERM: May 30-June 9, 2017

Organizing Committee

Shidong Jiang, New Jersey Institute of Technology
Andreas Kloeckner, Department of Computer Science, University of Illinois at Urbana-Champaign
Xiao-Ping Wang, The Hong Kong University of Science and Technology

Yang Xiang, The Hong Kong University of Science and Technology

Description
This program will focus on integral equation methods, fast algorithms and their applications to fluid dynamics and materials science. Integral equation methods have been used for more than a century to establish existence and uniqueness results for a variety of elliptic, parabolic and hyperbolic partial differential equations (PDEs). From a computational perspective, they have been used most extensively in the elliptic (steady state or time harmonic) case, because of their ability to handle complex geometry, unbounded domains and radiation conditions and because of the availability of fast algorithms to reduce the cost of handling the dense matrices that arise from their discretization. These algorithms include fast multipole methods (FMM), methods based on the Fast Fourier Transform (FFT) or the non-uniform FFT ("NUFFT"), and hierarchical compression-based methods (wavelet and SVD-based schemes, H-matrices, HSS-matrices, etc.). The fundamental issue is that discretization of an elliptic boundary integral equation yields a dense N × N matrix, where N denotes the number of degrees of freedom used to describe the unknown. The straightforward application of a dense matrix to a vector requires $O(N^2)$ work, while classical Gaussian elimination techniques require $O(N^3)$ work to solve the system. The various fast algorithms listed above provide the ability to apply the discretized integral operator to a vector in O(N) or O(N log N) operations. When combined with modern iterative methods (such as GMRES), well-conditioned integral equation formulations such as second kind integral equations (SKIEs) have reduced the total work required to near optimal complexity, bringing large scale simulations within practical reach.

The program will bring a group of researchers from the US and HKUST with common interests and complementary expertise to work intensively on constructing well-conditioned integral equation formulations, developing high-order, fast, and robust algorithms with scalable implementation, and applying them to solve complex, large-scale real physical applications in multiphase flows and dislocation dynamics and to propose positive conditions on the Hadamard conjecture.

Topics include:
Topic 1: Efficient methods for the threshold dynamics method and interface dynamics
Topic 2: Fast Numerical Methods for Simulations of Dislocation Climb
Topic 3: Experimentation on the Hadamard Conjecture on Clamped Plate Problem
Topic 4: Efficient Simulation of Photonic Metamaterials

Completed Talks and Projects:

Organizer Talks

- Shidong Jiang - Introduction on integral equation methods, fast algorithms, and the Hadamard conjecture
- Andreas Kloeckner - Introduction to singular quadrature, simulation of photonic metamaterials, and software frameworks for integral equation computations
- Xiao-Ping Wang - Introduction to interface problem and numerical methods
- Yang Xiang - Introduction to dislocation climb and numerical methods

Student Talks

- Quadrature by Multipole Expansion (Matt Wala)
- Integral Equation Methods for Vortex Dominated Flows, a High-order Conservative Eulerian Approach (Josh Bevan)
- Coupled Elliptic Solvers for Embedded Mesh and Interface Problems (Natalie Beams)
- Parallel algorithms for interface problems (Luo Li)

- Step bunching in epitaxial growth with elasticity effects and convergence from atomistic models to the Peierls-Nabarro model of dislocations (Tao Luo)
- Energy of low angle grain boundaries based on continuum dislocation structure (Luchan Zhang)
- Solving continuum dislocation and plasticity model using finite element method (Xiaoxue Qin)
- Dislocation climb models from atomistic scheme to dislocation dynamics (Xiaohua Niu)
- Normal mode analysis for nanoscale hydrodynamic model determination (Xiaoyu Wei)

"Integral Equation Methods…" Participants

Name	Organization
Natalie Beams	University of Illinois at Urbana-Champaign
Joshua Bevan	University of Illinois at Urbana-Champaign
Szu-Pei Fu	New Jersey Institute of Technology
Wei Hu	Hong Kong University of Science and Technology
Shidong Jiang	New Jersey Institute of Technology
Andreas Kloeckner	University of Illinois at Urbana-Champaign
Haohan Li	The Hong Kong University of Science and Technology
Tao Luo	The Hong Kong University of Science and Technology
Li Luo	The Hong Kong University of Science and Technology
Xiaohua Niu	The Hong Kong University of Science and Technology
Xiaoxue Qin	The Hong Kong University of Science and Technology
Manas Rachh	Yale University
Matt Wala	University of Illinois at Urbana-Champaign
Xiao-Ping Wang	The Hong Kong University of Science and Technology
Dong Wang	The Hong Kong University of Science and Technology
Xiaoyu Wei	The Hong Kong University of Science and Technology
Yang Xiang	Hong Kong University of Science and Technology
Luchan Zhang	The Hong Kong University of Science and Technology

Note: No exit surveys were collected for this program. The organizing committee's final report can be found in Appendix A

Phase Retrieval: Theory, Application and Algorithms

At HKUST: Jan 9-23, 2017; at ICERM: June 5-18, 2017

Organizing Committee

Bernhard G. Bodmann, University of Houston
Jian-Feng Cai, The Hong Kong University of Science and Technology
Peter G. Casazza, University of Missouri
Yang Wang, The Hong Kong University of Science and Technology

Description

This program will focus on phase retrieval, a research area introduced by Pete Casazza (one of the organizers of this program) and others. Phase retrieval originates from harmonic analysis, where one wants to recover a function from the magnitude of its Fourier transform without any phase information.

The phase retrieval problem has a natural generalization to finite dimensional Hilbert spaces. A finite dimensional signal is sought to fit the magnitudes of its linear measurements. Phase retrieval in this finite dimensional setting has become one of the growing research areas in recent years. The techniques from the finite dimensional setting are promising to become indispensable in many imaging techniques such as x-ray crystallography, electron microscopy, diffractive imaging, astronomical imaging, x-ray tomography etc. It also has other important applications in optics, communication, audio signal processing, and more. Many challenging and fundamental problems in phase retrieval remain open. For example, it is still unknown what is the minimal number of measurements needed for any d-dimensional signal is phase retrievable. A challenging problem of very practical importance is the computational efficiency of phase retrieval algorithms. So far, the existing phase retrieval algorithms can be loosely divided into three categories: (a) Using a very large number of measurements N, in the order of N>=O(d^2); (b) Convex relaxation algorithms using random measurements, and (c) Constructing special measurements that allow fast and robust phase retrievals.

The program will bring a group of researchers from the US and HKUST with common interests and complementary expertise to work intensely on new theory, applications and algorithms for phase retrieval.

"Phase Retrieval: Theory, Application and Algorithms" Participants

Name	Organization
Bernhard Bodmann	University of Houston
Sara Botelho-Andrade	University of Missouri - Columbia
Jian-Feng Cai	The Hong Kong University of Science and Technology
Peter Casazza	University of Missouri
Dylan Domel-White	University of Houston
John Haas	University of Missouri
Mark Iwen	Michigan State University
Zhenzhen Li	HKUST
Shuyang Ling	University of California Davis
Haixia Liu	The Hong Kong University of Science and Technology
Yi-Su Lo	The Hong Kong University of Science and Technology
Lizhang Miao	The Hong Kong University of Science and Technology
Josiah Park	Georgia Tech
Yi Rong	The Hong Kong University of Science and Technology
Ju Sun	Stanford University
Aditya Viswanathan	Michigan State University
Tianming Wang	The University of Iowa
Yang Wang	The Hong Kong University of Science and Technology
Ke Wei	University of California at Davis
Dongmian Zou	University of Maryland, College Park

Note: No exit surveys were collected for this program. The organizing committee's final report can be found in Appendix B.

Robust Methods in Probability & Finance

June 19 - 23, 2017

Organizing Committee

Tomasz R. Bielecki, Illinois Institute of Technology
Patrick Dondl, University of Freiburg
Philipp Harms, University of Freiburg
Eva Lutkebohmert-Holtz, University of Freiburg
Marcel Nutz, Columbia University
Thorsten Schmidt, University of Freiburg

Description

On financial markets one never observes the same data twice; market configurations are subject to change across time. This poses some specific challenges to inference, prediction, and optimal control in financial contexts. Classically, strong model assumptions are needed, while current research aims at methods which are robust with respect to model misspecification. This issue lies at the heart of the envisaged workshops, and the program of the workshops will reflect recent developments in this direction.

The last decade saw a rise of robust methods in probability and finance resulting in new numerical and theoretical challenges. Interestingly, these challenges bring together methodologies from PDEs, probability, stochastic analysis, and control theory. Mathematically speaking, robustness typically translates into nonlinearity showing up as a defining feature. Examples in this direction are nonlinear expectations, nonlinear PDEs, and H-infinity optimal stochastic control. Finance has a long tradition of fruitful interactions between these areas. Numerical results often build the first step for subsequent theoretical analysis (and vice versa), thus fitting specifically into ICERM's orientation towards computational and experimental research.

Topics of particular interest are dynamic and robust methods in the following areas: filtering, prediction, optimal control, calibration, pricing, risk management, and machine learning.

This workshop is held under the auspices of the VI-MSS program, in collaboration with the University of Freiburg. A follow-up activity in Freiburg is tentatively planned for spring 2018.

"Robust Methods in Probability & Finance" Workshop Participants

Name	Organization
Beatrice Acciaio*	London School of Economics
Tamer Basar*	University of Illinois at Urbana-Champaign
Tomasz Bielecki*	Illinois Institute of Technology
Rene Carmona*	Princeton University
Tao Chen	Illinois Institute of Technology
Igor Cialenco*	Illinois Institute of Technology
Sam Cohen*	University of Oxford
Rama Cont*	Imperial College London
Patrick Dondl	Albert-Ludwigs-UniversitÃ¤t Freiburg

Ibrahim Ekren*	ETH Zurich
Tolulope Fadina	University of Freiburg
Shibi Feng	Illinois Institute of Technology
Routing Gong	Illinois Institute of Technology
Jia Guo	University of Michigan
Philipp Harms*	University of Freiburg
Yicong Huang	Illinois Institute of Technology
Donghan Kim	Columbia University
Eva Lutkebohmert-Holtz	University of Freiburg
Ning Ning	University of California, Santa Barbara
Marcel Nutz*	Columbia University
Weijie Pang	Worcester Polytechnic Institute
Hyungbin Park	Worcester Polytechnic Institute
Thorsten Schmidt*	University of Freiburg
Glenn Shafer*	Rutgers Business School
Florian Stebegg	Columbia University
Yavor Stoev	University of Michigan
Stephan Sturm	WPI
Tushar Vaidya	Singapore University of Technology and Design
Gu Wang	Worcester Polytechnic Institute
Haoran Wang	The University of Texas at Austin
Yan Xu	Carnegie Mellon University
Yuchong Zhang*	Columbia University

*Workshop speaker

Some Workshop Organizer Comments for "Briefly describe workshop highlights":
"The presenters were internationally leading researchers and did a great effort to make nice presentations. The discussion atmosphere was great and very interactive Size was optimal and facilities just great."

"Interesting lectures of high caliber. Plenty of time for discussion and exchange of ideas."

Some Workshop Participant Comments for "Briefly describe workshop highlights":
"The workshop was on a very hot and timely topic "robust methods in finance" and personally I learned many new things and ideas."

"ICERM provided an opportunity to learn from leading experts in the area of mean-field games and its applications."

Note: The full exit survey for this event can be found in Appendix C.

Mathematics Institute Directors Meeting (MIDs) Minutes

See Appendix D for the May 2017 MIDs meeting minutes.

APPENDICES:

Appendix A: Organizer's final report for Integral Equation Methods, Fast Algorithms and Their Applications to Fluid Dynamics and Materials Science
Appendix B: Organizer's final report for Phase Retrieval: Theory, Application and Algorithms
Appendix C: Exit survey for Robust Methods in Probability & Finance
Appendix D: MIDS meeting minutes

NSF required materials also available in the appendix:

Appendix E: VI-MSS Participant List and Summary Table
Appendix F: VI-MSS Financial Support List
Appendix G: VI-MSS Income and Expenditure Report

APPENDIX A

Summary Report for the HKUST-ICERM VI-MSS Program: 'Integral Equation Methods, Fast Algorithms and Their Applications to Fluid Dynamics and Materials Science'

Xiao-Ping Wang, Yang Xiang, Shidong Jiang, Andreas Kloeckner

June 11, 2017

The HKUST-ICERM VI-MSS program on "Integral Equation Methods, Fast Algorithms and Their Applications to Fluid Dynamics and Materials Science" has been held at HKUST on January 2-13 and the ICERM on May 30-June 9, 2017. All participants would like to thank the ICERM and the HKUST for having provided a fruitful opportunity to collaborate and exchange ideas and kick-start a number of projects, an opportunity that would not have arisen without the generous financial support for the workshop. We all had a great experience and enjoyed friendly and relaxing research environment at both institutions. Many students participated in this workshop will graduate this summer. They thank the ICERM for providing a stimulating and collaborative environment during this final stage.

All participants have worked on collaborative projects in fluid dynamics and materials science in small groups. During the two stages of the program at HKUST and ICERM, the participants have given many seminars and informal talks, engaged in fruitful discussions on various research topics.

The topics of the talks given by the program organizers are:

1. Shidong Jiang - Introduction on integral equation methods, fast algorithms, and the Hadamard conjecture.

2. Andreas Kloeckner - Introduction to singular quadrature, simulation of photonic metamaterials, and software frameworks for integral equation computations.

3. Xiao-Ping Wang - Introduction to interface problem and numerical methods.

4. Yang Xiang - Introduction to dislocation climb and numerical methods.

The topics of the talks given by the student participants are:

1. Quadrature by Multipole Expansion (Matt Wala)
2. Integral Equation Methods for Vortex Dominated Flows, a High-order Conservative Eulerian Approach (Josh Bevan)
3. Coupled Elliptic Solvers for Embedded Mesh and Interface Problems (Natalie Beams)
4. An efficient threshold dynamics method for general interface motions (Dong Wang)
5. Brownian dynamics simulations of lipid bilayer membrane with hydrodynamic interactions in LAMMPS (Szu-Pei Fu)
6. Parallel algorithms for interface problems (Luo Li)
7. Step bunching in epitaxial growth with elasticity effects and convergence from atomistic models to the Peierls-Nabarro model of dislocations (Tao Luo)
8. Energy of low angle grain boundaries based on continuum dislocation structure (Luchan Zhang)
9. Solving continuum dislocation and plasticity model using finite element method (Xiaoxue Qin)
10. Dislocation climb models from atomistic scheme to dislocation dynamics (Xiaohua Niu)
11. Graph based segmentation and image processing (Haohan Li)
12. Normal mode analysis for nanoscale hydrodynamic model determination (Xiaoyu Wei)
13. Cahn-Hilliard Equation: Sharp interface limits (Wei Hu)

We have been (and will continue) working on the following joint projects.

1. **Efficient high order method for dislocation climb in three dimensions.**
   A preliminary code has been written for the problem and we will keep working on this problem after the workshop.

2. **Efficient boundary integral methods for threshold dynamics via the non-uniform FFT.**
   A paper titled "An Efficient Boundary Integral Scheme for the MBO Threshold Dynamics Method via the NUFFT" has been accepted by Journal of Scientific Computing. We are working on a subsequent paper on the extension of the algorithm to nonsmooth cases that may involve topological changes and the application of the algorithm to the wetting problem.

3. **Boundary integral equation methods for solving the Yukawa equation in three dimensions with applications to membrane simulation.**

4. **Integral equation solver for the Cahn Hilliard equation in the wetting problem.**
   We have found a stable second kind integral equation formulation for solving the Cahn Hilliard equation in the wetting problem. We are currently working on an efficient, high-order, parallel implementation of the integral equation formulation.

5. **Experiments on the Hadamard conjecture.**
   We have discussed how to implement a high-order and efficient numerical scheme for computing the Green's function for the clamped plate problem using integral equation methods during our meeting at the ICERM.

6. **Efficient and accurate modularization of photonic device simulation via integral equation methods and scattering matrices.**
   We have discussed the integral equation formulation for the dielectric photonic devices, worked out the scattering matrix formalism in detail, and started preliminary implementation of the whole scheme during our meeting at the ICERM.

7. **Robust image segmentation methods.**
   We have discussed robust image segmentation methods based on frac-

tional derivatives and threshold dynamics methods. Preliminary numerical formulation has been obtained. Numerical examples have been performed and have shown that the new method has many advantages compared with the existing ones.

We have created a website for all the participants to share their talk slides, to-do lists, and concrete timelines for some projects. The website is managed by Andreas Kloeckner. The aforementioned talks are stored online at the URL `https://ssl.tiker.net/nextcloud/index.php/s/3tOwBnN4pDbm1FK` and we are happy to have them posted on the related ICERM website so that they are accessible by the general scientific community. We will inform ICERM when the papers related to this workshop are published

Once again, organizers and participants would like to express their sincere gratitude towards ICERM and HKUST for providing the environment and means to initiate and sustain these exciting projects.

APPENDIX B

Summary of the ICERM/HKUST program
Phase Retrieval: Theory, Application and Algorithms

The ICERM/HKUST research program on *Phase Retrieval: Theory, Application and algorithms* was held at Hong Kong University of Science and Technology (HKUST) during January 9-20, 2017 and at ICERM during June 5-16, 2017.

The goal of this program is to bring a group of researchers from the US and HKUST with common interests and complementary expertise to work intensely on new theory, applications, and algorithms for phase retrieval. Some targeted problems are foundations of phase retrieval, efficient phase retrieval algorithms, generalized phase retrieval, and multiresolution phase retrieval. With this program, we hope to establish a long-term collaboration between the US and HK teams.

Researchers from HKUST and universities in US attended activities in this program. Participants of the HKUST workshop are Jianfeng Cai, Yang Wang, Zhiqiang Xu, Zhenzhen Li, Lizhang Miao, Haixia Liu, Yi-Su Lo, Yi Rong, Tianming Wang, Yimin Wei, Rui Zhang, Bing Gao, Pete Casazza, Janet Tremain, Bernhard Bodmann, Desai Cheng, Sara Andrade, John Haas, Dongmian Zou, and Dylan Domel-White. Participants of the ICERM workshop are Jianfeng Cai, Yang Wang, Zhenzhen Li, Lizhang Miao, Haixia Liu, Yi Rong, Bing Gao, Rui Zhang, Bernhard Bodmann, Mark Iwen, Desai Cheng, Sara Andrade, John Haas, Dongmian Zou, Dylan Domel-White, Wei-Hsuen Yu, Ju Sun, Shuyang Ling, and Ke Wei.

During this program, the participants are divided into several groups, and each group is assigned some research problems to solve. Below are some results obtained and progress made.

- **Foundations of phase retrieval.** Many recent results on phase retrieval aim for exact recovery of a vector, up to an overall unimodular factor, from the magnitudes of frame coefficients. When the number of measured coefficients is small, this leads to algebraic-geometric conditions that need to be satisfied by the frame. In a more generalized setting, the norms of the vector's projections onto subspaces is measured, which also leads to algebraic-geometric conditions that the subspaces need to satisfy. Part of the discussion in the workshops was dedicated to relating complex phase retrieval to real phase retrieval with projections onto two-dimensional subspaces. The main result from this discussion was that identifying complex lines with two-dimensional real subspaces did not provide a simple way to perform real phase retrieval, because the solutions remained underdetermined. Another part of the discussion was dedicated to approximate phase retrieval. In this part, the magnitudes of the frame coefficients or projected norms were assumed to be quantized and only an approximate solution was required. In analogy with works by Plan and Vershynin, approximate recovery from coarsely quantized norms of projections onto subspaces of a fixed fraction of the Hilbert space was derived.
- **Efficient phase retrieval algorithms.** Phase retrieval can be viewed as a special

case of low-rank matrix reconstruction. During the program, we adopted non-convex optimization methods for generic low-rank matrix reconstruction to phase retrieval. In particular, we modified the gradient descent algorithm on the Riemannian manifold of rank-1 matrices (RGrad) to phase retrieval problem. Numerical experiments demonstrate the advantage of the RGrad algorithm over state-of-the-art phase retrieval algorithms. Theoretically, we prove RGrad algorithm can have the exact phase retrieval with dominant probability from O(d) measurements. We are now writing a paper summarizing this result.

- **Generalized phase retrieval.** Generalized phase retrieval allows the magnitudes of linear measurements to be replaced by any quadratic measurements. So essentially we are asking the following: how can we recover a data point (unknown) from its quadratic measurements. This problem shares many similarities with the classical setting, but it is more complex and yields some surprises. In fact, the well-known phase retrieval from projections is a special case and few results were proved. During the program, especially the session in HKUST, we discussed some potential approaches that have eventually led to significant progress on the problem. We were able to solve the "minimal measurements" problem for phase retrieval by projection as a special case of a more general result. We introduced algebraic geometry techniques to resolve a large class of such problems, including problems in matrix completion, using algebraic geometry techniques. One of the best part about it is that the research has involved graduate student.
- **Multiresolution phase retrieval.** The work by Iwen and Viswanathan was considered as a starting point to developing compactly supported filters that allow phase retrieval within a multiresolution analysis structure. The current state of this project includes the recovery in shift-invariant spaces.

The phase retrieval problem arises in many computation-oriented applications, such as x-ray crystallography, electron microscopy, diffractive imaging, astronomical imaging, x-ray tomography, optics, communication, audio signal processing, and more. Therefore, computation and numerical experiments are indispensable tools for the research of phase retrieval, and they are intensively involved in our program. 1) To study the theoretical aspect of phase retrieval, some symbolic computations are used to construct examples to prove the phase retrievability for some particular dimensions and numbers of measurements. 2) One targeted problem is the efficient phase retrieval numerical algorithms. Computer simulations and numerical experiments are performed to test the effectiveness and efficiency of the proposed algorithms. 3) We also studied some problems beyond phase retrieval, where computer and experiment helped the research. For example, numerical computation with semidefinite programming and convex optimization are utilized to attempt to find the maximum equiangular lines in high dimensional Euclidean spaces.

In the future, the US and HK teams will continue to collaborate on the research of phase retrieval. Currently, there are some on-going collaborations initialized during the

program.

- Geometry of phase retrieval.
- Geometric conditions for approximate phase retrieval.
- Minimal measurements for phase retrieval by semidefinite programming.

tw17-6: Robust Methods Finance

tw17-6-rmpf

(51% Response Rate: 28/55)

Q2 - During this workshop, how satisfied were you with the opportunities to:

#	Question	Not at all satisfied - 1 -		- 2 -		Satisfied - 3 -		- 4 -		Extremely Satisfied - 5 -	
1	Ask questions and have scientific discussions	0.00%	0	0.00%	0	40.00%	2	27.78%	5	35.59%	21
2	Develop collaborations	100.00%	1	0.00%	0	40.00%	2	27.78%	5	33.90%	20
4	Make scientific connections	0.00%	0	100.00%	1	20.00%	1	44.44%	8	30.51%	18
	Total	Total	1	Total	1	Total	5	Total	18	Total	59

Q3 - During this workshop, how satisfied were you with the opportunities to:

#	Question	Not at all satisfied - 1 -		- 2 -		Satisfied - 3 -		- 4 -		Extremely Satisfied - 5 -	
5	Add to your knowledge of experimental/computational methodologies within this topic	50.00%	1	0.00%	0	62.50%	5	61.11%	11	39.29%	11
6	Add to your knowledge of theoretical developments within this topic	50.00%	1	0.00%	0	37.50%	3	38.89%	7	60.71%	17
	Total	Total	2	Total	0	Total	8	Total	18	Total	28

Q4 - Please describe how ICERM has (or has not) added to your knowledge of experimental/computational methodologies and/or theoretical developments within this topic.

The great number of talks and subsequent discussions during coffee or lunch breaks provided the perfect opportunity to enrich my knowledge on several topics within mathematical finance.
the workshop was on a very hot and timely topic "robust methods in finance" and personally i learned many new things and ideas.
ICERM provided an opportunity to learn from leading experts in the area of mean-field games and its applications.
Some of the talks were too technical, appealing only to an audience who had already seen the material several times. I suppose the speakers decided to talk about their own research and didn't communicate their ideas very well. The quality of presentations was overloaded with technical mathematical symbols and jargon and one didn't even have enough time to read a slide completely during the talks.

ICERM has provided with the opportunity for scientific networking and collaboration within the framework of robust finance.

Got introduced the most recent development in Mean-Field Games, which is something I'm interested in.

Q5 - Rate the importance of knowledge gained within this workshop topic that:

#	Question	Not at all important - 1 -		- 2 -		Important - 3 -		- 4 -		Extremely Important - 5 -	
1	Will advance your current research	0.00%	0	50.00%	2	54.55%	6	50.00%	8	48.00%	12
2	Will influence directions of your future research	0.00%	0	50.00%	2	45.45%	5	50.00%	8	52.00%	13
	Total	Total	0	Total	4	Total	11	Total	16	Total	25

Q6 - Rate the importance of the scientific connections made with other participants during this workshop that:

#	Question	Not at all important - 1 -		- 2 -		Important - 3 -		- 4 -		Extremely Important - 5 -	
1	Are relevant to your current research	33.33%	1	50.00%	2	30.00%	3	38.10%	8	30.43%	14
2	May influence directions of your future research	66.67%	2	0.00%	0	30.00%	3	33.33%	7	34.78%	16
3	Will become a part of your professional network	0.00%	0	50.00%	2	40.00%	4	28.57%	6	34.78%	16
	Total	Total	3	Total	4	Total	10	Total	21	Total	46

Q7 - How many new scientific connections did you make during this workshop?

#	Answer	%	Count
1	None	7.14%	2
2	1-5	60.71%	17
3	6-10	21.43%	6
4	More than 10	10.71%	3
	Total	100%	28

Q8 - Did you present a poster?

#	Answer	%	Count
1	Yes	0.00%	0
2	No	100.00%	28
	Total	100%	28

Q9 - How beneficial was the poster session to you?

#	Answer	%	Count
5	Extremely beneficial	0.00%	0
4	Very beneficial	0.00%	0
3	Beneficial	0.00%	0
2	Not very beneficial	0.00%	0
1	Not at all beneficial	0.00%	0
	Total	100%	0

Q10 - What, if any, suggestions do you have for improving the poster session experience?

None reported

Q11 - Briefly describe the highlight of this workshop for you:

First, the workshop itself is a highlight for me. Secondly, the topic inspires me a lot, not just in this field.
There were very good opportunities to discuss recent work and approaches to robust methods in finance.
- Stimulating and broad discussions after every presentation. - Good schedule which left time for further discussions. - Perfect seminar room and common space
The chance of meeting so many researchers and start what could hopefully be long term and fruitful relations was definitely the highlight for me
Interesting lectures of high caliber. Plenty of time for discussion and exchange of ideas.
extremly interesting and vivid discussuions
Making connections with other researchers for future collaborations.
The people were great, and ICERM's space is simply fantastic. A very comfortable place to discuss and work with peope!
The opportunity to discuss with great mathematicians within a very nice atmosphere. Especially as young researcher this opportunity is of great importance. This was also possible due to the well-planned time framework.

The overall organization was good. Staff were friendly.
Fantastic building, relaxed environment for discussion.
I was able to work over time with a co-author from London
I benefited tremendously from every session, and the presentation of my research work was the highlight for me.
The talk by Marcel Nutz

Q12 - What, if any, suggestions do you have for improving participants' research experiences during workshops?

For the contributed talks, can we see the slides or titles in advance? I don't think I found it on the website.
I think the organization was truly impeccable, the only thing I can think of is the AC. Sometimes it was "friezing" in the lecture hall
air condition at the first day was far too cold
It would be great to have an informal dinner or evening outing to network with other participants.
Perhaps more (and easier to find) outlets for charging laptops.
Better regulation of the air condition. Especially at the first day, it was so cold that a lot of people were freezing.
Maybe have a chair who asks participants during the event that they are making scientific connections and pair up people. Ensure comfortable seating. During the talks the seating was unbearably uncomfortable. The chairs should have more padding.
Organize lunch so that young researchers have more opportunity to talk to established researchers.

Q13 - I am a:

#	Answer	%	Count
1	Tenured Faculty	32.14%	9
2	Tenure-track Faculty	7.14%	2
3	Non Tenure-track Faculty	7.14%	2
4	Postdoctoral Fellow	17.86%	5
5	Graduate Student	32.14%	9
6	Undergraduate Student	3.57%	1
7	National Lab Scientist	0.00%	0
8	Non-academic Researcher	0.00%	0
	Total	100%	28

Q14 - Are you one of the organizers of this workshop?

#	Answer	%	Count
1	Yes	17.86%	5
2	No	82.14%	23
	Total	100%	28

Q15 - As an organizer, overall how satisfied were you with how well the scientific goals of this workshop were met:

#	Answer	%	Count
5	Extremely satisfied	100.00%	5
4	Very satisfied	0.00%	0
3	Satisfied	0.00%	0
2	Somewhat dissatisfied	0.00%	0
1	Not at all satisfied	0.00%	0
	Total	100%	5

Q16 - From the perspective of an organizer, briefly describe the ways in which your scientific goals for this workshop were met, or not:

The presenters were internationally leading researchees and did a great effort to male nice presentations. The discussion atmosphere was great and very interactive Size was optimal and facilities just great

Q18 - Please tell us your gender:

#	Answer	%	Count
1	Male	75.00%	21
2	Female	21.43%	6
3	Decline to respond	3.57%	1
	Total	100%	28

Q19 - Please tell us your race/ethnicity, checking all that apply:

#	Answer	%	Count
1	American Indian or Alaskan Native	0.00%	0
2	Asian	37.93%	11
3	Black or African American	3.45%	1
4	Hispanic or Latino	3.45%	1
5	Native Hawaiian or Other Pacific Islander	0.00%	0
6	White	51.72%	15
7	Decline to respond	3.45%	1
	Total	100%	29

Position

Answer	%	Count
Faculty	46.43%	13
Graduate Student	35.71%	10
Postdoctoral Fellow	14.29%	4
Undergraduate Student	3.57%	1
Total	100%	28

Role

Answer	%	Count
ATTENDEE	60.71%	17
ATTENDEE,ORGANIZER	3.57%	1
ATTENDEE,ORGANIZER,SPEAKER	14.29%	4
ATTENDEE,SPEAKER	21.43%	6
Total	100%	28

2017 Math Institute Directors Meeting
Statistical and Applied Mathematical Sciences Institute (SAMSI)
19 T.W. Alexander Drive, RTP, NC, 27709
April 28-29, 2017

Meeting Minutes

DAY 1, Friday April 28, 1:15-4:45pm (Room 150, SAMSI)

Meeting was chaired by **Robert Calderbank** (Duke University and Chair of SAMSI Governing Board)

Attendees:
AIM: Brian Conrey and Estelle Basor
IAS: Richard Taylor
ICERM: Brendan Hassett
IMA: Daniel Spirn
IPAM: Russ Caflisch and Christian Ratsch
MBI: Tony Nance, Greg Rempala,
MSRI: David Eisenbud and Hélène Barcelo
SAMSI: Richard Smith and Sujit Ghosh
Additional Guests: Ilse Ipsen and Thomas Witelski (SAMSI Assoc. Dir.s), Peter Mucha (UNC), Mike Reed (MBI, Duke University)

Agenda items and discussions:

1. **Introductions**

2. **Approval of 2016 minutes:** 2016 MIDs Minutes were approved.

3. **Discussion of Math Institute (MI) activities and issues, positive experiences and continuing challenges**: The chair solicited inputs and remarks and following items were brought up by the participants:

   - **Online Colloquium at MBI**: A new MBI activity was described by Mike Reed: the National Mathematical Biology Colloquium initiated in the Fall of 2016. Talks by prominent speakers are broadcast over the web on a regular monthly schedule. The Bluejeans web-conferencing system is used and allows for questions to be texted or

voiced live by the real-time audience (handled by a moderator). MBI purchased time on the company's webservers to ensure good bandwidth for high-quality broadcasting. Scheduling at noon Eastern Time (ET) allows for viewers on the west coast and in Europe as well. The speakers can present from their home-institution office (avoiding the need for travel makes it easier to get high profile speakers). The web-broadcast makes it possible for the talk to reach students and faculty at a very broad range of schools that might otherwise not be able to attract the speakers to visit. The series will continue in Fall 2017. The Bluejeans system has also been used by other institutes for some of their meetings. Folks interested to use such web-based facilities are encouraged to contact MBI.

- **Unique identifiers for participants**: ORCID (https://orcid.org/) was discussed as system for uniquely identifying participants in MI activities. ORCID ID numbers will soon be a requirement for reimbursement for participants from NSF funds. Questions were raised about ease of use and whether the system can avoid duplicate records. The fundamental question of interest was identified as understanding NSF's interests and goals in making use of ORCID for evaluating MI activities. It was also pointed out that some journals in mathematical sciences and other interdisciplinary sciences are also requesting authors to provide ORCIDs.

- **Evaluation Metrics for MIs**: Further discussion relating to evaluating MI activities touched on MI's missions in core research programs and being one of NSF's mechanisms for reaching the broader mathematics community (people not having their own NSF funding) (including outreach to under-represented groups). For several years, DMS contracted with the Science and Technology Public Institute (STPI) to coordinate an evaluation of the full institutes portfolio, but this effort had been abandoned after the attempt to conduct randomized surveys did not produce useful results. Nevertheless, it's possible that the next DMS director will want to revive the process. It was pointed out that highlighted case study stories and notable ancedotal descriptions or blogs (e.g., SAMSI regularly posts blogs written by its participants) might be of more impact value than tabulated statistics on participants. There were some concerns raised about how effective the MathInstitutes.org website might be at presenting these activities.

- **Coordination among Math Institutes Activities:** Cooperation and coordination among the MI's included activities for the Math of Planet Earth, the Institutes Postdoc program, the MI Diversity committee and the MIDS meeting itself. It was noted that the idea for an annual MIDS meeting originated with former DMS Director Philippe Tondeur, who envisioned that it would serve as a leadership council for the US Mathematics community, but the role has evolved and become

more specialized over the years. However avoiding scheduling of similar programs seemed a sensitive topic which has previously received criticism (and has practical issues in terms of burning out the key researchers in given topic areas). MSRI and the Fields Institute maintain lists of recent/upcoming programs shared among NSF-MI's (MSRI) and other North-American MI's (Fields).

- Overall, DMS seem to support the idea of institutes working together (the whole being bigger than the sum of its parts) but the message has been mixed. For example, there was a proposed collaboration among IPAM, IMA and ICERM that would have looked at inverse problems with oil industry funding, but DMS did not support this.

- **Funding Raising Activities**: Discussion of partnerships that the MI's can have with industry and other funding sources was raised in light of concerns about flat or decreasing NSF funding. Challenges in raising money arise from seeking to fit in with parent university's strategic plans while maintaining focus serving the public-good at the national level for the mathematics community. Building endowments allowing for the MI's to become independent of NSF funding feels out of reach for almost all MI's.
- Discussion continued on whether NSF might help facilitate MI's forming partnerships with outside entities (industry, others?). Background was given about past NSF views on providing finite-term seed money with goals of MI's becoming self-sustaining in the long term. This seems challenging to achieve in the current financial climate. With some exceptions (e.g., IMA), support from companies is becoming more difficult to secure and issues like ownership of intellectual property can be significant problems.

4. **The state of the MathInstitutes.org website:**
   - Some directions for improvement were identified in the 2016 MIDS meeting and some changes have been made.
   - The diversity pages are still in need of improvement to make them more visually appealing, lively and compelling (adding stories, videos, etc.). These pages seem to play a very important part in DMS's overall diversity activities. DMS have expressed concerns that diversity activities of the MIs are not well broadcast via the mathinstitute.org site and more work is needed to revamp the diversity pages. E.g., stories, feedback from participants, blogs which are sometimes available in the individual institute website can be re-posted on the mathinstitute.org diversity webpage (see the blog written by Jessica Matthews, a participant of the Spring Opportunities workshop at SAMSI)
   - Grant supplements may be needed to hire web-design/IT-support to implement more significant changes (improving searching of video archives was one area

noted). ICERM staff can handle routine maintenance but some requested changes would require hundreds of man-hours and this cannot be done as part of their regular duties.

- Obtaining input from NSF on what kind of changes would be helpful was emphasized.
- There is a strong need for all MI's to contribute more content to be posted on the website.

5. **The MI Diversity Committee report**: Helene Barcelo provided overview of the MI diversity activities and following items were discussed:
   - The 2012-16 NSF supplement managed by MSRI supported various conferences and activities coordinated by the Diversity Committee including the Modern Math Workshop, the Blackwell-Tapia Conference, the Infinite Possibilities Workshop and the Spring Opportunities Workshops (a complete list is available on the MI diversity website: https://mathinstitutes.org/diversity/)
   - The supplement was extended by only one year during 2016-17 while MSRI went through its renewal process, but after that was completed, the Diversity Committee put together a proposal for a further 4-year supplement. The first version of the proposal was asked to be withdrawn and NSF asked for more detailed documentation of prior MI diversity activities. The MI diversity committee coordinated with each of the MIs in collecting more details of about the diversity workshops and activities, the proposal was revised and resubmitted and subsequently funded at the requested level.
   - In anticipation of the uncertain amount of funding available for 2016 (while the proposals were being evaluated by NSF), some of the major diversity workshops in 2016 (e.g., Spring Opportunities, MMW, Blackwell-Tapia) spent less amount than those originally allocated, which resulted into a surplus. The diversity committee finds that if we take into account the surplus from previous grant and keep underspending throughout the next 4-year cycle, the projected amount of surplus will be close to $100K. So, the diversity committee solicited ideas for including new diversity initiatives
   - There has been dissatisfaction with holding the MMW at SACNAS due to the logistics of supporting students which is partly managed by SACNAS, but after fruitful coordination between the current SACNAS annual conference management team and MI diversity committee, this has now been resolved and the 2017 MMW will continue to be part of the SACNAS meeting.
   - Russ Caflisch reported on IPAM's organization of the "Latinos in the Mathematical Sciences Conference," informally known as Lat@Math. The first installment of this conference took place in 2015 and the second is scheduled for March 8 - 10, 2018.

The earlier conference had an organizing committee led by Alejandro Adem, Ricardo Cortez and Tatiana Toro, though Alejandro has since left the committee. There was an excellent line-up of speakers including Ana Mari Cauce (President of the University of Washington), Terrence Tao and Erika Camacho. However, it's not so easy to find funding because companies don't seem very interested in sponsoring this kind of activity. For example, it was pointed out that Google has funding for societal projects but not for science. The long-term plan is to repeat the conference at 3-year intervals at rotating locations. After further discussion the following motion was proposed and approved: the Diversity Committee is authorized to spend $50,000 from the current Diversity Grant budget to fund the 2018 conference. It was decided to forward this request to NSF IMT for their approval on the Day 2 of the meeting.

6. **Other items**:

(i) **Department of Justice Ruling**: UC Berkeley has deleted some online content (or put it behind a University-only accessible firewall) in response to an ADA (Americans with Disabilities Act) lawsuit on accessibility of the video contents.

- IAS was not concerned about this. It was informed that posting videos on Youtube covered them sufficiently (Youtube has some automated means of generating captioning for videos, which may or may not be sufficient for this purpose.)
- At SAMSI, contacts with Duke indicate that the University is formulating policies on this issue, but is currently not very concerned and believes existing videos can remain, but new videos may have to meet some compliance standards by 2018.…though it is not clear yet exactly what is needed. Duke believes that SAMSI's current website should be acceptable for ADA expectations for now.
- AIM will be running a workshop on Web accessibility of Mathematics (May 21-25, 2018). So it is good to tell NSF that the MI's are concerned with this issue and are taking steps to be on top of it.
- The use of Youtube and other commercial web platforms for distributing content may be useful for shielding the MI's from some issues being litigated regarding web based materials.

(ii) "**Video nuggets" (video highlights)** – short videos rather than text-based descriptions may be a valuable new way to convey information about notable activities and outcomes. For short videos (3-minutes or less are appropriate), good (near-professional) quality production/editing are feasible. Some activities by the iiD center at Duke have been asked students to record and produce such "micro-documentaries". It was suggested that a Youtube channel could be established for

all MI videos. A question should be put to the NSF IMT about their preference and guidance for such videos vs. old-style text-based highlights.

(iii) **New NSF solicitation for MI's**. There will be no more mid-term site-visits. All MI's would be synchronized on the same 5-year cycle with no stagger. 2020 would also coincide with Phase II of the TRIPODS proposals. There were concerns about logistical issues in the review process, specifically how NSF would manage potentially 10 or 12 site visits during a 3-month period, but the motivation for the new schedule was understood to be encouraging frequent and active competition. Questions should be put to the IMT on their expectations for this process.

(iv) **Cost-sharing** continued to be an area needing more clarity on what is being encouraged and what is prohibited in preparation of proposals. TRIPODS centers were also discussed as channels for collaboration (and possible competition) for the MI's in the area of data science.

(v) **FOIA requests**: Several MI's noted that they received FOIA (Freedom of information act) requests for copies of their proposals – all coming from the same journalist.

7. **Questions to be posed to the NSF Institutes Management Team** (IMT) were drafted and following questions were shared with the NSF IMT before Day 2 meeting:

   i. What are NSF thoughts about creating unique identifiers?
   ii. Math Institute Diversity committee has some surplus budget and would like to use $50K towards sponsoring "LatMath" workshop to be held at UCLA in 2018 (hosted by IPAM). MIDs have unanimously voted in favor of this. Would NSF have any objections?
   iii. What synergies would you like to see across the Math institutes?
   iv. What items have you significantly changed in the new NSF solicitation for the Math institutes?
   v. Can you describe the process of proposal evaluation for the Math Institutes?
   vi. How can we help with creating video nuggets using some of the advanced technologies?
   vii. Some institutes have been told they should aggressively pursue alternative funding strategies. What are NSF expectations in this regard for the 2019 institutes competition?
   viii. What are NSF's views about the relationships between TRIPODS and Math Institutes?
   ix. Can you please enlighten us about the hiring process of the next DMS director?

2017 Math Institute Directors Meeting
Statistical and Applied Mathematical Sciences Institute (SAMSI)
19 T.W. Alexander Drive, RTP, NC, 27709
April 28-29, 2017

Meeting Minutes
DAY 2, Saturday April 28, 9:00-11:45am (Room 150, SAMSI)

Meeting was chaired by **Robert Calderbank** (Duke University and Chair of SAMSI Governing Board)

Attendees:
AIM: Brian Conrey and Estelle Basor
IAS: Richard Taylor
ICERM: Brendan Hassett
IMA: Daniel Spirn
IPAM: Russ Caflisch and Christian Ratsch
MBI: Tony Nance, Greg Rempala,
MSRI: David Eisenbud and Hélène Barcelo
SAMSI: Richard Smith and Sujit Ghosh
NSF: Christopher Stark, Joanna Kania-Bartoszynska, Nandini Kannan,Tie Luo, Henry Warchall and Michael Vogelius
Additional Guests: Ilse Ipsen and Thomas Witelski (SAMSI Assoc. Dir.s)

Agenda: NSF IMT personnel presented information on various topics of interest and responded to questions posed by the MI directors (not necessarily in the order the questions are listed on the Day 1 meeting minutes):

Following questions prepared by the MI Directors were shared with the NSF Institute Management Team (IMT) representatives attending the meeting:

i. What are NSF thoughts about creating unique identifiers?
ii. Math Institute Diversity committee has some surplus budget and would like to use $50K towards sponsoring "LatMath" workshop to be held at UCLA in 2018 (hosted by IPAM). MIDs have unanimously voted in favor of this. Would NSF have any objections?
iii. What synergies would you like to see across the Math institutes?
iv. What items have you significantly changed in the new NSF solicitation for the Math

institutes?

v. Can you describe the process of proposal evaluation for the Math Institutes?
vi. How can we help with creating video nuggets using some of the advanced technologies?
vii. Some institutes have been told they should aggressively pursue alternative funding strategies. What are NSF expectations in this regard for the 2019 institutes competition?
viii. What are NSF's views about the relationships between TRIPODS and Math Institutes?
ix. Can you please enlighten us about the hiring process of the next DMS director?

The following items came out of brief presentations by the DMS IMT presentations:

1. There was interest in projections for the NSF and DMS budgets in the upcoming Federal budgets, but no further information beyond what was publicly known from news coverage was clear. The DMS budget for FY18 (up to 9/30/2018) should be known by the end of May 2017. Within DMS, the Math Institutes (MI) program is highly valued and this point of view is expected to continue under future DMS directors.

2. The new TRIPODS proposals (supported jointly with CISE) will be treated as part of the DMS MI portfolio, along with a new DMS institute solicitation involving a partnership with a private foundation; a call for proposals to be put out soon. Uncertainties in the upcoming NSF budgets won't affect these plans, which are considered as existing activities.
   Post meeting note: The new solicitation has now been released:
   https://www.nsf.gov/pubs/2017/nsf17560/nsf17560.htm

3. IMT will be in charge of TRIPODS. There will be 8-10 centers for the first phase (3 yrs, next phases are 5 yrs each). TRIPODS centers are expected to be smaller in scale/funding, will not be part of the MIDS meetings.

4. DMS is moving the location of its offices in late August or early September to Alexandria. The grants and agreements division is moving earlier (in June). They are aiming to get as many award letters as they can out by that date.

5. From now on, the MI program will be an open competition each 5 years. For the next round, proposals will be due in early 2019, with a letter of intent in December 2018. There will be greater emphasis on the panel reviews and only those institutes that are highly recommended will receive site visits, to limit the number of site visits needed (likely around 7 site visits in fall 2019 after the initial panel reviews). There will no longer be midterm site visits, instead DMS representatives will be more involved in advisory boards for each of the MI's. The switch to a 5-year cycle was viewed as highly desirable by the mathematics community and NSF's Board of Visitors for timely response to new

ideas.

6. The budget for the MI program is about $30 Million per year with each award being in the range of $5M per year (some bigger/smaller), $30M=$5M x 6MI's. There is no pressure to create a new institute, but the community wants flexibility to let things evolve. DMS actions are not directed to save money, but to allow for evolution within the current budget levels.

7. Questions arose about partnerships and expectations for cost-sharing.
   (i) NSF's rules on cost-sharing are to prevent wealthier universities from having strong advantages over smaller schools.
   (ii) There will be MOU's defining firewalls on activities being supported from NSF budgets vs activities from private foundation funding and their rules. Budgets and funding will not get co-mingled.
   (iii) Dollar amounts of any cost-sharing can NOT be included in proposals or letters of support, or anywhere in the budget justification. Some general terms about cost-sharing can be mentioned in the proposal but no specifics should be included. The tone was “Don't brag about money, brag about activities, successes, and output.” Avoid issues connecting to Federal spending rules.
   (iv) The new MI CFP has no rule changes in this area from the previous call for proposals.

8. Changes in the new solicitation for MI's were noted:
   - Language is included to ensure that the MI won’t be just of narrow interest to one university. It needs to serve the broad national interest and have nationwide recruiting. All current MI's are fully compatible.
   - There's a new list included of strengths for MI's – not ALL things are expected to be covered by a single MI, they are just examples of typical traits being sought.
   - Participant expenses cannot be reimbursed from NSF funds without ORCIDs. The purpose is to help manage participant data collection.

9. There was an extended discussion about ORCID and participant data collection:
   - A DMS working group with representatives from MIs will be formed to discuss issues and logistics on collecting participant data: how to feasibly collect data and what data is being asked for that can be done across all institutes. It was concluded that we really need to ask all current items about participants in order to continue various metrics of impact. The number of questions can’t be reduced, but at least no new questions are being added.
   - Collection of data has been recognized as a challenge, it is also a challenge for NSF to process the spreadsheets by MI's in annual reports. This has motivated exploring options for better data management, but there has been slow progress on selecting

a system.

- One option is to copy the approach from REU sites: undergraduate students applying for any REU program will register at a central NSF web portal.
- At the Institutes level, people who want to attend a program at one MI, say IPAM, would be directed to the mathinstitute.org website and use a centralized system to fill in the data that NSF wants and then the site send them back to IPAM to fill in further information (housing, dates, etc) needed by IPAM. This kind of common portal system lets NSF get data directly without intermediate steps of MI's needing to report data. MI's workload would be reduced to just financial reporting in each annual report.
- A mock-up of a registration portal was set up as a Google Docs form: https://goo.gl/forms/RCfI5FB1lz6gV6sy1 was illustrated by Hank Warchall.
- There was a very lively discussion of various practical considerations:
    - Walk-in participants at workshops could register on-site at a computer at the registration desk.
    - People that applied but end up not attending should not be registered.
    - A question was raised: Doesn't this system add more stages to the registration process? It seems to add to the burden involved for participants while only making work for MI's slightly easier.
    - If participants' information is saved in the system, it means they would only have to enter it once (or occasionally edit it), which should overall save time for participants.
    - There were concerns expressed about participants forgetting ORCID accounts or having multiple accounts. It was shown that the ORCID registration process was very short and thereafter, one's ID number is information publicly available on the ORCID system.
    - There were still concerns about MI's efforts and use of IT employees to ensure data integrity.
    - NSF's participant registration data would be made available to all MI directors.
    - ORCID will become required for NSF reimbursement of participants. It is currently optional for PI's but may become required in the future. A similar requirements are also being demanded by some of the journal publishers.
    - Tracking ORCID IDs is separate from the idea of having a centralized MI registration portal.
    - DMS has an interest in doing long-term tracking of people's involvements in programs over the years.
    - DMS recognizes the need to clean up the data that will be collected.
    - The imagined registration portal will be supported by a grant supplement

from the NSF to one of the MI's.
- NSF is less concerned about the data of foreign participants.

10. Many of the planned questions (from Day 1) to be posed to the NSF were already covered during the course of the earlier discussion.

11. The diversity committee described the Latinos in the Mathematical Sciences Conference (Lat@Math) to be held at UCLA in 2018 and requested NSF's approval to use money from their budget to support the workshop. NSF was very supportive and welcomes new initiatives from the diversity committee to increase diversity beyond the continuation of the previously defined workshop series.
    Diversity activities were acknowledged as a challenge and 'out of the box' thinking was encouraged to experiment with new approaches. Award supplements can be requested for additional activities. [Support for Lat@Math was approved.]
    There will be a forthcoming CFP for bridge programs to connect undergrad education to graduate school training, support coming from DMS and EHR. EHR is more focused on scalability and assessment aspects while DMS prioritizes quality in mathematical contents. So, co-funding is very possible for further diversity activities.

12. The outgoing DMS director (Michael Vogelius) was asked about how his ideas on math at the NSF have evolved.

    The advertisement for the next director has been posted. MV found the position to be an important public service. He didn't come in with pre-set ideas on mathematical focuses within DMS. There was an opportunity to look at how the MI program could evolve.
    The MI directors also provide important service to their mathematical communities. Philippe Tondeur was held up as a role model for directors.

    Increasing opportunities in the field of mathematical sciences will be accomplished by increasing interdisciplinary studies rather than have different divisions competing against each other for more of NSF's budget. Co-funding like "Math+X" includes Math+Data, Math+Education, Math+Bio and others. The focus is funding of good science and math can then gain support from other sources. DMS's size is unlikely to grow within NSF.

    Hank Warchall was noted for his efforts in creating the EDT program. There will be a new DMS-funded internship program with a new portal from the Oak Ridge institute for science education to enable graduate students to apply for internships at national labs. Later it may be expanded to connect to opportunities at private companies too. It will

include matching/screening mechanisms. It has received a lot of interest from grad students. The internships are very good broadening experiences for students, beyond just working with an advisor. This program will also try to reach pure math students. That will be a bit harder to make that work, but we are trying to show people more career options and paths forward.

13. There were questions about how institutes could best demonstrate their collective impact on the mathematical sciences community.

    Research highlights (no longer called "nuggets") are very useful. Ultimately these go to several places including the NSF Office of Legislative and Public Affairs and the NSF home page.

    The mathinstitute.org diversity activities webpage is very important. More highlights should be added there. Adding videos and blog posts would be great.

    Short reports (white papers) from program organizers on open problems, trends in the field and high level perspectives would also be very good. These would be important online resources for the community. Also having good archives of lectures, slides and other materials. Some specifics that were mentioned were the AIM problem lists and MSRI resources.

    Feedback was sought on any particular types of activities that worked notably well and should be pursued more frequently.

    Long-term impact was recognized as being difficult to track and requiring sustained efforts and longitudinal studies to follow downstream activities and citations of papers for several years.

    SAMSI will share information about a participant survey that it had done, it included questions on new collaborations and new directions in research as impacts on participants.

    There was discussion about how valuable it could be to present narratives of notable activities and individual case studies where developments in mathematics have directly led to new technological advances or patents. Tracing back the connections to the original motivating sources would bring together many people and fully illustrate the broader impact. Such narrative stories could resonate more with Congress and other decision makers. They may very positively complement existing quantitative measures

of activity. Showing direct impacts on science and impacts on people is very valuable.

The NSF Office of Legislative and Public Affairs has professional writers that could be put in touch with MI directors for developing such presentations.

There are organizations like the Coalition for National Science Funding that lobby in favor of funding research, but in general it can be very difficult to make impact on Congress. Sustained efforts in inviting local Congress-people to notable events might be helpful.

Public events may not have immediate scientific impact, but they are still very good on the communicating the goals of activities. The work of the Diversity Committee and other joint efforts to broaden participation have also been very good. Real life individual stories could be highlighted. There may be avenues for interacting with NSF-EHR.

14. In the past, the MI directors have acted as an informal advisory group to the DMS. They help the director by channeling community input. It is important for the MI's to maximize intellectual breadth and avoid duplication. There have been no problems lately, but there should be continued attention to avoid overlap in planned programs. The NSF strongly relies on the MI's providing participant data and activity highlights.

15. There was further interest in understanding the relations between the Math Institutes and the new TRIPODS institutes.

    The first round of TRIPODS awards will support 8-10 institutes. These will be smaller than the MI's. The second round will have fewer institutes remaining, but they will grow larger. Big data is an important area and DMS wants to be involved in data science and having good partners in computer science. The Phase II proposals must include some people from Phase I proposals, but they don't have to be involved all the way from the beginning. TRIPODS is hoped to improve the math/stat footprint in data science. People in math/stat know how to study and formulate right questions for data collection, these may complement the skills of researchers from computer science. MIs are encouraged to get involved where there is an overlap of research interests in the data science field.

    Phase II of TRIPODS will occur at the same time as the 2019 MI proposals, but the two programs are separate (DMS+CISE collaboration vs DMS-only). The current plans for funding TRIPODS only cover the initial 3+5 year periods.

16. The schedule for the 2018 MIDS meeting was briefly discussed. It will be next held at AIM. A poll will be conducted by AIM representative via email or other means. Potential

dates were floated: April 26-27, 2018 or the first weekend in May 2018.