

Institute for Pure and Applied Mathematics, UCLA
Final Report for 2014-2015
Award #0931852
November 30, 2016

TABLE OF CONTENTS

EXECUTIVE SUMMARY	2
A. PARTICIPANT LIST	3
B. FINANCIAL SUPPORT LIST	3
C. INCOME AND EXPENDITURE REPORT	3
D. POSTDOCTORAL PLACEMENT LIST	5
E. INSTITUTE DIRECTORS' MEETING REPORT	5
F. PARTICIPANT SUMMARY	9
G. POSTDOCTORAL PROGRAM SUMMARY	11
H. GRADUATE STUDENT PROGRAM SUMMARY	12
I. UNDERGRADUATE STUDENT PROGRAM SUMMARY	13
J. PROGRAM DESCRIPTION	14
K. PROGRAM CONSULTANT LIST	46
L. PUBLICATIONS LIST	48
M. INDUSTRIAL AND GOVERNMENTAL INVOLVEMENT	49
N. EXTERNAL SUPPORT	50
O. COMMITTEE MEMBERSHIP	51
P. CONTINUING IMPACT OF PAST IPAM PROGRAMS	52

Institute for Pure and Applied Mathematics, UCLA
Final Report for 2014-2015
Award #0931852
November 30, 2016

EXECUTIVE SUMMARY

This is the final report for the grant. We received a no-cost extension to allow us to spend unused funds after August 31, 2015. We estimate that about a third of our activities in 2015-16 were supported by the remaining funds from this grant; therefore we are including the first four months (through Dec. 31, 2015) of the 2015-16 year in this report. This report, then, covers IPAM's activities taking place between Sept. 1, 2014, and December 31, 2015 (which we will refer to in this report as the reporting period).

IPAM held three long programs during the reporting period. Each long program included tutorials, several workshops, and a culminating retreat. Between workshops, the participants planned a series of talks and focus groups.

- Mathematics of Turbulence (fall 2014)
- Broad Perspectives and New Directions in Financial Mathematics (spring 2015)
- Mathematical Challenges in Traffic Flow Management (fall 2015)

Scientific workshops in this reporting period included:

- Multiple Sequence Alignment
- Symmetry and Topology in Quantum Matter
- Computational Photography and Intelligent Cameras
- Zariski-dense Subgroups
- Machine Learning for Many-Particle Systems

IPAM held six “reunion conferences” for four long programs: Plasma Physics, Materials Defects, Interaction between Analysis and Geometry, and Materials for Sustainable Energy. They are held at UCLA's Lake Arrowhead Conference Center.

In the summer of 2015, three student research programs were offered - RIPS-Hong Kong, RIPS-LA and Graduate-level RIPS in Berlin – along with a summer school entitled “Games and Contracts for Cyber-Physical Security.”

IPAM held several “special events” during the reporting period, including two large diversity conference, and several one or two day events:

- Blackwell-Tapia Conference and Awards Ceremony
- Grad School and Beyond: Advice for the Aspiring Mathematician (undergraduate event)
- Latinos/as in the Mathematical Sciences Conference
- Inaugural National Meeting of Women in Financial Mathematics

- Mathematical Sciences Internship Workshop
- IPAM's 15th Anniversary Event

IPAM's programming for women included the Women in Financial mathematics meeting mentioned above as well as a women's luncheon during a Mathematics of Turbulence workshop, and a women's breakfast during the Latinos in Mathematics Conference.

With the other NSF math institutes, IPAM co-sponsored the Modern Math Workshop at SACNAS (October 2014 and 2015) and shared a booth in the exhibit hall.

The Green Family Lecture Series in 2015 featured Andrew Lo, director of MIT's Laboratory for Financial Engineering.

IPAM hosted the Transforming Post-Secondary Education in Mathematics (TPSE) meeting in February of 2015.

In 2014, Leland Wilkinson and Nancy Potok joined the Board of Trustees, and Iain Couzin joined the SAB.

IPAM became UCLA's first Zero Waste Pilot Program site in early 2015.

A. PARTICIPANT LIST

A list of all participants in IPAM programs were provided in electronic form (Excel). The list includes participant lists for programs whose start dates fall between September 1, 2014 and August 31, 2015.

B. FINANCE SUPPORT LIST

A list of participants that received support from IPAM was provided in electronic form (Excel). The list includes all funded participants of programs that occurred between September 1, 2014 and August 31, 2015.

C. INCOME AND EXPENDITURE REPORT

This table covers years September 1, 2010 through August 31, 2016 for grant #0931852. IPAM received a five-year grant ending August 31, 2015 and received a one-year No-Cost Time Extension through August 31, 2016.

Budget Category	Appropriations	Expenses through August 2016	Balance as of August 2016
A. Operations Fund	\$7,561,470	\$8,113,036	<\$551,566>
B. Participant Costs	\$11,150,000	\$10,661,213	\$488,787
C. Indirect Costs	\$3,857,270	\$3,939,203	<\$81,933>
D. Program Income	\$144,712	Note 1: \$0	\$144,712
Totals	\$22,713,452	\$22,713,452	\$0

IPAM received funding of \$22,500,000 for the first five years of this grant (\$4,500,000 annually for five years). IPAM also received supplemental grants totally \$68,740 for special projects requested by the NSF. Lastly, program income of \$144,712 was earned during the grant. Accordingly, total appropriated funds are \$22,713,452. IPAM received a one-year no cost extension through August 31, 2016. All appropriated funds were spent on the project. Total expenditures were \$22,713,452 leaving a balance of zero at August 31, 2016.

Expenditures for the six years ended August 31, 2016:

- A. The Operations Fund is composed of salaries, benefits, equipment, supplies, and travel.
- B. Participant Support Costs include stipends, travel, housing, and subsistence for the scientists working on IPAM Programs. IPAM also conducts a nine-week intensive applied mathematics research program for undergraduates called Research in Industrial Projects for Students (RIPS). We typically offer nine industrial projects to 36 students. IPAM covers all costs for students to participate in this program including travel, housing in dormitories, a stipend of \$3,000, meals and reimbursement for industrial site visits.
- C. Indirect Costs: Indirect Costs rates are based on current facilities and administrative cost rates negotiated with the Federal government and the University of California. IPAM’s work is conducted at an on-campus location which is subject to 54% facilities and administrative cost rate. Indirect costs are not applied to equipment and participant support costs. Indirect costs are only applied to the first \$25,000 of each subaward. Typically one IPAM Associate Director is a faculty member at another university “on-loan” to IPAM. IPAM compensates the Associate Director’s home university by a subaward.
- D. Program Income: Registration fees for NSF-supported conferences are accounted for as program income. IPAM charges modest registration fees primarily to discourage non-serious registrations. Registration fees for workshops are \$75 for faculty and government/military participants, \$100 for industry participants, \$50 for post-doctoral scholars and \$25 for graduate students.

Note 1: Program income totaled \$144,712 and was spent entirely on participant support expenses.

D. POSTDOCTORAL PLACEMENT LIST

IPAM did not appoint postdoctoral fellows during the reporting period, so we have no data to report in this section.

E. MATH INSTITUTE DIRECTORS' MEETING REPORT

Below are the minutes from the meeting held on May 1-2, 2015 at IPAM.

In attendance:

Name	institution
Helene Barcelo	Mathematical Sciences Research Institute
Estelle Basor	American Institute of Mathematics
Jorge Balbas	Institute for Pure and Applied Mathematics
Stacey Beggs	Institute for Pure and Applied Mathematics
Russel Caflisch	Institute for Pure and Applied Mathematics
Brian Conrey	American Institute of Mathematics
David Eisenbud	Mathematical Sciences Research Institute
Skip Garibaldi	Institute for Pure and Applied Mathematics
Sujit Ghosh	Statistical and Applied Mathematical Sciences Institute
Martin Golubitsky	Mathematical Biosciences Institute
Tony Nance	Mathematical Biosciences Institute
Stan Osher	Institute for Pure and Applied Mathematics
Jill Pipher	Inst. for Computational and Experimental Research in Math (ICERM)
Christian Ratsch	Institute for Pure and Applied Mathematics
Fred Roberts (chair)	DIMACS, Rutgers University
Fadil Santosa	Institute for Mathematics and its Applications
Richard Smith	Statistical and Applied Mathematical Sciences Institute
Thomas Spencer	Institute for Advanced Study

Friday, May 1st

1pm Introduction and presentation of 2014 minutes

Fred Roberts as moderator began the meeting. Each attendees introduced themselves.

There was a request for comments or questions about the 2014 minutes. There were none. The 2014 Minutes were approved.

Requests for additions to the agenda: None

1:30 Continuing items

Fred encourages us to give feedback to NSF about the renewal process. Several issues were raised, including the measures of success used in the site reports, the importance of communication of the institutes with the math community, and the significance of outside fundraising. The MIDs generally agree that they would prefer site visits to include the program officer for the institute.

There was also discussion about possible overlap among institute programs. MSRI proposes to collect information about scheduled and planned programs at the institutes, in order to facilitate coordination among the institutes and prevent overlap. Most institutes review proposals in November. We can add to the list in December, after our science board meetings. Helene prepared a form that would be filled out by each institute, with queries in September and again in January.

Institutes-wide collection of diversity data (MSRI)

The diversity committee is working on this, but they are not ready to share the data yet.

Indexing of video archives (IMA, ICERM)

This project is funded by a \$200K grant administered by MSRI and has been divided into two phases: 1) scoping out the project 2) build the database. The vendor was selected. Contract has been signed. The project should be completed in two months. We have spent less than half of the money. The remainder can be used to hire students to enter data and purchase servers (\$10K each). ICERM will replace IMA as the host for this website. There may be a service fee.

Fair reimbursement rates for visitor subcontracts (SAMSI):

There are two issues related to reimbursement of visitors, who need to get teaching release. NSF may start to require a formal subcontract, with overhead. Also, the institutes discussed having a fixed upper limit on what the institutes would pay for teaching release.

Math Institutes web site.

ICERM has agreed to be the new host for the website. IMA staff is preparing a version of the site that the new host will load on their own server. Institutes can upload their own research highlights.

3pm New Items

Math education workshops at institutes (MSRI)

Kate Stevenson (CSU Northridge) joined the meeting and gave a presentation. This is a very important issue for the math community, and there are groups within AMS, SIAM, and MAA that are considering what basic math skills are needed to be an effective citizen. Institutes can work nationally, regionally and locally. Many of the institutes have ongoing activities related to education. Some of the institutes have been involved with the TPSE effort. Grant opportunities include NSF (Improving Undergraduate STEM education) as well as private foundations such as Simons, Gates, Kresge, Hewlett, Lumina.

MPE 2013 Special lecture Series report (MSRI)

Helene presented everyone with a copy of the Math for Planet Earth (MPE) report.

Institute Directors Searches

IPAM will begin looking in the fall for a new director to start in two years.

ICERM started last fall and hope to include the search this summer/fall to start in 2016.

The MSRI director's term ends in summer 2017; a search will start in January 2016.

4pm Topics to bring up with NSF

NSF Postdoc Policy – proposed changes

The institutes are asking that the NSF allows flexibility for postdocs to spend their first year (rather than second year) at an institute.

Change in the renewal cycle.

NSF proposed a change at the last MID's meeting. T

Diversity Activities

The institutes will contribute to the Modern Math Workshop, about \$500 each. MBI and IMA plan to participate for two more years.

JMM 2015. Should we continue to do the reception? The cost was high last year. ICERM will organize it this year. Last year, the film was scheduled at the same time as our reception; many

people left. This year, Fred and Richard made brief remarks. Whoever is chairing it should decide on the format. Guests should be reminded that it is an NSF math institutes' reception.

4:30 Adjourn

Saturday, May 2nd

NSF representatives joined the meeting: Maryann Horn, Joanna Kania-Bartoszyńska, Nandini Kannan, Chris Stark, Michael Vogelius, and Henry Warchall.

9am Introductions.

Michael Vogelius presented a slide presentation, "perspectives on the institute program." Once the awards have been made, he will write an article that will appear in SIAM News, Notices of AMS, and MSTAT News.

The institutes support a larger community than NSF can reach. The institutes would like to see data used to support this claim. It would be best communicated by DMS in the article that Michael writes.

Joanna gave an update on status of the institute renewals. Hank described an extra layer of review, called CAAR Cost Accounting and Audit Resolution.

There was a discussion of evaluation of the portfolio of institutes. Results are inconclusive. Bibliographic tools are controversial (bibliometry). Hank and Chris advise that tracking participants is best tool. Stay in touch with or identify participants, track their careers. Look for good stories about influence of the program. We want to ask you to keep highlights coming, post on institutes' webpage. They encourage us to post them frequently. We have been able to send some math related stories to congress.

There was a discussion of NSF's goals for the institutes. One set comes from the 2002 solicitation: "Mathematical sciences research institutes exemplify large-scale projects that are effective...", but NSF says that these are examples rather than goals. They prefer a different list of three bullet points are "reviewable" – "successful proposals in this competition will spell out the proposed institute's plans and prospects..."

- National resources
- National reach
- Nationwide representation.

There was a question about using DMS funds for activities that the institutes conduct. Institute should use funds for what was in their proposal. We want to avoid funds used by another entity; do not use DMS funds to sponsor a summer school at another party in which the institute has no direct control. The issue is whether the institute personnel are involved in the oversight of the activity. It is part of the NSF expectation of management of NSF funds.

David Eisenbud described the national math festival on April 18, 2015 which was sponsored by MSRI. He showed a video documenting the festival, produced by Arlie Petters and Amanda Goldin. There is also a two minute slide show, available at Mathfest.org. They recorded the talks as well. Stay tuned for other products, as well as a booth at the national book festival.

Mathematical sciences postdocs attending programs at other institutes in first year

David summarized the proposal from the math institutes. A few postdocs each year want to attend a program at another institute in first year. We should encourage it. Deadline for the postdoc application is in October. Postdoc candidates may not know by then that they want to attend the math institute's program. NSF agreed to take the idea back to the institute team for discussion and consideration.

Project Outcomes Report

Hank described this new requirement. There is no opportunity for the NSF staff to preview, edit or reject what we write, since it is posted immediately. It is for the general public, including congressional staff. It should describe the activities of the institute, and it will accept URLs. Stress the impact of the activities on training of the next generation, impact on scientific research. Program offers would be happy to review it before we submit. would be happy to review it.

Proposal Pressures:

This was an agenda of a recent JPBM meeting. In NSF budget requests for 2016 heavily rely on proposal pressure. What can we do as a community to improve the culture? The four societies agreed action was needed, but did not agree on a course of action. Can the institutes help? In our workshops, can we set aside time to talk about the importance of other opportunities through NSF. NSF would like to see more proposals

The next meeting will be at MBI. Marty will send an email around to schedule it. The first weekend of May is 6-7.

F. PARTICIPANT SUMMARY

In this reporting period, 2,754 participants enrolled in our programs. IPAM actively seeks women and members of underrepresented ethnic groups to participate in its programs as organizers, speakers and participants. While most participants report their gender and ethnicity, some choose not to do so, and some did not respond to our request for the data. Note that during this reporting period, we held several conferences with a focus on diversity.

In this period, 16.5% of IPAM participants were members of an underrepresented minority group (combined), and 23.3% were women. See table F-1, below.

Table F-1: All Participants' Gender and Ethnicity by Program Type (9/2014-12/2015)							
Program Type	Total Participants	Gender		Underrepresented Ethnic Groups*			
		Female*	No. Reporting Gender	Amer. Indian	Black	Hispanic	No. Reporting Ethnicity
Long Programs	187	39	185	0	3	7	163
Workshops	1815	323	1791	3	39	88	1571
Summer School	94	18	92	0	0	2	78
Student Research Programs	70	29	70	2	5	6	68
Special Events and Conferences	466	203	458	2	61	176	420
Reunion Conferences	121	20	118	0	2	1	102
Total	2753	632	2714	7	110	280	2402
Percent of No. Reporting		23.3%		0.3%	4.6%	11.7%	

all members of underrepresented groups 397 16.5%

*gender and ethnicity is self-reported

IPAM also looked at unique participants for this period. (Some of our participants attended more than one program—usually multiple workshops within a long program.) There were 1,743 unique participants. Out of those reporting gender, 24.1% were women. Out of those reporting ethnicity, 19% reported that they are a member of an underrepresented ethnic group.

IPAM tries to balance the expectation that we primarily serve the U.S. community (citizens and permanent residents) with the goal of attracting the best organizers, speakers and participants in the relevant fields. See Table F-2.

Table F-2: All Participants' Citizenship by Program Type (9/2014-12/2015)			
Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency	percent
Long Programs	75	181	41%
Workshops	833	1739	48%
Summer School	35	89	39%
Student Research Programs	52	70	74%
Special Events and Conferences	335	432	78%
Reunion Conferences	56	115	49%
Total	1386	2626	53%

The majority (90.6%) of the participants of IPAM programs during this period hold academic positions (faculty, postdoc, graduate student, or undergraduate student). Out of the remaining participants, 70 (2.6%) hold positions in government or military, and 188 (6.9%) work in industry. (We do not have participant category for 10 participants.) The following sections provide summary data for the requested sub-groups: postdocs, graduate students, and undergraduate students.

G. POSTDOCTORAL PROGRAM SUMMARY

Postdocs attend IPAM’s workshops, long programs, reunion conferences, special events and conferences, and summer school, and a few serve as academic mentors in RIPS, our undergraduate summer program. See tables G-1 and G-2.

Table G-1: Postdocs' Gender and Ethnicity by Program Type (9/2014-12/2015)

Program Type	Total Participants	Gender		Underrepresented Ethnic Groups*			
		Female*	No. Reporting Gender	Am. Indian	Black	Hispanic	No. Reporting Ethnicity
Long Programs	23	8	23	0	0	1	20
Workshops	238	49	237	1	5	16	204
Summer School	7	2	7	0	0	0	6
Student Research Programs	4	1	4	0	0	1	3
Special Events and Conferences	33	10	33	0	7	14	31
Reunion Conferences	28	7	27	0	0	1	22
Total	333	77	331	1	12	33	286
Percent of No. Reporting		23.3%		0.3%	4.2%	11.5%	

all members of underrepresented groups 46 16.08%
 *gender and ethnicity is self-reported

Table G-2: Postdocs' Citizenship by Program Type (9/2014-12/2015)			
Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency	percent
Long Programs	4	23	17%
Workshops	71	234	30%
Summer School	2	7	29%
Student Research Programs	2	4	50%
Special Events and Conferences	22	33	67%
Reunion Conferences	7	26	27%
Total	108	327	33%

H. GRADUATE STUDENT PROGRAM SUMMARY

Graduate students participate in all categories of IPAM programs. Graduate students often find a compelling thesis topic at an IPAM long program, and also make contacts that lead to their first job. See tables H-1 and H-2.

Table H-1: Graduate Students' Gender and Ethnicity by Program Type (9/2014-12/2015)							
Program Type	Total Participants	Gender		Underrepresented Ethnic Groups*			
		Female*	No. Reporting Gender	American Indian	Black	Hispanic	No. Reporting Ethnicity
Long Programs	58	14	57	0	1	5	54
Workshops	604	131	600	0	14	36	550
Summer School	61	13	60	0	0	2	57
Student Research Programs	10	7	10	1	2	0	10
Special Events and Conferences	107	50	107	1	11	49	105
Reunion Conferences	33	7	33	0	1	0	30
Total	873	222	867	2	29	92	806
Percent of No. Reporting		25.6%		0.2%	3.6%	11.4%	
all members of underrepresented groups				123	15.26%		
*gender and ethnicity is self-reported							

Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency	percent
Long Programs	14	57	25%
Workshops	182	597	30%
Summer School	13	61	21%
Student Research Programs	9	10	90%
Special Events and Conferences	56	106	53%
Reunion Conferences	9	33	27%
Total	283	864	33%

I. UNDERGRADUATE STUDENT PROGRAM SUMMARY

Undergraduate students participate in two of our student research programs. RIPS Projects Day is counted as a workshop, because it is open to the public and some local undergraduate students (and others interested in the results of their research) attended. Undergraduates also participated in several of our special events and conferences.

Program Type	Total Participants	Gender		Underrepresented Ethnic Groups*			No. Reporting Ethnicity
		Female*	No. Reporting Gender	American Indian	Black	Hispanic	
Workshops	36	17	36	1	2	4	36
Student Research Programs	44	20	44	1	2	5	44
Special Events and Conferences	103	48	103	1	1	63	98
Total	147	68	147	3	5	72	178
Percent of No. Reporting		46.3%		1.7%	2.8%	40.4%	
all members of underrepresented groups				80	44.94%		
*gender and ethnicity is self-reported							

Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency	percent
Workshops	23	36	64%
Student Research Programs	31	44	70%
Special Events and Conferences	83	99	84%
Total	137	179	77%

J. PROGRAM DESCRIPTION

The programs are listed in chronological order by start date. The list includes all IPAM programs from September 1, 2014 through December 31, 2015, which includes:

- Three long programs, and the workshops associated with each
- Five IPAM independent workshops, one week in length
- Six special events and conferences, 1-3 days long each
- Three student research programs
- One summer school
- Six reunion conferences of long programs held at IPAM in previous years
- Three public lectures, including the Green Family Lecture Series
- Other outreach activities

Public lectures feature a speaker with a national reputation who speaks on a topic of broad interest to an audience that includes non-scientists. Most of the speakers giving public lectures also gave research lectures during the workshop held the same week. We do not take attendance at public lectures.

Most IPAM workshops include poster sessions; all participants are invited to present a poster, but graduate students are especially encouraged to participate.

For some programs, we have included testimonials from participants of the program.

Mathematics of Turbulence. September 8 - December 12, 2014

Organizing Committee:

Charles Doering (University of Michigan, Departments of Mathematics and Physics)

Gregory Eyink (Johns Hopkins University)

Pascale Garaud (University of California, Santa Cruz (UC Santa Cruz))

Michael Jolly (Indiana University)

Keith Julien (University of Colorado Boulder)

Beverley McKeon (California Institute of Technology)

Turbulence is perhaps the primary paradigm of complex nonlinear multi-scale dynamics. It is ubiquitous in fluid flows and plays a major role in problems ranging from the determination of drag coefficients and heat and mass transfer rates in engineering applications, to important dynamical processes in environmental science, ocean and atmosphere dynamics, geophysics, and astrophysics. Understanding turbulent mixing and transport of heat, mass, and momentum remains an important open challenge for 21st century physics and mathematics.

This IPAM program is centered on fundamental issues in mathematical fluid dynamics, scientific computation, and applications including rigorous and reliable mathematical estimates of physically important quantities for solutions of the partial differential equations that are believed,

in many situations, to accurately model the essential physical phenomena. This program will bring together physicists, engineers, analysts, and applied mathematicians to share problems, insights, results and solutions. Enhancing communications across these traditional disciplinary boundaries is a central goal of the program.

Being able to meet and spend an extended amount of time with the other mathematicians at the IPAM program was very helpful. It allowed me to learn more about other people's research more deeply. It also gave me the opportunity to present my research to an interested and engaged group, which has opened up future potential collaborations that are now coming to fruition. I will be a postdoc at the University of Michigan in the fall with Charlie Doering and we will be collaborating on convection problems. I have also begun talking about a potential collaboration with Vincent Martinez, which we feel optimistic about.

-Karen Zava, Graduate Student, University of Illinois at Chicago

This IPAM program provided an opportunity to present the ideas underlying the statistical state dynamics approach in depth to a wide group of interested people. It has resulted in a number of invitations to speak at other institutions and many opportunities to introduce the method of SSD to a wider audience beyond the atmospheric sciences where we initially developed this approach.

-Brian Farrell, Professor, Harvard University

It provided an incredible opportunity to meet a great diversity of researchers related to my area and opened up such great possibilities for collaboration. The program provided such a wonderful space and time to exchange ideas so freely. Out of all the experiences I've had in my young career, the program at IPAM has proved to be truly singular among them all. I currently have projects with Eric Olson, Hakima Bessaih, Mike Jolly, Edriss Titi, Aseel Farhat, which have either originated from IPAM or have been inspired by ideas exchanged there.

-Vincent R Martinez, Postdoctoral fellow, Tulane University

Mathematics of Turbulence Tutorials. September 9 - 12, 2014.

Part of the Long Program Mathematics of Turbulence

Organizing Committee:

Charles Doering, Chair (University of Michigan, Departments of Mathematics and Physics)

Gregory Eyink (Johns Hopkins University)

Pascale Garaud (University of California, Santa Cruz (UC Santa Cruz))

Michael Jolly (Indiana University)

Keith Julien (University of Colorado Boulder)
Beverley McKeon (California Institute of Technology)

The long program opens with four days of tutorials that will provide an introduction to major themes of the entire program and the four workshops. The goal is to build a foundation and common language for the participants of this program who have diverse scientific backgrounds. Registration for tutorials is free, to encourage broad participation.

Workshop I: Mathematical Analysis of Turbulence. September 29 - October 3, 2014.

Part of the Long Program Mathematics of Turbulence

Organizing Committee:

Peter Constantin (Princeton University)
Gregory Eyink (Johns Hopkins University)
Michael Jolly (Indiana University)
Anna Mazzucato (Pennsylvania State University, Mathematics)

This workshop will focus on recent analysis and simulations supporting the theories of 2D and 3D turbulence. On the rigorous side there are proofs of the locality in wave number of energy and enstrophy fluxes, as well as sufficient conditions for, and connections between energy power laws, cascades, and dissipation laws. Direct numerical simulations have shed light on mode interactions, intermittency, condensates, and coherent structures, as well as the effects of rotation and stratification. In addition to the fundamental system, the Navier-Stokes equations, these phenomena are examined for a variety of fundamental systems including stochastic models, probabilistic approaches, and quasi-geostrophic, magnetohydrodynamic, and Rayleigh-Bénard convection equations.

It is the goal of this workshop to bring together mathematicians, physicists, and engineers who work in the area of Mathematical Analysis of Turbulence. We expect this workshop will attract junior as well as senior participants.

Workshop II: Turbulent Transport and Mixing. October 13 - 17, 2014.

Part of the Long Program Mathematics of Turbulence

Organizing Committee:

Annalisa Bracco (Georgia Institute of Technology)
Colm-cille Caulfield (University of Cambridge)
Charles Doering (University of Michigan, Departments of Mathematics and Physics)
Alexander Kiselev (Rice University, Mathematics)
Jean-Luc Thiffeault (University of Wisconsin-Madison, Mathematics)

Turbulent Transport and Mixing is concerned with the fundamental physics, mathematical modeling, analysis, and computation of the enhanced advection and diffusion of heat, mass, and momentum that often characterizes turbulence. Turbulent mixing is a familiar phenomenon but one which still presents many interesting open questions. For example, how can turbulent mixing

of, say, passive scalars be quantitatively characterized? What aspects of turbulent diffusion can be rigorously deduced from the fundamental equations of motion? What are the most effective approaches to reduced and/or closed models of turbulent mixing? What are the primary computational challenges for fluid transport and mixing and, and how can insights from rigorous mathematical studies and experimental investigations aid numerical analysis and simulations? These are questions that will be addressed in this workshop.

It is the goal of this workshop to bring together mathematicians, physicists, and engineers who work in the area of Turbulent Transport and Mixing. We expect this workshop will attract junior as well as senior participants.

Workshop III: Geophysical and Astrophysical Turbulence. October 27 - 31, 2014.

Part of the Long Program Mathematics of Turbulence

Organizing Committee:

Jonathan Aurnou (University of California, Los Angeles (UCLA))

Oliver Bühler (New York University, Courant Institute of Mathematical Science)

Baylor Fox-Kemper (Brown University)

Pascale Garaud (University of California, Santa Cruz (UC Santa Cruz))

Keith Julien (University of Colorado, Boulder)

This workshop will cover a number of selected topics that are common to Oceanography, Planetary Geophysics, Atmospheric Dynamics and Astrophysics including turbulent convection, turbulence induced by baroclinic instabilities, shear turbulence (both stratified and unstratified), double-diffusive convection, and wave-induced turbulence. In all these cases geophysicists and astrophysicists strive to model the effects of the specific type of turbulence considered on heat, compositional and momentum transport. In many instances progress on common problems has been made in parallel without much interaction between the scientific communities.

This workshop will bring together scientists from different backgrounds to share their most recent results, attempting to bridge the subject-gap, and foster fruitful collaborations.

Grad School and Beyond: Advice for the Aspiring Mathematician

Thursday, November 13, 2014, 4:00 pm – 7:00 pm

The Institute for Pure and Applied Mathematics (IPAM) is pleased to host four mathematicians at various stages in their academic careers for a special event for undergraduate students. Each panelist will give a 15-minute presentation on their research and then participate in a panel discussion covering their careers choices, mentorship experiences and the importance of diversity in math, and offer advice to undergraduates who want to pursue mathematics as a career.

The moderator was Ron Buckmire, Occidental College. The panelists were Amanda Ruiz, University of San Diego; Monica Jackson, American University; Mario Bencomo, Rice University; and Ryan Hynd, University of Pennsylvania.

Blackwell-Tapia Conference and Awards Ceremony. November 14 - 15, 2014

Organizing Committee:

Ricardo Cortez (Tulane University)

Monica Jackson (American University, Mathematics and Statistics)

Trachette Jackson (University of Michigan, Dept of Mathematics)

Herbert Medina (Loyola Marymount University, Mathematics)

IPAM hosted the 2014 Blackwell-Tapia Conference and Awards Ceremony. The conference and prize honors David Blackwell and Richard Tapia (who won the National Medal of Science in 2010), two seminal figures who inspired a generation of African-American, Native American and Latino/Latina students to pursue careers in mathematics. This will be the eighth conference since 2000, held every other year.

The conference will offer a mix of activities including scientific talks, poster presentations, panel discussions, ample opportunities for discussion and interaction, and the awarding of the Blackwell-Tapia Prize. Participants will come from all career stages and will represent institutions of all sizes across the country, including Puerto Rico.

The goals of the conference are:

- Recognize and showcase mathematical excellence by minority researchers
- Recognize and disseminate successful efforts to address under-representation
- Inform students and mathematicians about career opportunities in mathematics, especially outside academia
- Provide networking opportunities for mathematical researchers at all points in the higher education/career trajectory

The Blackwell-Tapia Prize recognizes a mathematician who has contributed significantly to research in his or her area of expertise, and who has served as a role model for mathematical scientists and students from underrepresented minority groups, or has contributed in other significant ways to addressing the program of underrepresentation of minorities in math.

The National Blackwell-Tapia Committee selected Jacqueline M. Hughes-Oliver to receive the 2014 Blackwell-Tapia Prize. Hughes-Oliver has been a professor of statistics at North Carolina State University since 1992. She is visiting George Mason University until May 2014. She has made important contributions in a number of statistical research areas including methodological research on prediction and classification, variable and model selection with dimension reduction, design of experiments, and spatial modeling. She has worked passionately on the cause of increasing diversity of individuals working of the statistical and mathematical sciences

Workshop IV: Turbulence in Engineering Applications. November 17 - 21, 2014.

Part of the Long Program Mathematics of Turbulence

Organizing Committee:

Rich Kerswell (University of Bristol)

John Kim (University of California, Los Angeles (UCLA))

Joseph Klewicki (University of New Hampshire)

Beverley McKeon, Chair (California Institute of Technology)

Ati Sharma (University of Southampton)

Turbulence in Engineering Applications is motivated by the staggering financial and environmental impact of turbulence in engineering applications: manage to quell turbulence in the thin boundary layers on the surface of a commercial airliner and you could almost halve the total aerodynamic drag, dramatically cutting fuel burn, emissions and cost of operation. Concurrent advances in experimental, numerical and mathematical representations of turbulence, particularly close to walls, make this a timely opportunity to review progress in this area and lay the groundwork for analytical approaches with a tight connection to real-world flow configurations. This workshop will address the relationship between mathematical and systems-level approaches, in which the characteristics of the flow are considered at a global rather than local level, to observations of turbulent flows of importance to engineering applications. While this type of connected analysis is standard in the transition community, research in turbulent flows would benefit from stronger connections between analysis, modeling, computation and experimental implementations with regard to scientific and engineering applications.

It is the goal of this workshop to bring together mathematicians, physicists, and engineers who work in the area of Turbulence in Engineering Applications.

Culminating Workshop, Mathematics of Turbulence. December 7-12, 2014.

Part of the long program on the Mathematics of Turbulence. The culminating workshop was organized by the long program organizing committee.

The final workshop in the long program, held at Lake Arrowhead Conference Center, provided an opportunity for the program's core participants to report on their work during the past three months and to discuss future projects. Many of the collaborations and interactions that were formed during the program had a chance to deepen.

Interaction Between Analysis and Geometry Reunion Conference I, December 7-12, 2014.

The reunion conference was organized by the original long program organizing committee.

This was the first reunion conference for participants of the spring 2013 long program "Interaction Between Analysis and Geometry." It was a timely get-together to continue some of the collaborations that were started during the long program and at the first reunion. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations.

Computational Methods in High Energy Density Plasmas Reunion Conference II,
December 7-12, 2014.

The reunion conference was organized by the original long program organizing committee.

This was the second reunion conference for participants of the spring 2012 long program “High Energy Density Plasmas.” It was a timely get-together to continue some of the collaborations that were started during the long program. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations.

WORKSHOP: Multiple Sequence Alignment. January 12 – 16, 2015

Organizing Committee:

Jim Leebens-Mack (University of Georgia)
Sebastien Roch (University of Wisconsin-Madison, Mathematics)
Tandy Warnow (University of Illinois at Urbana-Champaign, Computer Sciences)

In multiple sequence alignment (MSA), a set of nucleotide or amino-acid sequences are “aligned” through the addition of spaces or rearrangement of individual sequences. A gap in the alignment indicates a possible loss or gain of an element and rearrangements account for inversions or translocations (particularly important for genome alignments); thus evolutionary inference of the insertion and deletion, translocation and inversion processes is inherent in MSA. In addition, MSA estimation is closely tied to phylogenetic estimation – a mathematically rich area with connections to probability theory, geometry, algebra, and graph theory. MSA estimation also informs protein function and structure prediction, and thus has strong connections to structural biology. However, these disciplines approach MSA estimation very differently. As a result, a variety of techniques have been explored, including combinatorial optimization, biophysical models of protein structure, machine learning, and probabilistic models of evolution. Despite the importance of MSA estimation and active research, many challenges persist. The research community is addressing these through improved mathematical formalization of MSA estimation; development of sophisticated and biologically meaningful models of sequence evolution that include insertions, deletions, and rearrangements; and design of new methods that have good mathematical properties and empirical performance for large datasets. This workshop will engage researchers from different fields, including mathematicians, statisticians, evolutionary biologists, structural biologists, and computer scientists, with the aim of integrating diverse viewpoints, improving mathematical foundations, and developing new and more powerful methods for estimating MSAs. This workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.

WORKSHOP: Symmetry and Topology in Quantum Matter. January 26 – 30, 2015

Organizing Committee:

Daniel Freed (University of Texas at Austin, Mathematics)
Michael Hermele (University of Colorado Boulder, Physics)
Anton Kapustin (California Institute of Technology, Physics)
Victor Ostrik (University of Oregon, Mathematics)
Ashvin Vishwanath (University of California, Berkeley (UC Berkeley), Physics)

Topological phases of matter are remarkable both for their richness of physical phenomena, and for their mathematical description by topological quantum field theories (TQFTs). Recently, the prediction and experimental discovery of topological insulators has spurred physicists to explore the role of symmetry in topological phases, leading to the identification of new classes of phases of matter, and new insights into their classification, properties, and potential physical realizations. This is an area with a history of strong connections between physics and mathematics, and the time is ripe for the emerging understanding of symmetric topological phases to benefit from new mathematical ideas in TQFTs, and vice versa.

This interdisciplinary workshop will bring together theoretical physicists and mathematicians to discuss symmetric topological phases and TQFTs, with a goal of forging productive new interactions between these communities.

This workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.

WORKSHOP: Computational Photography and Intelligent Cameras. February 4 – 6, 2015.

Organizing Committee:

Amit Agrawal (Amazon Lab126)
Richard Baraniuk (Rice University, Electrical and Computer Engineering)
Lawrence Carin (Duke University)
Oliver Cossairt (Northwestern University)
Stanley Osher (University of California, Los Angeles (UCLA))
Yohann Tendo, Chair (École Nationale Supérieure de Télécommunications, TSI)

Until recently, digital photography has mostly just replaced the traditional film with a silicon sensor, without substantial changes to the interface or the capabilities of a still camera. However, as the computational power of cameras, cell phones, and other mobile or embedded systems has increased, computation can now be coupled much more tightly with the act of photography. Computational photography is a new area of computer graphics and vision, seeking to create new types of photographs and to allow photographers to acquire better images or images they never could observe before. This involves research into new software algorithms for fusing data from multiple images, video streams, or other types sensors as well as into new hardware architectures for capturing the data needed for the software and numerical processing. Applications of computational photography paradigms include compressed sensing cameras, extended depth of field/refocusing, high dynamic range images, invertible motion blurs, and plenoptic cameras, and

mathematics is an important tool for inventing and optimizing these new cameras. This workshop will serve as a gathering place for all those interested in theories, algorithms, methodologies, hardware designs, and experimental studies in computational photography.

This workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.

WORKSHOP: Zariski-dense Subgroups. February 9 - 13, 2015.

Organizing Committee:

Gopal Prasad (University of Michigan, Mathematics)
Andrei S. Rapinchuk (University of Virginia, Mathematics)
Alan Reid (University of Texas at Austin, Dept of Mathematics)

This workshop will survey the recent progress in the study of Zariski-dense subgroups (both arithmetic and non-arithmetic) of semi-simple algebraic groups; the impact of this work on adjacent areas such as algebraic groups, division algebras, and Galois cohomology; and applications in further areas such as geometry (isospectral and length-commensurable locally symmetric spaces) and combinatorics (expander graphs). These developments have led to new connections between different areas of mathematics (algebra, number theory, algebraic and Lie groups, differential geometry and topology, and combinatorics), and the workshop will bring together people working in those areas, using the subject of Zariski-dense subgroups as a common thread to build new scientific connections as well as to solve new problems that have recently appeared.

This workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.

WORKSHOP: Machine Learning for Many-Particle Systems. February 23 - 27, 2015.

Organizing Committee:

Alán Aspuru-Guzik (Harvard University)
Gabor Csanyi (University of Cambridge)
Klaus-Robert Müller (Technische Universität Berlin)
Alexandre Tkatchenko (Fritz-Haber-Institut der Max-Planck-Gesellschaft, Theory)

This workshop aims to create novel synergistic collaborations between researchers in two different fields: modeling of many-particle (quantum and classical) systems and machine learning. Interactions between many constituent particles generally give rise to collective (or emergent) phenomena in matter. Even when the interactions between the particles are well

defined and the governing equations of the system are understood, the collective behavior of the system as a whole does not trivially emerge from these equations.

Machine learning (ML) methods have been used extensively in a wide variety of fields ranging from e.g. the neurosciences, genetics, multimedia search to drug discovery. Recently, ML techniques have started to be vigorously applied for understanding many-particle systems. However, this is an emergent field and many open questions remain. Therefore, the aim of this IPAM workshop is to shine light into the ML “black box” by bringing together experts in many-particle systems in condensed-matter physics, materials, chemistry, and protein folding, together with experts in machine learning to synergetically address the problem of tackling emergent behavior and understanding the underlying collective variables in these systems.

This workshop will address the reaches and limitations of ML as applied to many-particle systems and highlight examples where physical models can be successfully combined with ML algorithms. It will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.

LONG PROGRAM: Broad Perspectives and New Directions in Financial Mathematics.
March 9 - June 12, 2015.

Organizing Committee:

René Carmona (Princeton University, Mathematics)

George Papanicolaou (Stanford University, Mathematics)

Thaleia Zariphopoulou (University of Texas at Austin, Departments of Mathematics and IROM)

The financial crisis of 2007-2008 has dramatically changed research in quantitative finance. The perfect replication paradigm, at the root of the success of the Black and Scholes model, became unsound in light of the dire illiquidity problems that caused several major collapses. As a result, the center of gravity of research in quantitative finance has shifted away from pricing and hedging and from the credit markets. While these problems remain of great importance, new problems are now taking center stage.

This IPAM program will address the stability of the network of financial institutions, the impact of high frequency and algorithmic trading, the financialization of the commodity markets, and the huge challenges raised by the size and the speed of trade data. This program will bring together academic mathematicians, economists, regulators, and experts from the finance industry to seed research – even if speculative – in these areas.

I think the impact of IPAM's FM2015 program was crucial for my research. I had decided to leave the academic world for an industry job; at IPAM I regained confidence in my research. I hold now a permanent position in a prestigious university.

-Julius Bonart, Lecturer (Assistant Professor), University College London

My networking opportunities at IPAM have proved invaluable in starting research collaborations and securing a postdoc position after graduation. I also gained a greater perspective on the field of Financial Mathematics and understanding of where the field is headed so that I can direct my future researching accordingly. At IPAM, I participated in a reading group in systemic risk with Stephan Sturm and Eric Schanning that has developed into a continuing research collaboration.

-Mackenzie Wildman, Graduate Student, Lehigh University

Because of the exposure to a broad variety of research in my areas (network models, systemic risk, commodities), it brought my research to a different level. Also, being invited to the program in such a prestigious university, has raised my profile in my home institution, gave my career a boost and increased my chances for career advancement. Andreea Minca, Hamed Amini and I are planning joint research in the area of financial networks.

-Svetlana Borovkova, Associate Professor, Free University of Amsterdam

TUTORIAL: Financial Mathematics Tutorials. March 10 - 13, 2015.

Part of the long program on Financial Mathematics

Organizing Committee:

René Carmona (Princeton University, Mathematics)

George Papanicolaou (Stanford University, Mathematics)

Thaleia Zariphopoulou (University of Texas at Austin, Departments of Mathematics and IROM)

The long program opens with four days of tutorials that will provide an introduction to major themes of the entire program and the four workshops, aimed at providing a foundation for the participants of this program who have diverse scientific backgrounds. The tutorials will include courses on:

- the mathematics of systemic risk (4 hours)
- energy and commodity markets (3 hours)
- high frequency markets (4 hours)
- portfolio theory (3 hours)

Registration for tutorials is free, to encourage broad participation.

WORKSHOP I: Systemic Risk and Financial Networks. March 23 - 27, 2015.

Part of the long program on Financial Mathematics

Organizing Committee:

Rama Cont (Imperial College)

Jean-Pierre Fouque (University of California, Santa Barbara (UC Santa Barbara), Statistics and Applied Probability)

George Papanicolaou (Stanford University, Mathematics)

The recent financial crisis has highlighted the importance of the stability of the financial system as a whole and the interconnectedness of its components, prompting new research efforts directed at understanding the key determinants of the structure and stability of the network(s) underlying the financial system and the mechanism which govern the onset of systemic risk and the propagation of distress propagation across financial markets and institutions. This interdisciplinary workshop will bring together mathematical scientists, economists and regulators who have made key contributions to the recent research efforts for explaining, monitoring or regulating systemic risk. Capital requirements, central clearing, default contagion through insolvency and illiquidity, and nonlinear feedback effects are some of the proposed key elements of recent models and will be discussed in the workshop.

This workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.

Latino/as in the Mathematical Sciences Conference (Lat@math). April 9-11, 2015

Organizing Committee:

Alejandro Adem (Mitacs)

Federico Ardila (San Francisco State University, Mathematics)

Rodrigo Bañuelos (Purdue University, Mathematics)

Russel Caflisch (Institute for Pure and Applied Mathematics, Director)

Jose Castillo (San Diego State University, CSRC)

Ricardo Cortez (Tulane University)

Angela Gallegos (Loyola Marymount University)

Nancy Rodríguez (UNC - Chapel Hill, Mathematics)

Joseph Teran (UCLA)

Tatiana Toro, Chair (University of Washington, Mathematics)

Alejandro Uribe (University of Michigan)

IPAM sponsored a three day conference showcasing the achievements of Latina/os in the mathematical sciences. The conference will feature talks by junior and senior researchers, as well as events for undergraduates, graduate students, and postdoctoral fellows. There will be plenary lectures, community lectures, panel discussions, and activities to facilitate networking. The goal of the conference is to encourage Latina/os to pursue careers in the mathematical sciences, to promote the advancement of Latina/os currently in the discipline, to showcase research being conducted by Latina/os at the forefront of their fields, and, finally, to build a community around shared academic interests.

Sponsors included IPAM, UCLA, NSA, and Raytheon Corporation. 156 people attended. In addition, about 20 high school students attended an activity on Friday morning.

I remember flying back to North Carolina from the Latino in the Mathematical Sciences conference in Los Angeles. I could not stop thinking about how thankful I was to have participated in this amazing opportunity. This conference helped me stay focused on my goal of being successful in STEM as a minority student. This was the first time I saw so many math majors that could relate to my struggles, academically and emotionally. After attending this conference, I felt empowered to fight for my dream to obtain a PhD. I was motivated to seek academic opportunities for underrepresented minorities and [joined] the National Astronomy Consortium, where I was part of a program that targets underrepresented minorities who want to expand their research experience in Radio Astronomy through the National Radio Astronomy Observatory. Through this opportunity, I found out about the Fisk-Vanderbilt Bridge Program, the number one program producing African American Master's degree awardees in the nation. I applied and became part of the Fisk-Vanderbilt community where now I am a first year graduate student in Astrophysics. The first Latinos in the Mathematical Sciences conference gave me the motivation to pursue a graduate degree by getting to know other Latino mathematicians that went through similar struggles than me. Although I am now in Physics, I would love to be part of this conference once again and hopefully contribute to our tight Latino community of scientists.

-Antonio Porras, PhD student, Astrophysics, Vanderbilt University

Professor Joseph Teran's talk about scientific computing in movies changed my perspective how and where scientific computing could be found. I decided to look further into this field and do my master's thesis related to this field. I am now applying to Ph. D. programs in applied math to pursue research in scientific computing.

-Martin Rodriguez, Graduate Student, San Diego State University

LAT@MATH strengthened and expanded my network of faculty engaged in diversifying the profession (through creating opportunities for students and young faculty as well as through mutual support of people doing this work). Also, Pres. Ana Mari Cauce's talk and later comments in a panel made a big impact on how I think about institutional leadership (vs. leading from within the faculty); as a result, I've taken some big steps at my institution. I am now chair of Academic Senate.

-Cynthia Wyels, Professor of Mathematics, CSU Channel Islands

WORKSHOP II: The Mathematics of High Frequency Financial Markets: Limit Order Books, Frictions, Optimal Execution and Program Trading. April 13 - 17, 2015

Part of the long program on Financial Mathematics

Organizing Committee:

René Carmona (Princeton University, Mathematics)

Alexander Schied (Universität Mannheim, Department of Mathematics)

Thaleia Zariphopoulou (University of Texas at Austin, Departments of Mathematics and IROM)

The notion of one price, publicly known, at which transactions can happen in arbitrary sizes has seriously been challenged over the last few years. The existence and the importance of liquidity friction and price impact due to the size and frequency of trades are recognized as the source of many of the most spectacular failures (e.g., LTCM, Amaranth, Lehman) prompting new research in applications of stochastic optimization to optimal execution and predatory trading among many other challenges.

Also, the impact of algorithmic and high frequency trading on the stability and the integrity of the financial system is a growing concern of regulators, practitioners, and academics. While the presence of electronic market makers and brokers is supposed to increase liquidity and price discovery, the appearance and the growth of dark markets, as well as occurrences like the flash crash of May 6, 2010, and computer glitches like those which took down Knight Capital, have raised serious concerns. Research on the developments of Limit Order Book (LOB) and algorithmic trading models and their impact on trading are clearly some of the most exciting emerging topics in quantitative finance research.

A short course of three 1hr 20 minute lectures will be given at the beginning of the workshop.

WORKSHOP III: Commodity Markets and their Financialization. May 4 - 8, 2015

Part of the long program on Financial Mathematics

Organizing Committee:

René Carmona (Princeton University, Mathematics)

Ronnie Sircar (Princeton University, ORFE)

Wei Xiong (Princeton University)

The proliferation of commodity indexes and the dramatic increase of investors gaining commodity exposure through ETFs tracking indexes have changed the landscape of the commodity markets and increased the correlations between commodities and equity, and among commodities included in the same indexes. On the other hand, because of the crucial role played by commodities in modern economies, the growing concern about environmental issues inherent to the production of energy, and the combination of both physical and financial trades, the commodity markets require a treatment independent of the traditional equity, fixed income, foreign exchange and credit markets. A growing number of economists, econometricians and mathematicians are studying the financialization of the commodity markets, which has been taking place over the last 10 years and which cannot be explained by relying on the fundamentals of the physical markets. New approaches and new synergies are needed, especially in light of recent and pending regulations (such as emissions control) and public policy issues related to renewable technologies (e.g. solar and wind) in energy production.

Monday morning and afternoon and Tuesday morning will consist of tutorial courses covering statistical analysis of commodity market data, the economic fundamentals of commodity prices and the financialization of the commodity markets. Tuesday afternoon will include a panel on the economics of commodity financialization.

Inaugural National Meeting of Women in Financial Mathematics. May 14, 2015

Organizing Committee:

Tanya Beder (SBCC Group)

Xin Guo (University of California, Berkeley (UC Berkeley))

Thaleia Zariphopoulou (University of Texas at Austin, Departments of Mathematics and IROM)

The inaugural national conference of Women in Financial Mathematics (WFM) will provide a dynamic platform to promote and foster networking and collaboration between academics, practitioners, supervisors, and others in the field of financial mathematics. Through panel discussions and networking sessions, the conference will offer an exclusive opportunity to discuss the latest issues and problems of interest to practitioners, academics, regulators and service providers in financial mathematics.

The topics and panelists (listed alphabetically):

Quantitative Trading

- Lisa Borland, Head of Research and Co-Portfolio Manager, T2AM
- Kathryn Kaminski, Director of Investment Strategies, Campbell & Company
- Monique Miller, Head of Alternative Strategy, Wilshire Funds Management – panel chair

Portfolio Allocation

- Samantha Foster, Investment Officer, University of Southern California – panel chair
- Thaleia Zariphopoulou, Chair in Mathematics, V.F. Neuhaus Centennial Professor, University of Texas, Austin
- Anjun Zhou, Head of Multi-Asset Research, Mellon Capital Management Corporation

Mathematical Finance Communication Tips

- Cristina Polizu, Managing Director, Standard and Poor's*
- Mila Sherman, Associate Professor of Finance, Isenberg School of Management, University of Massachusetts – panel chair
- Margaret S. Stumpp, Senior Advisor, Quantitative Management Associates LLC

Data Analytics

- Xin Guo, Coleman Fung Chair Professor in Financial Modeling, University of California, Berkeley – panel chair
- Rosemary Macedo, Chief Investment Officer, QS Investors
- Isa Watson, Vice President Strategy, JPMorgan Chase

New Directions in Financial Mathematics – FinTech, Cyber, ETFs, Systemic Risk and Beyond

- Katie Benner, Technology and Innovation Columnist, Bloomberg – panel chair
- Joanne Hill, Head of Institutional Investment Strategy, ProFunds
- Gudrun Neumann, Senior Vice President and CTO, American Century Investments

Women in Financial Mathematics will foster new collaborations for addressing cutting-edge issues in mathematical finance and provide a forum to debate the relevance and importance of new directions, initiate novel interdisciplinary research, promote mentoring of young scientists and create an environment for fruitful and innovative dialogue among academics, practitioners, supervisors and others in the field. Throughout this networking forum, participants will discuss the presence of women in the field and explore opportunities for collaboration. Due to the nature of this meeting, only women will be invited to speak and may apply for funding. Men are welcome to register and attend the meeting.

WORKSHOP IV: Forensic Analysis of Financial Data. May 18 - 21, 2015.

Part of the long program on Financial Mathematics

Organizing Committee:

Marco Avellaneda (New York University)

Jean-Philippe Bouchaud (Capital Fund Management)

René Carmona (Princeton University, Mathematics)

Andrew Lo (Massachusetts Institute of Technology)

George Papanicolaou (Stanford University, Mathematics)

Thaleia Zariphopoulou (University of Texas at Austin, Departments of Mathematics and IROM)

This workshop will bring together researchers in machine learning from computer science, statistics, and electrical engineering; financial engineers and economists; applied mathematicians; legal scholars; econometricians; practitioners; and regulators to address the challenging questions raised by the post-mortem analysis of financial crisis data. In light of recent theoretical, empirical, and technological progress (e.g. big data analytics, better understanding of fire sales and liquidity shocks, and secure multi-party computation), the participants will revisit recent market anomalies to find, in hindsight, what could have been done to predict, prepare for, and/or prevent them given the current technology.

The tools and methods for bank supervision and the implementation of the Dodd-Frank Act will be addressed, and experience from “forensic agencies” such as NTSB and OFR will be central to these discussions.

The workshop will promote research on diagnostics for online detection of market manipulation and the identification of data patterns foreshadowing crashes. Examples of specific topics to be covered include the dynamic nature of the data at current trading speeds; the influence of social networks on trading; analysis of the Flash Crash of 2010 and the mini flash crashes since then; forensic analysis of OTC trading; real-time risk-monitoring of exchange traded securities; and the role of complexity in creating new forms of systemic risk in the financial industry.

This workshop will feature the 2015 Green Family Lectures by Andrew Lo. This series consists of a public lecture (Monday, 5/18), a research lecture aimed at a general math and computer science audience (Tuesday, 5/19), and a technical lecture that is part of the workshop (Monday, 5/18).

GREEN FAMILY LECTURE SERIES, May 18-19, 2015

The Green Family Lecture Series in 2015 featured Andrew Lo. He gave a public lecture, aimed at a general audience, and a research lecture, for a scientific audience.

Speaker Bio:

Andrew W. Lo is the Charles E. and Susan T. Harris Professor at the MIT Sloan School of Management, the director of MIT’s Laboratory for Financial Engineering, a principal investigator at MIT’s Computer Science and Artificial Intelligence Lab, and an affiliated faculty member of the MIT Department of Electrical Engineering and Computer Science. He is a graduate of the Bronx High School of Science, received his B.A. in economics from Yale University in 1980, his A.M. and Ph.D. in economics from Harvard University in 1984, and taught at the University of Pennsylvania’s Wharton School from 1984 until 1988 when he joined MIT’s faculty.

He has published numerous articles in finance and economics journals, and has authored several books including *The Econometrics of Financial Markets*, *A Non-Random Walk Down Wall Street*, and *Hedge Funds: An Analytic Perspective*. His awards include an Alfred P. Sloan Foundation Fellowship, a Guggenheim Fellowship, the Paul A. Samuelson Award, election to Academia Sinica, the Econometric Society, the American Academy of Arts and Sciences, *Time Magazine*’s 2012 list of the “100 most influential people in the world,” and teaching awards from the University of Pennsylvania and MIT.

His most recent research interests include econometric models of systemic risk, evolutionary and neurobiological models of investor behavior, and applications of financial engineering to support translational medicine in cancer, orphan diseases, and Alzheimer’s disease.

Public Lecture, May 18, 2015: “Can Financial Engineering Cure Cancer? A New Approach to Funding Biomedical Innovation”

As disruptive as the recent financial crisis has been, the important lessons to be learned from the spectacular failure of financial technologies gone awry may actually pave the way for some of the most significant achievements of the 21st century. In this talk, Prof. Lo will provide a brief overview of the key role that financial innovation played in the crisis, and how a deeper appreciation of human nature, incentives, and the mathematics of financial engineering may allow us to focus the enormous power of global financial markets on one of society’s most pressing challenges: curing cancer.

Research Lecture, May 19, 2015: “Evolutionary Foundations of Economic Behavior, Bounded Rationality, and Intelligence”

Rational economic behavior in which individuals maximize their own self-interest is only one of many possible types of behavior that arise from natural selection. Given an initial population of individuals, each assigned a purely arbitrary behavior with respect to a binary choice problem, and assuming that offspring behave identically to their parents, only those behaviors linked to reproductive success will survive, and less successful behaviors will disappear exponentially fast. This framework yields a single evolutionary explanation for the origin of several behaviors that have been observed in organisms ranging from bacteria to humans, including risk-sensitive foraging, risk aversion, loss aversion, probability matching, randomization, and diversification. The key to understanding which types of behavior are more likely to survive is how behavior affects reproductive success in a given population’s environment. From this perspective, intelligence is naturally defined as behavior that increases the likelihood of reproductive success, and bounds on rationality are determined by physiological and environmental constraints.

Culminating Workshop, Broad Perspectives and New Directions in Financial Mathematics, June 7-12, 2015.

Part of the long program on Financial Mathematics. The culminating workshop was organized by the long program organizing committee.

The final workshop in the long program, held at Lake Arrowhead Conference Center, provided an opportunity for the program’s core participants to report on their work during the past three months and to discuss future projects. Many of the collaborations and interactions that were formed during the program had a chance to deepen.

Materials for a Sustainable Energy Future Reunion Conference I, June 7-12, 2015.

The reunion conference was organized by the original long program organizing committee.

This was the first reunion conference for participants of the fall 2013 long program “Materials for a Sustainable Energy Future.” It was a timely get-together to continue some of the collaborations that were started during the long program. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations.

Materials Defects Reunion Conference II, June 7-12, 2015.

The reunion conference was organized by the original long program organizing committee.

This was the second reunion conference for participants of the fall 2012 long program “Materials Defects.” It was a timely get-together to continue some of the collaborations that were started during the long program. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations.

SUMMER PROGRAM: Research in Industrial Projects for Students (RIPS)-Hong Kong 2015, June 8 - August 7, 2015.

In collaboration with Hong Kong University of Science and Technology (HKUST), IPAM recruited eight U.S. students to work on cross-cultural teams with eight HKUST students on four projects, each sponsored by a company based in the region. The student team, with support from their academic mentor and industry mentor, research the problem and present their results, both orally and in writing, at the end of the program.

The program is nine weeks. IPAM provides the U.S. participants with a travel allowance and a stipend of \$3,000. Housing and most meals are also included.

U.S. citizens and permanent residents are eligible for RIPS-Hong Kong. English is the only language required for participation.

Students stay in residence halls and eat most meals in the campus dining halls. The HKUST math department provides technical support and offices, and offers some cultural activities and Cantonese lessons.

IPAM’s partner, HKUST, recruited four project sponsors from local industry:

Sponsor	Title of Project
China International Capital Corp (CICC)	On the Efficiency of the Market and Text-Mining with Historical Data
Hong Kong Observatory	Development of Clustering Algorithms for Ensemble Weather Forecasts
Huawei	Temporal-Spatial Visualization of Urban Dynamics
Lenovo	Creation and Optimization of a Logo Recognition System

SUMMER PROGRAM: Research in Industrial Projects for Students (RIPS) 2015. June 22 - August 21, 2015.

The Research in Industrial Projects for Students (RIPS) Program provides an opportunity for talented undergraduate students to work in teams on a real-world research projects proposed by sponsors from industry or the public sector. The student team, with support from their academic mentor and industry mentor, will research the problem and present their results, both orally and in writing, at the end of the program.

The 2015 sponsors and projects included:

Industry	Title of Project
Aerospace Corporation	Dynamics and Control of CubeSat Orbits for Distributed Space Missions
Google LA	Personalized Local Recommendations
Gum Gum	RTB Optimization for Online Advertising
HRL Laboratories	Modeling stimulation-enhanced synchrony among distributed brain areas
LA Police Department	Detecting Foot-Chases from Police Body-Worn Video
Lawrence Livermore National Lab	Exact formulas for a set of orthogonal polynomials
Shoah Foundation	Improving the accessibility and graphical realization of the USC Shoah Foundation archive
Symantec	Incremental Set Cover
Twitter	#Conversations

The program is nine weeks. IPAM provides each undergraduate student with a travel allowance and a stipend of \$3,000. Housing and most meals are also included. RIPS-LA students live in residence halls on the UCLA campus and will work at IPAM. International students, including students attending a university outside the U.S., are eligible to apply for RIPS-LA, as are graduating seniors.

We have provided below a selection of responses from RIPS2015 students to the question “How has your participation in RIPS affected your career and research?” which demonstrate the impact of the program.

Revolutionized my concept of leadership both academically and culturally. I was challenged greatly to learn more about mathematics research but also how to function as a leader of a team that was half Chinese.

-Owen Richfield, RIPS-Hong Kong 2015 - PhD Student in BioInnovation, Tulane University

RIPS was my first research experience in applied mathematics, the field in which I am now doing graduate work; I had previously only done pure math and engineering research. The work I did and saw at RIPS and my interactions with others in the program heavily influenced my decision to go into applied math. RIPS was also the first time I had led the writing of a mathematical paper, and it exposed me to a different mode of mathematical collaboration than I had worked in before. While we did not pursue publication of our work, we did present at the Joint Mathematics Meetings.

-Jessica Oehrlein, RIPS-LA 2015 - PhD Student, Columbia University

It was decisive for my career. It gave me a new perspective that convinced me to pursue a PhD and an academic career in applied mathematics.

-Monica Ribero, RIPS-LA 2015 - Researcher, Quantil

I was awarded a 2016 Goldwater Scholarship for an essay about my RIPS research project. In addition, it introduced me to the field of data science and has been a great stepping stone to subsequent research opportunities.

-Tamar Lichter, RIPS-LA 2015 - Undergraduate student, CUNY Queens College

It gave me a whole new perspective into industrial research and how it could be very fascinating. RIPS also gave me valuable speaking and presentation skills.

-Aritra Ghosh, RIPS-LA 2015 - Applications Engineer, Oracle India Pvt. Ltd.

I'm very appreciative of the opportunity I had at RIPS 2015 to dedicate myself to a project before starting my PhD. It taught me good research skills (presenting, reading papers, collaborating) that I have been able to put into practice in my PhD studies.

-Peter Baddoo, RIPS-LA 2015 - 2nd year PhD student, Cambridge University

RIPS convinced me to pursue a higher degree in Statistics. It enabled me to collaborate with some best students in the world to solve difficult problems. From comprehensive research skills to public speaking, RIPS program helped me achieve significant self-improvement.

-Hangjian Li, RIPS-LA 2015 - PhD student, UCLA

Participation in RIPS helped me make the decision to return to school to pursue a PhD in the same field and specialization that I did research on during the program. Although I am taking a year off to work, RIPS is the main reason I want to pursue research instead of staying in industry.

-Chelsea Chandler, RIPS-LA 2015 - Software Engineer, Lockheed Martin

WORKSHOP: RIPS 2015 Projects Day. August 18, 2015

The nine RIPS-LA teams presented their industry-sponsored research on the projects listed above. Representatives of the industry sponsors attend, and the event was open to the public. Guests included friends and family members of the students, IPAM supporters, and members of UCLA's math and science community.

SUMMER PROGRAM: Graduate-Level Research in Industrial Projects for Students (GRIPS)-Berlin. June 29 - August 21, 2015.

Graduate-Level Research in Industrial Projects for Students (GRIPS) offers graduate students in mathematics and related disciplines the opportunity to work on industry-sponsored research problems. Six students from the U.S. and six from Europe work on cross-cultural teams on three research problems designed by the industrial sponsor. The projects will be of serious interest to the sponsor and will offer a stimulating challenge to students; most will involve both analytic and computational work. At the end of the program, the teams will present the results of their work and prepare a final report. English is the only language required for participation.

Round-trip travel to Berlin and accommodations in Berlin are included. Students also receive a meal allowance and a stipend of \$3,000 for their full participation. (These terms apply to U.S. participants recruited by IPAM.)

The Institute for Pure and Applied Mathematics (IPAM) partners with the Research Campus MODAL in Berlin, Germany. MODAL has existing industrial partners affiliated with their laboratories that provide their research groups with interesting and challenging research problems.

All work was based on real-world data provided by the industry partner. The sponsors and projects for 2015 included:

1. SAP-Innovations Center Potsdam (Biotech)

Company: SAP's Innovation Center is located in Potsdam, in close proximity to more than 30 renowned educational and research institutions. In recent years Potsdam has emerged as an important center of technological innovation in Germany. The innovation center is involved in the deployment of the new in-memory computing technology introduced by SAP, including SAP High-Performance Analytic Appliance (SAP HANA) software. This technology enables entirely new application scenarios and real-time analyses through the parallel processing of very large data-sets, thus laying the groundwork for intelligent and user-friendly software solutions for the future.

Project: Building on SAP's newest HANA database technology students will develop new machine-learning techniques to analyze medical massive data sets. First, students will learn the necessary biological foundation needed to successfully complete the project. They will then use

data from a large clinical trial to model medical phenomena using latest network-of-networks theory.

2. Deutsche Bahn (German Railways)

Company: Deutsche Bahn (DB) is the main German railway company. It transports on average 5.4 million customers every day over a rail network that consists of 33,500 km of track, and 5,645 train station. DB operates in over 130 countries world-wide. It provides its customers with mobility and logistical services, and operates and controls the related rail, road, ocean and air traffic networks.

Project: This project will help develop new and optimized schedules. In general, there is a trade-off for complex systems between robustness and efficiency. The students will do simulations and develop analytic models to explore this trade-off.

3. SAP AG Walldorf (Supply Chain Management)

Company: Headquartered in Walldorf, Germany, with locations in more than 130 countries, SAP is the market leader in enterprise application software, developing innovations that help businesses run better. SAP empowers people and organizations to work together more efficiently and use business insight more effectively to stay ahead of the competition. SAP applications and services enable more than 248,500 customers to operate profitably, adapt continuously, and grow sustainably

Project: Supply Chain Management (SCM) deals with the combination of procurement, production, storage, transport and delivery of commodities. Problems of this kind occur in all kinds of industry branches. Since the integrated planning of these processes contains a high potential for optimization it is of great importance for the companies' efficiency. One method of choice to find optimal solutions in SCM is linear and integer programming. Nevertheless, there are big challenges to overcome (concerning both hardware and algorithms) due to very detailed and therefore large models. This project will aim at implementing state-of-the-art algorithms for computing high-quality solutions within acceptable running times. Selected approaches from the SCM literature will be implemented and compared computationally. An analysis of performance bottlenecks will ideally lead to an improvement of the algorithms for the specific data sets at hand.

SUMMER SCHOOL: Games and Contracts for Cyber-Physical Security. July 7 - 23, 2015.

Organizing Committee:

Saurabh Amin (Massachusetts Institute of Technology)

Asuman Ozdaglar (Massachusetts Institute of Technology)

Galina Schwartz (University of California, Berkeley (UC Berkeley))

This summer school will provide an advanced introduction on how the mathematical tools of game theory can be applied to improve the resilience (security and reliability) of cyber-physical systems (CPS) that control critical national infrastructures, such as our electricity, water, and transportation networks. The operations of such CPS are driven by actions of many human decision makers who need to make decisions based on limited information. In addition, these

humans frequently have conflicting objectives, which make them reluctant to share even partial information with others. Game-theoretic tools allow analyzing strategic behavior of the entities upon whose choices the CPS operations depend.

The summer school will cover:

- Mathematical tools from game theory.
- Economic applications of game theory, such as principal-agent theory, dynamic games and contracts, regulation, mechanism design and auctions, and matching and market design.
- Game theory for cyber physical systems, especially security and resilience with applications to various infrastructure domains.

The content will be targeted toward graduate students and postdocs coming from engineering sciences and economics.

WORKSHOP: Mathematical Sciences Internship Workshop. Sept. 1-2, 2015.

Organizing Committee

Russel Caflisch, Mathematics, UCLA

Alan Lee, VP of Engineering, Advanced Micro Devices (AMD)

Rachel Levy, Mathematics, Harvey Mudd College (Facilitator)

James L Rosenberger, Statistics, Penn State

The goal of the two-day workshop was to discuss recommendations for infrastructure and programs that could:

- increase the number of internships targeting mathematical sciences students
- open the internship pipeline to a diverse group of students
- provide assistance with timing and logistics for undergraduates, graduate students and postdocs in pure and applied mathematics
- provide training to prepare mathematical sciences students for internships
- develop viable models of how internships best work for mathematical sciences students, postdocs and faculty and for industry/government

During the workshop participants spent two sessions in one of the following working groups: support, training, logistics, recruiting, and culture. They also rotated to two other groups, participated in a charrette to respond to general questions, and provided comments in several all-group sessions. With the intentional overlap between topics and exchange between members of different groups, many ideas arose which resonated across the groups.

The diverse group of participants brought perspectives from academic (college/university, public/private), business (large/small) and governmental institutions as well as many areas of the mathematical sciences.

A report was presented to NSF-DMS in October 2015 and posted on IPAM's webpage.

LONG PROGRAM: New Directions in Mathematical Approaches for Traffic Flow Management. September 8 - December 11, 2015

Organizing Committee:

Alexandre Bayen, Co-chair (University of California, Berkeley (UC Berkeley))

Carlos Canudas de Wit (Centre National de la Recherche Scientifique (CNRS))

Christian Claudel, Co-chair (University of Texas at Austin)

Serge Hoogendoorn (Technische Universiteit te Delft)

Jean-Patrick Lebacque (IFSTTAR)

Hani Mahmassani (Northwestern University)

Daniel Work, Co-chair (University of Illinois at Urbana-Champaign)

Laura Wynter (IBM)

The recent emergence of new technologies such as sensor networks, smartphones, and new paradigms such as crowdsourcing social networks has induced profound transformations in the way traffic management will be done in the future. Sensor networks have enabled robust and resilient monitoring of the backbone of the transportation network. Smartphones have provided ubiquitous coverage of the transportation network, but provide unpredictable, sometimes unreliable data, which requires a significant amount of filtering. Finally, the emergence of social networks has enabled direct access to people's mobility patterns, and the ability to interact with them, thus opening the incentivizing behavior change (either as part of a social group or through the social network). All of these advances have created the need for new modeling approaches (in particular to encompass the new data), new estimation, inference and filtering methods and are leading to the development of new paradigms for control. This revival of traffic engineering at the age of web 2.0 and social networks has created a significant amount of excitement in the mathematics, applied mathematics and engineering communities, to support these new approaches. In this program we would like to capture these breakthroughs and bring together the world experts of these cross-disciplinary fields.

Participating this IPAM program has greatly broadened my eyes in traffic and related mathematical problems. Being a mathematician, I always have the feeling that mathematical tools should be applied in real world problems. However, collaboration with people in other field has never been easy. In IPAM, things are quite different. Here you may talk and discuss with people in other fields very easily. The talks offered by this IPAM program gave me not only a general background of the traffic problem and mathematical approaches that have been used, but also gave me many chances to discuss with others about how to apply new methods to solve problems in traffic.

-Yucheng Hu, Assistant professor, Tsinghua University

TUTORIALS: Mathematical Approaches for Traffic Flow Management Tutorials.

September 9 - 12, 2015

Part of the long program on Traffic Flow Management

Organizing Committee:

Alexandre Bayen, Co-chair (University of California, Berkeley (UC Berkeley))

Christian Claudel, Co-chair (University of Texas at Austin)

Daniel Work, Co-chair (University of Illinois at Urbana-Champaign)

The long program opens with four days of tutorials that will provide an introduction to major themes of the entire program and the four workshops. The goal is to build a foundation for the participants of this program who have diverse scientific backgrounds. Topics that will be discussed include:

- A tutorials on estimation, including particle filtering, Kalman filtering, and model filtering.
- An introduction to traffic flow on networks.
- A primer on ramp metering, traffic signal, and/or variable speed limit control.
- A tutorial on utilizing new (and big) datasets.

WORKSHOP I: Mathematical Foundations of Traffic. September 28 - October 2, 2015

Part of the long program on Traffic Flow Management

Organizing Committee:

Christian Claudel (University of Texas at Austin)

Paola Goatin (Institut National de Recherche en Informatique Automatique (INRIA))

Jean-Patrick Lebacque (IFSTTAR)

Benedetto Piccoli (Rutgers University)

Michael Zhang (University of California, Davis (UC Davis))

In the last two decades, the number of traffic models which have emerged from engineering research is quite significant. Most of the initial models can be traced back to the famous Lighthill-Whitham-Richards (LWR) model, and numerous extensions of these models have been created, which include second order models, jamiton models, systems of hyperbolic conservation laws, and many others. While some of the first instantiations of numerical solutions for these models also go back to the 1950s – for example, the famous Godunov scheme (1957) – these schemes have taken some time to permeate and make their way into the engineering community. Moreover, the models developed by traffic engineers are becoming so complex that the mathematical community has a hard time to keep up with modelers, to prove existence and uniqueness of the solutions which engineers produce analytically, numerically or heuristically. Some recent examples include the famous articles of Bardos, Leroux and Nedelec proving for

the first time in 1979 the existence and uniqueness of specific conservation laws on bounded domains. More recently, the viscosity solution of Crandall and Lions gave a new meaning to integral forms of conservations laws (Hamilton-Jacobi equations) which appear naturally in traffic.

The goal of this workshop is precisely to bring together communities which can mutually benefit from each other: traffic engineering and mathematics. The mathematics community has historically provided the engineering community with the proper ways to scientifically derive results used in practice, and the engineering community has provided the mathematics community with a variety of interesting problems to study. In the 21st century, the amount of work to be done on the mathematical side to provide a sound basis for the current work in engineering is considerable. It is growing due to new sources of data (such as smartphones) that have generated even more complicated problems.

The workshop will be divided into three parts, each of which will investigate various aspects of these considerable challenges. The first subtopic, fundamental models, will assemble experts who have made initial models such as the LWR model progressively more complex because of the need to incorporate new data and paradigms. The second subtopic will assemble experts who have worked on integral forms of the LWR model, in particular the Hamilton-Jacobi model. In the third topic, extensions of traffic flow models to better fit reality will be discussed. This workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.

IPAM's 15th Anniversary Event. October 6, 2015

IPAM will commemorate its 15th anniversary with an afternoon event featuring talks, networking and celebration.

IPAM was founded in 2000 by Mark Green, Tony Chan, and Eitan Tadmor as an NSF Mathematical Sciences Institute with a grant from the NSF Division of Mathematical Sciences. The five-year grant was renewed in 2005, 2010, and 2015. IPAM welcomes about 2,000 visitors from around the world to participant in over 20 workshops, long programs, student research programs, summer schools, and other programs each year. This anniversary event coincides with the start of IPAM's 15th year of programming.

The event will begin at 3:00 pm, and will consist of three short talks by former participants of IPAM programs whose research was greatly influenced by their participation at IPAM. A reception will follow. All activities take place at IPAM (Portola Plaza Building).

Presenters:

- Roja Bandari, Data Scientist at Twitter
- Maryam Fazel, Associate Professor in Electrical Engineering at the University of Washington
- Raanan Schul, Assistant Professor at SUNY Stony Brook

WORKSHOP: Advancing Traffic Control through Big Data and Connectivity. October 7, 2015

Part of the long program on Traffic Flow Management

Organizing Committee:

Alexandre Bayen, Co-chair (University of California, Berkeley (UC Berkeley))

Joe Butler (UC Berkeley PATH)

Christian Claudel, Co-chair (University of Texas at Austin)

Daniel Work, Co-chair (University of Illinois at Urbana-Champaign)

This one day workshop will include traffic management and traffic control experts from academia, industry, and government. It will include a series of presentations from these three sectors to go over challenges and opportunities in the field of traffic control and management, in particular on the following topics: (i) use of novel types of data, (ii) new paradigms in traffic lights coordination, metering etc; (iii) collaborations between multiple jurisdictions in integrated corridor management; and (iv) managing mobility at the level of corridors. The participants will discuss various progress made in the last years in the field of modeling, algorithm design, implementation, testing, and validation. Successes and challenges will be discussed. In the afternoon, there will be a tour of the Caltrans Los Angeles Traffic Management Center. A bus will be provided by IPAM for those who register by September 28, 2015.

Please register by sending an email to the address below and indicate if you plan to attend the morning talks, the afternoon tour, or both. Please respond by October 5, 2015.

WORKSHOP II: Traffic Estimation. October 12 - 16, 2015

Part of the long program on Traffic Flow Management

Organizing Committee:

Hani Mahmassani, Co-chair (Northwestern University)

Lyudmila Mihaylova (University of Sheffield)

Hans van Lint (Technische Universiteit te Delft)

Daniel Work, Co-chair (University of Illinois at Urbana-Champaign)

The last decade has seen a sharp increase in the amount of data available to estimate vehicular traffic, pedestrians and crowds, and human mobility patterns. Furthermore the type of data available has also diversified dramatically. This evolution has been particularly quick in the last few years, due to the prolific growth of mobile phones and the datasets they generate.

The workshop will investigate techniques that are commonly used for traffic estimation with partial differential equations, ranging from centralized and decentralized nonlinear extensions of Kalman filtering to particle filters (subtopic 1). It will also focus on statistical methods, in particular for the arterial networks where data is often sparse (subtopic 2). Subtopic 3 will cover optimization methods and games applied to networks of PDEs, with specific emphasis on traffic models. Subtopic 4 examines how to estimate mobility patterns on these networks, using massive datasets generated from call detail records and other positioning data. Subtopic 5 will explore estimation problems such as tracking and localization, generated at the scale of small groups of pedestrians and crowds. Finally, the fundamental challenges and new approaches to maintain privacy of users who contribute the data to be used for estimation will be the focus of subtopic 6.

WORKSHOP III: Traffic Control. October 26 - 30, 2015

Part of the long program on Traffic Flow Management

Organizing Committee:

Carlos Canudas de Wit (GIPSA Lab)

Roberto Horowitz (University of California, Berkeley (UC Berkeley))

Markos Papageorgiou (Technical University of Crete)

In the past decades, freeway traffic control has mainly included approaches based on ramp metering, i.e. actuation via traffic lights preventing a too high flow from entering the freeway during congestion times. In the last few years, with the advent of distributed computing, wireless communication, ubiquitous sensing and increased interest in the development of appropriate control methodologies, metering can be achieved at large scale (not only locally), and can be allied with numerous other approaches such as variable speed limits, special use lanes, etc. The mathematical formulation of the underlying problems is quite challenging; for example, variable speed limits change the underlying flow model used in the problem set up. The formulation of the corresponding control problems is also quite difficult, as many times it results in nonlinear non-convex optimization problems. Numerous approaches have been investigated to solve these problems, which include Lyapunov techniques, adjoint based optimization, and convex relaxation.

The workshop will focus on a number of different aspects of these problems. First, mathematical foundations of PDE control will be investigated as the foundational theoretical work on which control of traffic systems rely. This subtopic will cover the fundamental approaches which are typically used for controlling PDEs (and which appear in the traffic control literature), in particular: Lyapunov stability, differential flatness, adjoint based optimization and more.

Another subtopic of the workshop is network control, and will emphasize coupling aspects which appear when trying to do estimation, control or optimization on networks of PDEs (such as the transportation network). Yet another subtopic of the workshop is routing, which has gained a lot of attention in the last several years due to the availability of smartphones which have routing capabilities. Finally, the workshop will address problems arising in future traffic due to the introduction of a number of VACS (vehicle automation and communication systems).

PUBLIC LECTURE: “Missing in Translation – Where are the Innovations?” by Sadasivan Shankar. November 12, 2015

Abstract:

Innovations have driven much of the advancement of human civilization. Examples include the industrial revolution, electricity, manned flight, information technology, Moore’s law, the internet, etc. Similarly, products like the PC, iPhone, Tesla electric car, and Google search engine are also associated with innovation. Thus we could define innovation as the development of a new device, product or method of doing things that is different from what already exists. Since goods and services determine economic output, the ability of a nation or state to translate fundamental ideas, concepts, or research into reality determines its economic strength. In other words, innovations are essential to economic leadership. It is clear that the future belongs to those countries or communities where innovation thrives both organically and top-down. We will examine some examples of U.S. leadership in innovation. As we look at different metrics of innovation, we will assess the reasons that the U.S. is currently in danger of losing its leadership. We will argue that the problem is multi-dimensional and that solutions could come from STEM (Science, Technology, Engineering, and Mathematics) fields, businesses, and government policies.

Speaker’s Bio:

Sadasivan (Sadas) Shankar is the first Margaret and Will Hearst Visiting Lecturer in Computational Science and Engineering at Harvard School of Engineering and Applied Sciences, where he will be involved in teaching and research in the areas of large-scale computational methods, chemistry, materials, and in translational ideas. In fall 2013, as the first Distinguished Scientist in Residence at the Institute of Applied Computational Sciences in Harvard, he co-instructed a graduate-level class on Computational Materials Design, which covered fundamental atomic and quantum techniques and practical applications for new materials by design.

Sadasivan earned his Ph.D. in Chemical Engineering and Materials Science from University of Minnesota, Minneapolis. Sadasivan has initiated and led multiple efforts in Intel, most recently the Materials Design Program. Dr. Shankar is a co-inventor in several patent filings covering areas in new chemical reactor designs, semiconductor processes, bulk and nano materials, device structures, interface engineering, and algorithms. He is also a co-author in publications and

presentations in the areas of chemical synthesis, electrodeposition, direct simulation Monte Carlo, accelerated molecular dynamics, non-equilibrium electronic transport in gases and condensed matter, electromigration, three dimensional rarefied and continuum reacting flows, 3D die stacking, and atomic methods enabling high throughout calculations for material interfaces spanning all scales from atoms to macroscopic devices.

Sadasivan has been also involved in several collaborative national and international efforts with Semiconductor Research Corporation, SEMATECH, National Institute of Standards and Technology, Department of Energy, and President's Materials Genome Initiative.

WORKSHOP IV: Decision Support for Traffic. November 16 - 20, 2015

Part of the long program on Traffic Flow Management

Organizing Committee:

Alexandre Bayen (University of California, Berkeley (UC Berkeley))

Robert Bertini (California Polytechnic State University)

Serge Hoogendoorn (Technische Universiteit te Delft)

Laura Wynter (IBM)

The next decade will see numerous decision support tools emerge for traffic management. This is mainly due to the fact that all pieces necessary for the development of these tools are now at our disposal, and have emerged in the recent years. This includes sensing, communication, high performance and modeling capabilities. All over the world, several Departments of Transportation have started to investigate the steps required to build tools capable of advising humans in charge of optimization of mobility at the scale of a city. Specific breakthroughs are already visible in Australia, France and in the Netherlands. Such tools require significant amount of modeling (the interplay of various control schemes on a distributed parameter system, which can be modeled as a partial differential equation), which will be presented in the first subtopic of the workshop (for which we will invite experts who have already experience in building successfully such systems). Decision support tools also require the solution of the very difficult problem of dynamic traffic assignment, known to be NP hard in the discrete setting, and which has only be superficially studied at the continuous level (i.e. with traffic modeled by PDEs), in a dynamic setting. The dynamic traffic assignment is a fundamental problem in this field, which is at the heart of any allocation algorithm which attempts to optimize flow on a network. The second subtopic will focus specifically on dynamic traffic assignment. Finally, in the last subtopic, we will invite experts in the field of games and incentivization, which is one of the future backbones of control and ties with decision support. In this last topic, we will assemble a panel of experts who have worked on mechanisms which can be used to incentivize users of the transportation network to change their patterns based on options given to them by the system, or by a game in which they take part.

Culminating Workshop of Traffic Flow Management. December 6-11, 2015.

Part of the long program on Traffic Flow Management. The culminating workshop was organized by the long program organizing committee.

The final workshop in the long program, held at Lake Arrowhead Conference Center, provided an opportunity for the program's core participants to report on their work during the past three months and to discuss future projects. Many of the collaborations and interactions that were formed during the program had a chance to deepen.

Combinatorial and Computational Geometry Reunion Conference I, December 6-11, 2015.

The reunion conference was organized by the original long program organizing committee.

This was the first reunion conference for participants of the spring 2012 long program "Combinatorial and Computational Geometry." It was a timely get-together to continue some of the collaborations that were started during the long program. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations.

Interaction Between Analysis and Geometry Reunion Conference II, December 6-11, 2015.

The reunion conference was organized by the original long program organizing committee.

This was the second reunion conference for participants of the spring 2013 long program "Interaction Between Analysis and Geometry." It was a timely get-together to continue some of the collaborations that were started during the long program and at the first reunion. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations.

OUTREACH ACTIVITIES

The following outreach activities are in addition to the programs listed above.

IPAM participates in the Modern Math Workshop, a one-day program for undergraduate and graduate students held the day before the official start of the national meeting of SACNAS, on Oct. 15-16, 2014 and Oct. 28-29, 2015. IPAM was not the lead organizer, so the participants of the program, mostly Hispanic students, are not included in our report. IPAM provided a speaker for each workshop: in 2014, Wenlong Jin from UC Irvine, and in 2015, Isabel Meirelles, Ontario College of Art and Design. (They are participants in upcoming IPAM programs.) IPAM encouraged former participants of our programs, especially RIPS, to participate.

IPAM continued partnerships with two- and four-year schools in the Los Angeles area in order to increase the representation of minorities and women in its programs. IPAM invited students at East Los Angeles College, Santa Monica College, and Cal State Northridge to attend our public lectures. IPAM continues to support the UCLA chapter of SACNAS: The outreach coordinator

attends quarterly meetings and encourages them to participate in IPAM programs. The chapter used IPAM facilities for an annual K-12 educational event, their year-end banquet, and occasional meetings and study sessions.

IPAM held a women’s luncheon during the fall 2014 program on Mathematics of Turbulence, and during the fall 2015 program on Traffic Flow Management.

Other outreach and diversity activities during this reporting period:

- IPAM’s outreach coordinator attended the Nebraska Conference for Undergraduate Women in Math (NCUWM) in January 2015 to talk to undergraduate women about opportunities in math. Two RIPS students from the 2014 program also presented their research; IPAM paid for their travel.
- IPAM staff attended the national meeting of SACNAS to talk to conference attendees about IPAM programs.
- IPAM advertised RIPS (summer research program) through minority institutions and organizations.
- IPAM advertised its “call for proposals” on the AWM website and conducted an email marketing campaign, sent to subscribers of the journal *Science*.
- With the other NSF math institutes, IPAM supported the AWM Mentor Network Program.
- IPAM used funds from the Berland Foundation endowment to help two long program participants pay for child care expenses.

K. PROGRAM CONSULTANT LIST

IPAM consulted a variety of scholars and practitioners in the scientific planning of each program. The list below includes program organizers for the programs that took place between September 1, 2014 and December 31, 2015. We have excluded members of IPAM’s Board of Trustees and Science Advisory Board, since they are listed in section O. The list also excludes our own scientific staff (directors).

Full Name	Institution
Alejandro Adem	Mitacs
Amit Agrawal	Amazon Lab126
Saurabh Amin	Massachusetts Institute of Technology
Federico Ardila	San Francisco State University
Alán Aspuru-Guzik	Harvard University
Jonathan Aurnou	University of California, Los Angeles (UCLA)
Marco Avellaneda	New York University
Rodrigo Bañuelos	Purdue University
Richard Baraniuk	Rice University
Alexandre Bayen	University of California, Berkeley (UC Berkeley)

Tanya Beder	SBCC Group
Robert Bertini	Portland State University
Jean-Philippe Bouchaud	Capital Fund Management
Annalisa Bracco	Georgia Institute of Technology
Oliver Bühler	New York University
Joe Butler	UC Berkeley PATH
Carlos Canudas de Wit	GIPSA Lab
Lawrence Carin	Duke University
René Carmona	Princeton University
Jose Castillo	San Diego State University
Colm-cille Caulfield	University of Cambridge
Christian Claudel	University of Texas at Austin
Peter Constantin	Princeton University
Rama Cont	Imperial College
Ricardo Cortez	Tulane University
Oliver Cossairt	Northwestern University
Gabor Csanyi	University of Cambridge
Charlie Doering	University of Michigan
Gregory Eyink	Johns Hopkins University
Jean-Pierre Fouque	University of California, Santa Barbara (UCSB)
Baylor Fox-Kemper	Brown University
Daniel Freed	University of Texas at Austin
Angela Gallegos	Loyola Marymount University
Pascale Garaud	University of California, Santa Cruz (UC Santa Cruz)
Paola Goatin	Institut National de Recherche en Informatique Automatique (INRIA)
Xin Guo	University of California, Berkeley (UC Berkeley)
Michael Hermele	University of Colorado Boulder
Serge Hoogendoorn	Technische Universiteit te Delft
Roberto Horowitz	University of California, Berkeley (UC Berkeley)
Monica Jackson	American University
Trachette Jackson	University of Michigan
Michael Jolly	Indiana University
Keith Julien	University of Colorado Boulder
Anton Kapustin	California Institute of Technology
Rich Kerswell	University of Bristol
John Kim	University of California, Los Angeles (UCLA)
Alexander Kiselev	Rice University
Joseph Klewicki	University of Melbourne
Jean-Patrick Lebacque	IFSTAR
Jim Leebens-Mack	University of Georgia
Andrew Lo	Massachusetts Institute of Technology
Hani Mahmassani	Northwestern University
Anna Mazzucato	Penn State University
Beverley McKeon	California Institute of Technology

Herbert Medina	Loyola Marymount University
Lyudmila Mihaylova	University of Sheffield
Klaus-Robert Müller	Technische Universität Berlin
Stanley Osher	University of California, Los Angeles (UCLA)
Victor Ostrik	University of Oregon
Asuman Ozdaglar	Massachusetts Institute of Technology
Markos Papageorgiou	Technical University of Crete
George Papanicolaou	Stanford University
Benedetto Piccoli	Rutgers University
Gopal Prasad	University of Michigan
Andrei S. Rapinchuk	University of Virginia
Alan Reid	University of Texas at Austin
Sebastien Roch	University of Wisconsin-Madison
Nancy Rodríguez	UNC - Chapel Hill
Alexander Schied	Universität Mannheim
Galina Schwartz	University of California, Berkeley (UC Berkeley)
Ati Sharma	University of Southampton
Ronnie Sircar	Princeton University
Yohann Tander	École Nationale Supérieure de Télécommunications
Joseph Teran	University of California, Los Angeles (UCLA)
Jean-Luc Thiffeault	University of Wisconsin-Madison
Alexandre Tkatchenko	Fritz-Haber-Institut der Max-Planck-Gesellschaft
Tatiana Toro	University of Washington
Alejandro Uribe	University of Michigan
Hans van Lint	Technische Universiteit te Delft
Ashvin Vishwanath	University of California, Berkeley (UC Berkeley)
Tandy Warnow	University of Illinois at Urbana-Champaign
Daniel Work	University of Illinois at Urbana-Champaign
Laura Wynter	IBM
Wei Xiong	Princeton University
Thaleia Zariphopoulou	University of Texas at Austin
Michael Zhang	University of California, Davis (UC Davis)

L. PUBLICATIONS LIST

This year, we were advised to report on publications that resulted from long programs for which we had second reunion conferences in this reporting period. (The second reunion conference takes place two and a half years after the final week of the long program.) However, we had surveyed the participants of those long programs and included their publications in the 2011-12 and 2012-13 annual reports.

With this report, we included the publications of our Director, Associate Directors and Director of Special Projects with publication dates within the reporting period, as well as publications

resulting from RIPS and the 2014 and 2015 summer schools.

We reported them through Research.gov rather than in this document. We have chosen only to report published articles; articles that are submitted or under review are not included.

M. INDUSTRIAL AND GOVERNMENTAL INVOLVEMENT

We have significant involvement of industry and government labs in our summer program, Research in Industrial Projects for Students (RIPS). See the program description for RIPS-LA (Section J) for a complete list of sponsors in RIPS-LA 2015.

We also offered RIPS-Hong Kong for the fifth time in the summer of 2015. Our partner, Hong Kong University of Science and Technology, recruited the sponsors. See the program description (Section J) for more information.

Out of 2,754 total participants during this reporting period, 165 of them came from 84 different companies. Industry participation was particularly high for RIPS, the inaugural meeting of Women in Financial Mathematics, and two scientific workshops: Computational Photography and Intelligent Cameras, and Symmetry and Topology in Quantum Matter.

During the same period, 119 participants came from government or military institutions. Close to a half (55) of the participants to IPAM programs came from the national laboratories or from laboratories associated with the military. The workshops that were part of the long program on Traffic Flow Management attracted practitioners who work for city or state agencies.

IPAM received in-kind support from MathWorks in 2015. MathWorks contributed eight different toolbox licenses to MatLab to our “RIPS” program, with a total value of approximately \$1,200 for the student teams to use on their research projects. During this period, IPAM received gifts from Microsoft, AMD, and the RIPS sponsors, which included several companies and one national lab (see section N).

In 2014-15, our Board of Trustees included Al Hales (CCR West), David Balaban (Amgen), Alan Lee (AMD), Tanya Beder (SBCC Group Inc.), Nancy Potok (U.S. Census Bureau), Leland Wilkinson (Chief Scientist, H2O.ai), and Bill Coughran (Sequoia Capital). Monique Miller (Wilshire Funds Management) joined in fall 2015. Karina Edmonds, Executive Director for Corporate Partnerships at Caltech, also served on the Board that year. See section O for the complete list.

Our 2014-15 Science Advisory Board included Cynthia Dwork from Microsoft Research and Yann LeCun, who leads Facebook’s artificial intelligence efforts. See section O for the complete list.

N. EXTERNAL SUPPORT

In addition to the funding listed in Table N below, IPAM receives substantial in-kind financial support from UCLA. The Director’s entire salary and administrative stipend are paid directly by UCLA. The Director of Special Projects is released from two courses at the cost of replacing him by a junior person. IPAM is not charged for the use of its building or for custodial care. The value of these items is considerable. Additionally, senior long-term participants from other universities are usually funded on a teaching replacement-buyout basis, by which they are released from teaching for the cost of hiring a junior person as a replacement. The table shows other funding received from July 1, 2015 through June 30, 2016 which is UCLA’s fiscal year.

Table N: Other Funding Support	
Federal Funding	Amount
NSF-IRES: RIPS-Hong Kong	\$72,950
Sub-total	\$72,950
Support from Foundations	
Berland Foundation	\$12,000
Sub-total	\$12,000
University Funding Support	
Dean Physical Sciences	\$135,829
Vice Chancellor for Research	\$135,302
Sub-total	\$271,131
Industrial Affiliates and Other Support	
Arete	\$25,000
GumGum	\$25,000
Twitter	\$25,000
Aerospace	\$25,000
HRL, Inc	\$25,000
Los Alamos National Laboratory	\$6,000
Sub-total	\$131,000
Others	
Frontier’s Society and Other Contributions	\$94,126
Registration Fees-Programs	\$20,380
Green Family Foundation Net Investment Income	\$74
Sub-total	\$114,580
TOTAL	\$601,661

O. COMMITTEE MEMBERSHIP

IPAM’s committees include the Board of Trustees and Science Advisory Board. The members as of the date of the board meeting during the 2014-15 fiscal year are listed below. The IPAM directors are *ex officio* members.

Science Advisory Board Membership as of November 2014:

Full Name	Discipline/Expertise	Institution
Borodin, Alexei	Mathematics	MIT
Calderbank, Robert	Computer Science	Duke University
Candes, Emmanuel	Statistics	Stanford University
Couzin, Iain	Biology	University of Konstanz
Dwork, Cynthia	Computer Science	Microsoft Research
Jones, Peter Wilcox	Mathematics	Yale University
LeCun, Yann	Computer Science	New York University/Facebook
Levermore, David	Applied Math	University of Maryland
Naor, Assaf	Mathematics	Princeton
Tao, Terence	Mathematics	UCLA
Tomlin, Claire	Electrical Engineering	UC Berkeley
Wilkinson, Amie	Mathematics	Univ. of Chicago
Wright, Stephen	Computer Science	University of Wisconsin - Madison
Yu, Bin	Statistics	UC Berkeley

Board of Trustees Membership as of January 2015:

Name	Department or Title	Institution
Green, Mark	Mathematics	UCLA
Toro, Tatiana	Mathematics	University of Washington
Chan, Tony	President	HKUST
Hales, Alfred	Director	CCR West
Balaban, David	Vice President, Research & Development Informatics	Amgen
Stern, Ronald	Dean Emeritus	UC Irvine
Kra, Bryna	Professor of Mathematics	Northwestern University
Lee, Alan	Corporate Vice President of Engineering of Research	AMD Research
Keller, Sallie	Professor of Statistics, Director	Virginia Tech University
Coughran, Bill	Partner	Sequoia Capital
Edmonds, Karina	Executive Director for Corporate Partnerships	Caltech
Beder, Tanya	Chairman & CEO	SBCC Group Inc.

Potok, Nancy	Deputy Director and Chief Operating Officer	U.S. Census Bureau
Wilkinson, Leland	Vice President, Statistics	H2O.ai

P. CONTINUED IMPACT OF IPAM PROGRAMS

The following testimonials from IPAM program participants (collected in April 2016) demonstrate the continued impact of its programs on the careers and research of IPAM participants and on math and science research.

RIPS 2014

The summer of 2015 was spent at LLNL continuing the RIPS 2014 work, and I am entering a graduate program in mathematics next semester to take extra classes in pure math. I am again joining Frank Graziani and Christian Scullard this summer, this time to study extensions of the kinetic theory problem such as systems with many particles, asymmetries, and general distribution functions. If successful, this will result in another publication based on the RIPS 2014 work.

--Andrew Belt, Student intern, Lawrence Livermore National Laboratory

As a student researcher, I gained valuable technical skills that have improved the quality of my graduate research. As a project manager, I grew in my ability to lead, motivate, and communicate both technically and non-technically. And as a collaborator within a diverse group of applied mathematicians, police administrators and officers, and even an anthropologist, I developed a greater appreciation for the important role mathematics serves in studying and improving the human condition. My collaboration with anthropologist Jeff Brantingham involves furthering the development of predictive policing technology. My perspective on why we do mathematics was forever changed. I am grateful for having participated in RIPS 2014.

--Erik Bates, PhD Student in mathematics, Stanford

At the time of attending I was interested in applied math but had largely had pure coursework. After seeing the many interesting projects a started on a dual path of pure and applied course work that has led to several areas of research in various fields. I will be attending CU Boulder for a PhD in Applied Math and I feel like my research at IPAM was a large motivator and excellent experience that allowed me to be competitive in my applications.

--Caleb Miller, Graduate Student, Cal Poly San Luis Obispo

Materials for Sustainable Energy (fall 2013)

The program allowed me to embark on an entirely new research topic in Applied Mathematics, and have been able to interest quite a number of colleagues in Berlin for the topic - it may become one building block of a major research initiative there. I have ongoing cooperations with Claudia Draxl, Humboldt-University Berlin; Eric Cancès Ecole des Ponts, Paris; Carlos Garcia-Cervera, UCSB; Kieron Burke, UC Irvine, on the dynamics of excitons in semi-conductors. Exciting news are an emerging multi scale analytical theory for excitons and a new mathematical characterization of two of the workhorses of the field, the Hedin's and Bethe-Salpeter equation.

--Rupert Klein - University Professor, Freie Universität Berlin

Summer School: Electronic Structure Theory for Materials and (Bio)molecules (July 2014)

As a computational math student new to electronic structure theory, the program was an amazing introduction to many of the key ideas and areas of current research. I was really inspired by the talks and greatly appreciated the opportunity to interact with a lot of the presenters. Through the presentations and exercises I learned a lot about the types of applications where a computational mathematician may be able to contribute. I met several students and professors working in similar research areas from different universities, and have kept in touch with them at other conferences (for example at the Materials Research Society meetings). I hope and expect these connections and the valuable insights I learned to influence my research as I continue my PhD studies and beyond.

--Qian Yang – PhD student, Stanford University

Attending the IPAM Summer School was a rewarding experience for me. At this event I was able to interact with top electronic-structure theory researchers from the USA, Europe and China. Notably, I had the opportunity to closely interact with Matthias Scheffler (one of the organizers) who is the Director of the Theory Department at the Fritz Haber Institute of the Max Planck Society. I also was able to interact with Luca Ghiringhelli, Volker Blum, and Alexandre Tkatchenko who were Group Leaders at the Fritz Haber Institute. My interactions with so many leaders at the Fritz Haber Institute and especially Matthias Scheffler helped me obtain my current Postdoctoral Position at the Fritz Haber Institute, which I began in September 2015. I am about to publish a peer-reviewed journal article with Matthias Scheffler and Luca Ghiringhelli (who was also at the summer school) titled "Uncovering structure-property relationships of materials by Subgroup Discovery", B. R. Goldsmith, M. Boley, J. Vreeken, M. Scheffler, L. M. Ghiringhelli (submitted). At the IPAM program, I also had the chance to meet Xinguo Ren, a professor at University of Science and Technology China. This led to me visiting Xinguo Ren in March 2015 in China, where I presented a seminar to his group. The talk was titled "First-principles modeling of supported nanoparticle disintegration and amorphous catalyst site activity." Overall, the IPAM summer school was a great event for me to learn cutting-edge research methods and applications, as well as to gain fruitful scientific collaborations. These experiences undoubtedly made me a better scientist.

--Bryan Goldsmith, Postdoctoral Scholar, Fritz Haber Institute of the Max Planck Society

I'm part of a research group that doesn't have a lot of experience with electronic structure calculations, but routinely does other computational studies in condensed matter theory. My advisor and I agreed that branching out into electronic structure calculations would be a good idea, but without the experience we were having a hard time making it happen. I went to the IPAM summer school with a problem to work on, but was a bit stalled because I just didn't know enough about the DFT software I was trying to run. Even though the specific software at IPAM was different, the things I learned about the electronic structure problem there were applicable enough that I was making good progress before the summer school was even finished. I still have a lot to learn, of course, but the experience I got from IPAM has opened up new opportunities for me. It was the first experience that allowed me to get more experience doing electronic structure calculations.

--Tom Pace, PhD student in Physics, University of Kentucky