Institute for Pure and Applied Mathematics, UCLA
Annual Progress Report for 2017-2018
Award #1440415
July 6, 2018

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

This report covers our activities from June 11, 2017 to June 10, 2018 (which we refer to as the reporting period). The culminating retreat of the spring long program is part of this year's report, along with the two reunion conferences, which are held the same week. This report includes the 2017 summer programs (RIPS and GRIPS). The 2018 summer programs will be included in next year's report.

IPAM held two long program in the reporting period:

- Complex High-Dimensional Energy Landscapes
- Quantitative Linear Algebra

IPAM held the following workshops in the reporting period:

- RIPS Projects Day
- Mean Field Games
- Algorithmic Challenges in Protecting Privacy for Biomedical Data
- New Methods for Zimmer's Conjecture
- New Deep Learning Techniques

IPAM typically offers two reunion conferences for each IPAM long program; the first is held a year and a half after the conclusion of the long program, and the second is held one year after the first. IPAM held a total of four second reunion conferences during this reporting period.

IPAM offered five public lectures during the reporting period. We also held a public event entitled, "The Calculus of Comedy: Math in The Simpsons, Futurama, and The Big Bang Theory."

This report includes three 2017 student research programs: Research in Industrial Projects (RIPS) in LA and Hong Kong, both for undergraduate students, and Graduate-level RIPS in Berlin. We also cosponsored the Computational Genomics Summer Institute.

IPAM sponsored the second Latinx in the Mathematical Sciences Conference in March 2018, and with the other math institutes, cosponsored the Modern Math Workshop (ICERM was the lead organizer).

A. PARTICIPANT LIST

A list of all participants in IPAM programs will be provided to NSF in electronic form (Excel). The list will include participants for programs whose start dates fall between September 1, 2017 and August 31, 2018.

B. FINANCE SUPPORT LIST

A list of participants that received support from IPAM will be provided to NSF in electronic form (Excel). The list includes all funded participants of programs that occurred between September 1, 2017 and August 31, 2018.

C. INCOME AND EXPENDITURE REPORT

This table shows appropriations and expenses for the twelve-month period June 1, 2017 through May 31, 2018 for grant #1440415.

	A	B	C	D	E	F
			A-B=C		B+D=E	A-E=F
Budget Category	**Appropriation Year 3**	**Actual Expenses for the 12 months**	**Balance for the 12 months**	**Encumbered Expenses as of May 2018**	**Total & Encumbered Expenses at May 2018**	**Encumbered Balance as of May 2018**
A. Operations Fund	$1,855,822	$1,660,791	$195,031	$245,722	$1,906,513	<$50,691>
B. Participant Costs	$1,789,000	$1,825,530	<$36,530>	$52,280	$1,877,810	<$88,810>
C. Indirect Costs	$865,178	$767,310	$97,868	$0	$767,310	$97,868
Totals	$4,510,000	$4,253,631	$256,369	$298,002	$4,551,633	<$41,633>

IPAM received an appropriation of $4,510,000 for the twelve-month period June 1, 2017 through May 31, 2018. In November 2017 the NSF approved a rebudgeting from Participant Costs to Operations and Indirect Costs. This rebudgeting is reflected in the appropriation. Total expenses were $4,551,633 leaving a balance of <$41,633>. IPAM has surplus balances in years one and two of this grant and is overall operating with positive balances.

A. The Operational Fund (salaries, benefits, equipment, and supplies) for the twelve-month period has an appropriation budget of $1,855,822 with total expenditures of $1,906,513 leaving a balance of <$50,691>.

B. Participant Support Costs include stipends, travel, housing, and subsistence for the scientists working on IPAM Programs. Participant Support Costs for the twelve-month

period has an appropriation budget of $1,789,000 with total expenditures of $1,877,810 leaving a balance of <$88,810>.

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 for the twelve-month period has an appropriation budget of $865,178 with total expenditures of $767,310 leaving a balance of $97,868.

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 most workshops are $75 for faculty and government/military participants, $100 for industry participants, $50 for post-doctoral scholars and $25 for graduate students. Program income received was $34,400 for the twelve-month period and is spent entirely on participant support expenses.

D.POSTDOCTORAL PLACEMENT LIST

IPAM did not appoint postdoctoral fellows in 2017-18, so we have no data to report in this section.

E. MATH INSTITUTE DIRECTORS' MEETING REPORT

Math Institute Directors' Meeting: April 27-28, 2018

In attendance:

AIM: Brian Conrey (chair), Estelle Basor, David Farmer, Leslie Hogben, Kent Morrison
IAS: Helmut Hofer, Richard Taylor
ICERM: Brendan Hassett, Ulrica Wilson
IMA: Daniel Spirn, Ben Brubaker
IPAM: Dima Shlyakhtenko, Christian Ratsch
MBI: Catherine Calder, Janet Best
MSRI: David Eisenbud, Hélène Barcelo
SAMSI: David Banks, Elvan Ceyhan

Friday, April 27

The meeting started at 1:00 pm with introductions.

Brian led a brief discussion about the history of the MID meetings, the vision of Philippe Tondeur, and some things that the institutes have jointly done, including the diversity committee, the careers workshops, MPE 2013, and the post-doc initiative of 2009. He mentioned that it is good for the mathematics community to be involved in the NSF 10 Big Ideas.

Minutes from JMM MID meeting

The minutes from 2017 were approved with some minor changes.

Institutes re-competition 2019

First on the agenda was the re-competition of the institutes in 2019. Brian went over the time table. There was discussion about how many institutes would be funded. Mathematics is the only discipline with long term institutes. Often centers are limited to 10 years. It was noted that we should be pro-active about what we do in mathematics, e.g. advertising, the Notices, etc.

There are 12 funded TRIPODS projects. It is not clear how these will interact with the math institutes and this is a question for NSF.

Role of institutes in NSF 10 Big Ideas

It is not clear what the solicitation is for any of the projects, except for INCLUDES. Brian reported that AIM, MSRI, MAA, and some pilot projects submitted an alliance proposal, called the Community Alliance of Mathematics. The idea is to build math communities based on Math Teachers Circles, Math Circles, the Julia Robinson Math Festival, the Navajo Nation Project, all with the idea of broadening participation. Brian answered many questions about the proposal and also the existing projects. These projects do 'good' solid mathematics and all of the institutes could have some involvement.

David Banks commented that SAMSI is always happy to help and described a couple of other festivals. David Eisenbud mentioned the California Math Festival. Dima Shlyakhtenko mentioned the use of online resources for children. The MSRI YouTube channel was mentioned and Numberphile.

There was a discussion of how we get the math institutes involved in the 10 Big Ideas. We may be the incubators for appropriate projects for the 10 Big Ideas. Brendan Hassett gave an example and said that NSF is keen to see how institute programs lead to funded projects at other places.

Brian ended this part of the meeting with the comment that it makes sense to have every one of the institutes think about ways that we fit into the 10 Big Ideas.

Institutes diversity efforts

The next item of the agenda was a report by Leslie Hogben and Ulrica Wilson from the Institutes Diversity Committee.

There was some discussion of numbers of women participation at the Institutes, faculty from PUIs and under-represented minorities. Leslie led a discussion with highlights from slides. She distinguished "pervasive inclusion" and "targeted inclusion" of under-represented groups. She also gave an overview of efforts of the institutes to broaden participation and the different strategies that were used.

Ulrica discussed some of the issues that concern the Joint Institute Diversity Committee. She said that the new logo is well accepted. As we think about the next grant, the Modern Math workshop is well liked. Blackwell-Tapia and Spring Opportunities are also workshops the committee supports. LatMath works well and is driven by the leaders in the field.

We need to discuss with Infinite Possibilities members about the future of that workshop.

There was a discussion of the supplement of the AIM grant for the minority workshops.

A stumbling block for under-represented minorities at the Institutes is information about who should go to the programs. The suggestion was to change some of the information on the Joint Diversity page. We should perhaps shift to how to apply to a workshop, make it less institute specific, give first steps to get involved in an institute program, and a bit more on what happens at the institutes. We need to de-mystify the institutes.

Brendan Hassett made a motion for the Diversity Committee to create text to de-mystify the institutes. Brendan will send the text to all the institutes for approval before putting it on the joint institute page. The vote was unanimous.

There was also discussion of when and how to apply for the next diversity grant.

Participant data validation system

The next item was the topic of data validation. Brendan brought a preview of the report that Hank will bring to the meeting. Some things to note: Annual reports will be rejected without the proper data validation. ORCID ID is not required until 2020. Is generating a database of all participants a valuable thing for institutes? NSF wants to compare participants across institutes.

Joint Institutes webpages

Next came a discussion of the Joint Institute webpage (JIP).
Brendan noted that ICERM gets content from the institutes but does not edit the material.

There was a discussion of what should go on the highlights page. The text should not be just a report from the organizers. Helmut Hofer pointed out that it might be good to write about interesting mathematics. This should be a compelling story about different areas/fields and how the institutes played a role.

Richard Taylor offered to write a critique of the highlights.

We decided to remove the dates on the home page of the JIP and there was a motion that every institute do one highlight by the end of the summer (Sept. 21) for review. This also passed unanimously.

All highlights should have closed caption and/or a physical transcript, if possible. Videos should be listed by lecture date.

After a discussion about the purpose of the JIP, Dima Shlyakhtenko agreed to draft a white paper.

IMO-2021

Brian gave a short report and said that the competition will be in the U.S. with MAA hosting the competition. Brian agreed to be the Institute liaison with this effort.

Topics to bring up with NSF

1. What is the interface and relationship with the TRIPOD budget and the institute budget?
2. Where do we ask for funding for the institute diversity grant? Is it in DMS?
3. What is the long-term strategy of the funding of institutes?

2019 MID meeting

IAS is the host of the Spring 2019 MID meeting which will be April 26 and 27th

The meeting adjourned at 4:30 pm.

Saturday, April 28, 2018

The participants from Friday plus NSF - Juan Meza, Hank Warchall, Nandini Kannan, Joanna Kania-Bartoszynska, and Junping Wang.

Report from Juan Meza

The first item of the day was a report from the new DMS director. Juan Meza said he was very happy to see the institutes are doing so well. Budgets at NSF seem okay. "We should be in good shape." He is sure we all know about the 10 Big Ideas (10 BIs) and much of the budget increases will need to go hand and hand with those ideas. He wants to hear from the community to see how the institutes fit in.

The big three are "quantum leap", "harnessing data", and "rules of life". Deadline is June 1st for the "rules of life" workshops. He wants institutes to spread the word, wants engagement from the institutes, programs in those areas, and wants institutes to ask for money on those topics, maybe from the point of view of supplements.

Also Juan wants to have a conversation about the management of all the centers and institutes and long term strategic plans. He wants to highlight the activities of the institutes. How can the institutes come together to do an even better job?

Dima asked how an institute balances the new ideas with their scientific boards. Juan's answer was that his goal is to get the 10 BIs out in the community. The institutes need to figure out and keep track of funding. Make your advisory boards aware of the 10 BIs, so the programs fit in.

Juan also asked for help with creating and generating stories about the institutes. "We would like the institutes to coordinate their activities so they can build a bigger story." There was also a discussion about avoiding duplication of institute activities, but this is really left up to the institutes.

Joint Institutes webpages: comments from Hank Warchall

Hank Warchall also remarked that NSF is happy to see the video portal. It is very useful to NSF to be able to say here are 11,000 lectures. Juan asked if we had challenges maintaining the video library? Brendan said that the videos are maintained at the institutes itself. From ICERM's point of view, the library works fairly well. We want it to continue to be a robust research.

Juan asked how many of the videos are lectures? The answer is 95%. It would be useful to have short videos about the topics.

Brendan said that most of the videos are useful for the mathematicians. More things that are for the general public are on YouTube. Maybe there should be a link to YouTube.

Juan reminded us to always use the NSF brand.

Finally David Eisenbud asked if perhaps we should have a professional designer for the webpage and that feedback on highlights from NSF would be useful to the institutes.

Questions for NSF

Diversity Grant: Brian asked where the new grant should be submitted. Joanna Kania-Bartoszynska said it should go to DMS as a conference solicitation or to Infrastructure as a collaborative proposal.

Another question was how many institutes will be considered in the next competition? New ones can go 10 years. There will be up to eight awards made according to the solicitation. Ben Brubaker asked how do we view the institutes that are cycled off? What is their role?

Juan said the institutes are the most important aspect of DMS.

There was some discussion about the philosophy of adding/closing etc. institutes. The institutes need to make a very strong case about their usefulness and impact.

Data reporting

The discussion turned to the reporting of data. How far do the institutes reach into the community? Hank Warshall described the Participant Data Study and the difficulties of identifiers. The working group came up with an excel spread sheet format. An example of spread sheet was given. The working group is trying to make the process easy for the institutes.

Motion: The institutes would like to make the aggregate data available to all the institutes.

Brendan reported on their data collection system. The new system is called Cube and he distributed a report.

2019 JMM MID meeting and reception

Last item: IPAM is in charge of the JMM MID meeting and the reception. The meeting adjourned at 12:00 pm.

F. PARTICIPANT SUMMARY

In this report, we are reporting on participants of programs that took place between June 11, 2017 and June 10, 2018. We have included the participants of the culminating retreat of the spring long program, as well as the two reunion conferences, all of which were held on June 10-15, 2018. This report does not include the participants of our "RIPS" summer programs which start on June 12 or later.

Note that "Public Lectures" includes just one person (a faculty member) who was not part of a workshop. We do not collect RSVPs.

Table F-1: All Participants' Gender and Ethnicity by Program Type (June 11, 2017 - June 10, 2018)

		Gender		Underrepresented Ethnic Groups				
Program Type	Total Participants	Female	No. Reporting Gender	Amer. Ind.	Black	Hisp.	Pac. Isl.	No. Reporting Ethnicity
Long Program	117	18	113	0	0	6	0	103
Workshops	1253	200	1204	1	15	56	4	1085
Public Lectures	1	0	0	0	0	0	0	0
Student Research Programs	68	27	67	0	3	177	0	63
Special Events and Conferences	218	100	213	1	10	8	0	211
Reunion Conferences	97	24	94	0	1	6	0	88
Total	1754	369	1691	2	29	253	4	1550
Percent of No. Reporting		21.8%		0.1%	1.9%	16.3%	0.3%	
		All underrepresented ethnic groups:			*288*	*18.58%*		

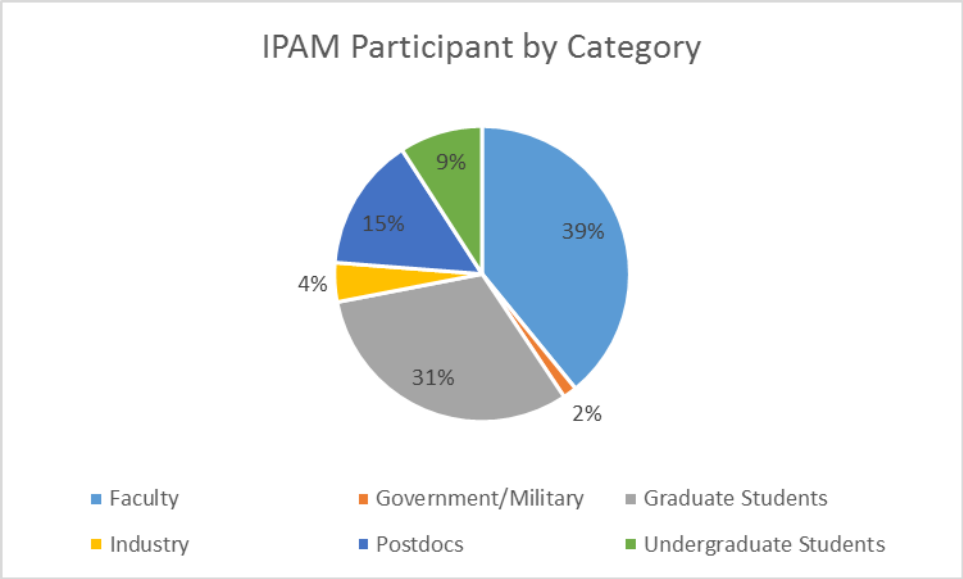
There were 1,204 unique participants for this same period. (Some of the participants attended more than one program, usually multiple workshops within a long program.) Out of those reporting gender, 23.9% were women. Out of those reporting ethnicity, 22.8% of unique participants were members of an underrepresented 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 (June 11, 2017 to June 10, 2018)

Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency	percent
Long Programs	49	116	42%
Workshops	600	1227	49%
Student Research Programs	53	68	78%
Special Events and Conferences	179	209	86%
Reunion Conferences	44	94	47%
Total	925	1714	54%

The majority of IPAM participants are faculty and graduate students. See the pie chart below for the percentage of participants in each category.



G. POSTDOCTORAL PROGRAM SUMMARY

Postdocs participated in many of IPAM's programs during the reporting period (June 11, 2017 to June 10, 2018). Four postdocs participants in IPAM's student research program, RIPS, as academic mentors. See tables G-1 and G-2.

Table G-1: Postdocs' Gender and Ethnicity by Program Type (June 11, 2017 - June 10, 2018)

Program Type	Total Participants	Gender		Underrepresented Ethnic Groups				
		Female	No. Reporting Gender	Amer. Ind.	Black	Hisp.	Pac. Isl.	No. Reporting Ethnicity
Long Program	17	1	16	0	0	2	0	12
Workshops	194	24	186	0	4	18	0	160
Student Research Programs	4	2	3	0	0	0	0	3
Special Events and Conferences	14	5	14	0	0	14	0	14
Reunion Conferences	21	7	21	0	0	2	0	17
Total	250	39	240	0	4	36	0	206
Percent of No. Reporting		16.3%		0.0%	1.9%	17.5 %	0.0 %	
		All underrepresented ethnic groups:			*40*	*19.42 %*		

Table G-2: Postdocs' Citizenship by Program Type (June 11, 2017 to June 10, 2018)			
Program Type	**U.S. Citizens & Permanent Residents**	**No. Reporting Citizenship & Residency**	**percent**
Long Programs	4	17	24%
Workshops	61	194	31%
Student Research Programs	3	4	75%
Special Events and Conferences	9	13	69%
Reunion Conferences	6	20	30%
Total	83	248	33%

H. GRADUATE STUDENT PROGRAM SUMMARY

Graduate students participated in IPAM's workshops and long programs during the reporting period, as well as in Graduate-level RIPS. A few participant in RIPS-LA as academic mentors. Graduate students often find a compelling thesis topic at an IPAM program, and also frequently make contacts that lead to their first job. See tables H-1 and H-2.

Table H-1: Graduate Students' Gender & Ethnicity by Program Type (June 11, 2017 - June 10, 2018)								
		Gender		**Underrepresented Ethnic Groups**				
Program Type	**Total Participants**	**Female**	**No. Reporting Gender**	**Amer. Ind.**	**Black**	**Hisp.**	**Pac. Isl.**	**No. Reporting Ethnicity**
Long Program	36	4	36	0	0	2	0	34
Workshops	412	67	409	0	4	16	4	383
Public Lectures	0	0	0	0	0	0	0	0
Student Research Programs	10	2	10	0	0	2	0	9
Special Events and Conferences	49	24	49	0	0	42	0	48
Reunion Conferences	28	4	27	0	0	2	0	26
Total	535	101	531	0	4	64	4	500
Percent of No. Reporting		19.0%		0.0%	0.8%	12.8%	0.8%	
		All underrepresented ethnic groups:			*68*	*13.60 %*		

Table H-2: Graduate Students' Citizenship by Program Type (June 11, 2017 to June 10, 2018)			
Program Type	**U.S. Citizens & Permanent Residents**	**No. Reporting Citizenship & Residency**	**percent**
Long Programs	12	36	33%
Workshops	156	412	38%
Student Research Programs	9	10	90%
Special Events and Conferences	37	49	76%
Reunion Conferences	6	27	22%
Total	220	534	41%

I. UNDERGRADUATE STUDENT PROGRAM SUMMARY

Undergraduate students participate in RIPS-LA and RIPS-Hong Kong (summer student research programs), and RIPS Projects Day (workshop). This year, they also participated in Latinx in the Mathematical Sciences Conference

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Table I-1: Undergraduates' Gender and Ethnicity by Program Type (June 11, 2017 - June 10, 2018)								
		Gender		**Underrepresented Ethnic Groups**				
Program Type	**Total Participants**	**Female**	**No. Reporting Gender**	**Amer. Ind.**	**Black**	**Hisp.**	**Pac. Isl.**	**No. Reporting Ethnicity**
Workshops	35	18	35	0	2	5	0	34
Student Research Programs	42	21	42	0	2	6	0	41
Special Events and Conferences	79	42	79	0	2	71	0	79
Total	156	81	156	0	6	82	0	154
Percent of No. Reporting		51.9%		0.0%	3.9%	53.2 %	0.0 %	
			All underrepresented ethnic groups:		*88*	*57.14 %*		

Table I-2: Undergraduates' Citizenship by Program Type (June 11, 2017 to June 10, 2018)			
Program Type	**U.S. Citizens & Permanent Residents**	**No. Reporting Citizenship & Residency**	**percent**
Workshops	24	35	69%
Student Research Programs	31	42	74%
Special Events and Conferences	71	79	90%
Total	126	156	81%

J. PROGRAM DESCRIPTION

The programs are listed in chronological order by start date. The list includes all IPAM programs with start dates between **June 11, 2017 through June 10, 2018**.

Most IPAM workshops include poster sessions; all participants are invited to present a poster, and graduate students are especially encouraged to participate. Most of IPAM's lectures, including lectures during workshops and public lectures, are available online.

We conduct evaluation of all IPAM programs. We administer an online, anonymous survey to all workshop participants. Long programs and our RIPS Program have pre-program and post-program surveys, which can be matched to compare responses before and after to some questions. We also conduct exit interviews with the junior participants of long programs. The reports are available upon request, and anonymous quotes from the surveys for some of the programs are included under the description of the program.

STUDENT RESEARCH PROGRAM: Research in Industrial Projects for Students (RIPS) – Hong Kong 2017. JUNE 12 - AUGUST 11, 2017

In collaboration with Hong Kong University of Science and Technology (HKUST), IPAM recruits 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, will 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 $3,500. Housing and most meals are also included.

U.S. citizens are eligible for RIPS-Hong Kong through IPAM. Local students and academic mentors were selected by HKUST.

Students will 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.

There were four projects. All projects involve some math, statistics, data, and computing:

Sponsor	Title of Project
AECOM	Environmental Modeling using AERMOD
FitMe	Skin Care Intelligent Assistant
MSRA	Efficient Communication in Distributed Machine Learning
Tencent	Exploring Reinforcement Learning Through a Falling Ball Game

The beautiful HKUST campus overlooks beautiful Port Shelter on the Clear Water Bay peninsula, several miles east of the city center. Public transportation is convenient and inexpensive. Weekends are available for sightseeing.

RIPS Hong Kong is the international version of our RIPS Los Angeles program.

Here are some quotes from the U.S. students in RIPS-HK 2017, collected in a post-program survey:

"RIPS-HK was the greatest educational experience I've had to date; I learned so much about mathematics and its impact in industry on a first-hand basis. At the same time, I also had the cultural experience of a lifetime while living in Hong Kong. I learned how inventive and creative Applied Mathematics can be, so I'm confident in pursuing a PhD in Applied Mathematics." Robben Teufel, FitME team

"My RIPS experience has motivated me to pursue a Master's degree in Applied Mathematics. My participation in RIPS was my first research experience as an undergrad, and it was the first time I ever considered research in mathematics as a viable option for me to pursue after graduation. I now intend on pursuing more research opportunities in applied mathematics and will later decide if a PhD is the right option for me. Before entering the program, the emphasis of my major was Financial Mathematics and Statistics, and I have now decided to change my emphasis to Applied Mathematics to get exposure to more math than I would have in my previous emphasis." Zariluz Alvarado, AECOM Team

"RIPS is a great opportunity to gain exposure to research that is applicable to industry as well as academia. For me, the greatest educational value of RIPS came from interacting with a diverse group of American students and an equally diverse group of Hong Kong students." Sarah Teichman, Tencent Team

"My project was on machine learning and data science. I have a better sense now of what a data scientist does day to day…RIPS connects students to industrial research projects that are

essentially inaccessible in any other way. This is a great way to see both industry, academia, and how the two combine." Tiffany Jann, MSRA Team

"The RIPS-HK program provided a great opportunity to work within and experience a new culture. I still intend to go to graduate school focusing more on pure math, but being exposed to industry math in the RIPS program has led me to think about applying my math skills for various business opportunities. The RIPS-HK program is already amazing because of the setting, but moreover it was great to be around smart people solving a variety of problems." Quentin Dubroff, Tencent Team

STUDENT RESEARCH PROGRAM: Research in Industrial Projects for Students (RIPS) 2017. June 19 - August 18, 2017

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 program is nine weeks. IPAM provides each undergraduate student with a travel allowance and a stipend of $3,500. Housing and most meals are also included. RIPS-LA students live in residence halls on the UCLA campus and have offices at IPAM.

There are 36 students assigned to nine projects. Projects vary, but all involve some math, statistics, data, and computing.

Susana Serna served as RIPS Director. The sponsors and projects in 2017 were:

RIPS Sponsor	**Project**
Aerospace Corporation	Bifurcation Properties for Navigation Constellation Design
Air Force Research Lab	Optimizing Sparse Representations of Kinetic Distributions via Information Theory
AMD	Exploration of Numerical Precision in Deep Neural Networks towards an Efficient Processor Implementation
Google LA	Taming Information Leaks in Machine Learning
Gum Gum	Facial Verification
LAPD	Conversational Turn-Taking in Police Body-Worn Video
Lawrence Livermore National Lab	Equation of State for Matter at Extreme Conditions

Los Alamos National Lab	Graph representations of atomic structures for materials data analytics
Shoah Foundation	Personalized Search using Collaborative Filtering

We collected the following comments from students in RIPS2017 on the post-program survey:

"Some academic researchers may not get the opportunity to work closely with an industrial partner during their careers. RIPS introduces young undergraduate mathematicians to real-world problems coming from the industry. This helps students plan their careers early by realizing differences and similarities between both worlds. This RIPS mix opens a world of opportunities for the participants." Islam Faisal, GumGum team

"As someone who is interested in using my math education to make a tangible difference in the world, RIPS was an invaluable experience. In order to make progress on my project, I had to learn how to relate mathematical techniques to concepts outside of mathematics, how to balance theoretical concerns with the need to develop a working solution, and how to devise approaches that played to the strengths of each member of my team." Collin Cademartori, LAPD team

"I really couldn't have asked for a better experience. It taught me quite a bit about what kind of researcher I am and how to work together with people on challenging, sometimes frustrating problems. It also made me a better writer and presenter."
Catalina Vajiac, AMD team

"RIPS provided a great environment for learning what working in industry is like. From meetings to team updates to sitting and debugging code, the entire program gave a good taste to what industrial research is!" Philip de Castro, AFRL team

"The educational value of RIPS is outstanding. I learnt a lot about research at the intersection of academia and industry, the complications of real-world data and team-work." Alistair Letcher, LAPD team

"The skills and experience I gained at RIPS has helped me understand the value the research can add to the real world, making it an even more meaningful pursuit. The projects were carefully chosen to be at the right level for undergraduates and this also helped us contribute substantially while learning a lot." Harjasleen Malvai, Google team

"I feel as though my RIPS experience will play a huge role in the decisions I make regarding my career choices, graduate school decisions, and academic interests because of the mentors that gave me helpful advice along the way." Ruth Lopez, LANL team

"I would certainly recommend the program because I grew as a student, professional, and academic. I had freedom to express my ideas, while working in an environment with a defined plan and a deadline." Julia Vasile, AFRL team

"RIPS is a unique program that approaches applied mathematics from a different angle. In most applied math settings, we start with math and then look for projects that match the math methods. For RIPS, it's the other way: you start with the project and then look for the math methods that suit the task at hand. This calls for open mindedness." Onward Mahachi, Google team

"I would definitely recommend RIPS to anyone studying math! IPAM was a very supportive environment …It felt like I was part of a little community of math people, a feeling I've never had before. One of the main reasons I chose to come to RIPS in the first place (I had several other REU offers) was to be in a program with international students. RIPS exceeded my expectations in this regard - I now have friends across the globe." Kira Parker, Shoah team

WORKSHOP: RIPS Projects Day, August 17, 2017

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.

STUDENT RESEARCH PROGRAM: Graduate-Level Research in Industrial Projects for Students (GRIPS)-Berlin 2017. July 3 - August 25, 2017

Graduate-Level Research in Industrial Projects for Students (GRIPS) will offer graduate students in mathematics and related disciplines the opportunity to work on industry-sponsored research problems. Students from the U.S. and Germany will work on cross-cultural teams on three research problems designed by the industrial sponsor. At the end of the program, the teams will present the results of their work and prepare a final report.

U.S. participants were recruited by IPAM. Round-trip travel to Berlin and accommodations in Berlin are included. Students will also receive a meal allowance and a stipend.

IPAM's partner in Berlin is the Research Campus MODAL (Mathematical Optimization and Data Analysis Laboratories), which promotes exchange and collaboration between public institutions and private (industrial) partners. The current academic partners of MODAL are the Free University of Berlin (FU Berlin) and the Konrad-Zuse Zentrum für Informationstechnik Berlin (ZIB).

The projects will involve both analytic and computational work. The three 2017 projects were:

Project 1: Therapy Planning – 1000shapes GmbH

Building on large medical image as well as an anthropometric 3D face databases, students will have the opportunity to investigate machine-learning approaches, i.e. deep learning, or the

application of regression forests, to identify, analyze, and classify features or patterns based on medical images or geometric models.

Several databases are the foundation for possible investigations: (1) The OAI database of the Osteoarthritis Initiative (OAI), which is a multi-center, longitudinal, prospective observational study of knee osteoarthritis, providing clinical evaluation data, radiological (x-ray and magnetic resonance) images, and a bio-specimen repository from over 5000 patients. This information has great potential, both for developing a better understanding of disease onset and progression, as well as improving future therapeutic concepts; (2) A database of several hundreds of 3D face models from various individuals and with varying facial expressions, providing information for anthropometrical studies or psychological experiments; (3) A huge collection of dental 3D image data, where bony structures, nerves, and teeth are to be segmented, anatomical relationships are to be analyzed, and suitable shape and appearance models are to be developed; (4) A database of human spines giving the opportunity to study the morphology of single vertebrae up to the complete spine as well as the functional performance within the context of biomechanics and orthopedic research. The processing of such databases requires automated image and geometry processing as well as sophisticated data analysis approaches.

For medical image processing, the challenge is to automatically extract anatomical shape and appearance information from image data, as well as to integrate this information in so called statistical 3D shape and appearance models to train and improve automated algorithms. For geometric data the challenge is to improve methods for determining correspondences, to analyze variation in shape, to establish suitable metrics for measuring similarities in various shape spaces, for clustering and population based analysis. To this end, machine learning combined with model-based approaches shall be employed and adopted.

Establishing correspondences between shapes lies at the core of many operations in image analysis and geometry processing. The majority of existing methods formulate the matching problem as finding optimal pairings of points or regions on shapes. This representation, however, renders the matching intractable as the space of possible point correspondences grows exponentially and does not naturally support constraints such as map continuity or global consistency. Within a possible project, we will investigate a recent alternative approach that generalizes the notion of correspondences to mappings between real-valued functions on the shapes rather than the standard point-to-point maps. One challenge that we will address is the adaptation of this functional maps framework to the matching of volumetric geometries from 3D medical image data. Based on this, we will further derive a scheme for inferring group-wise correspondences that takes advantage of the context provided by the collection of shapes.

Based on the aforementioned background several topics in medical image and geometry processing are conceivable. Results of our research may become a basis for improving existing segmentation, classification, and diagnosis algorithms that are currently under development by 1000shapes.

Quote from William Cuello, a student on this team: “GRIPS is a wonderful program. I think the opportunity to collaborate with individuals from institutions around the world is valuable for

both research and future collaboration. I was particularly happy with the work synergy I had with my project partner and will continue to work with him on future endeavors. My partner and I are aiming to publish our results in an appropriate journal."

Project 2: Nanophotonics – JCMwave GmbH

You will learn how to model and simulate nanophotonic setups. The underlying physical model is typically Maxwell's wave equation in three spatial dimensions. A main challenge in such simulations is to obtain simulation results with upper bounds to numerical discretization errors within short computation times. Accurate and fast results are required e.g. for design optimizations in high-dimensional parameter spaces, and for parameter retrieval in optical metrology. For in-line applications in industrial quality control, speed and accuracy of parameter retrieval is currently a limiting factor to production speed. As shown in various benchmarks, the finite-element method is well suited to handle such computations, as its performance for highly accurate results can be orders of magnitude faster than competing methods. However, to further improve on its performance various properties of the method and of the models of interest can be exploited. These include higher-order vectorial finite elements, adaptive mesh refinement, hp-adaptivity, and automatic differentiation. This project will also concentrate on recent developments exploiting symmetries of the underlying models.

It is planned that the team members will specialize in the fields of mesh generation, finite element convergence and post-processing techniques, respectively. The team will then join the experiences from these fields to investigate methods for improved simulation efficiency, exploiting symmetries of modern nanophotonic devices. This includes validating results from automatic symmetry-detection methods.

The project should result in a comprehensive report to be presented at the end, and in a collection of Matlab- or Python-based automatic test routines. We expect that the report will meet high standards as we aim at a joint publication of the results in a peer-reviewed journal.

Project 3: Selecting an Optimization Solver: Machine Learning under Expensive Function Evaluations – Satalia

Satalia's SolveEngine interfaces to a variety of optimization algorithms. A given optimization problem can often be solved by many of these algorithms, but their performance can vary widely in practice. Predicting the best-performing solver on-the-fly and under limited response time is an unsolved question. The aim of this project is to investigate and compare different machine learning techniques in order to select well-performing algorithms from instance features that can be collected with limited computational effort. This will involve understanding various machine learning algorithms, the design of experiments, and the use of existing machine learning packages and own implementations. Practitioners from Satalia and mixed-integer programming solver developers from MODAL SynLab will provide support. Students will gain experience in the implementation and use of machine learning as a research tool and gain insight into the world of mixed-integer programming algorithms.

Quote from U.S. student David Haley: "I believe that I have learned a new research angle that I am able and willing to pursue going forward. I have a strong feeling that I may even continue on this exact project."

SUMMER SCHOOL: Computational Genomics Summer Institute 2017. July 10 – 14, 2017

Over the past two decades, technological developments have substantially changed research in Bioinformatics. New methods in DNA sequencing technologies are capable of performing large-scale measurements of cellular states with a lower cost and higher efficiency of computing time. These improvements have revolutionized the potential application of genomic studies toward clinical research and development of novel diagnostic tools and treatments for human disease.

In 2015, Profs. Eleazar Eskin (UCLA), Eran Halperin (UCLA), John Novembre (The University of Chicago), and Ben Raphael (Princeton University) created the Computational Genomics Summer Institute (CGSI) with support from the NIH. CGSI aims to develop a flexible program for improving education and enhancing collaboration in Bioinformatics research. It includes a "short course" for about 100 participants and a longer program for 25-30 participants. IPAM was a cosponsor of the short course only; we offered staff support and a venue for some of the activities.

Because IPAM was a cosponsor, we did not include the participants in our participant list or in the participant tables in this report.

WORKSHOP: Mean Field Games. AUGUST 28 - SEPTEMBER 1, 2017

Organizing Committee:

Pierre Cardaliaguet (Université de Paris IX (Paris-Dauphine))
René Carmona (Princeton University, Mathematics)
Wilfrid Gangbo (University of California, Los Angeles (UCLA))

Scientific Overview:

Mean Field Games (MFGs) are games with a very large number of agents interacting in a mean field manner in such a way that each agent has a very small impact on the outcome. As a result, the game can be analyzed in the limit of an infinite number of agents. This subject, introduced independently by Lasry & Lions and by Huang, Caines & Malhame in 2006, is widely recognized as an important approach to study large systems such as financial markets, crowd dynamics, communications networks, power systems or war games. At the same time, both the theory and numerical computations of mean field game equilibria remain significant challenges.

There are currently two approaches to the formulation and the analysis of MFGs. The first is based on the solution of a coupled system of highly nonlinear PDEs (Hamilton-Jacobi-Bellman

and Fokker-Planck). The second approach is probabilistic: it relies on the solution of a forward-backward stochastic differential system of equations of McKean-Vlasov type.

This workshop will bring together experts in the field and researchers in other fields with an interest in Mean Field Games. It will cover the formulation and theory of MFGs, generalizations including additional effects, numerical methods and applications of MFGs.

Workshop participants wrote the following comments in the anonymous survey:

"It is a rare conference where mathematicians and non-mathematicians communicate so seamlessly as they did here. Everyone's contribution was interesting, valuable and valued. This was exceptionally well done. The choice of speakers was excellent. It could not have been better."
"I really enjoyed the workshop. I am going to use the new techniques I learned to address large-scale problems in environmental economics. My suggestion for the future is to continue to organize more of these conferences around the topics of mean field games applied to social economic problems …I am going to invest more energy in using new MFG techniques in addressing large scale environmental economic problems."

LONG PROGRAM: Complex High-Dimensional Energy Landscapes. September 11 - December 15, 2017

Organizing Committee
Cecilia Clementi (Rice University, Physics)
Graeme Henkelman (University of Texas at Austin)
Richard Hennig (University of Florida)
Tony Lelièvre (Ecole des Ponts ParisTech)
Mitchell Luskin (University of Minnesota, Twin Cities, School of Mathematics)
Noa Marom (Carnegie-Mellon University, Materials Science and Engineering)
Petr Plechac (University of Delaware)
Christof Schuette (Freie Universität Berlin)

Recent advances in computational resources and the development of high-throughput frameworks enable the efficient sampling of complicated multivariate functions. This includes energy and electronic property landscapes of inorganic, organic, biomolecular, and hybrid materials and functional nanostructures. Combined with the recent focus on data science and the materials genome initiative, this leads to a rapidly growing need for numerical methods and a fundamental mathematical understanding of efficient sampling approaches, optimization techniques, hierarchical surrogate models and coarse graining techniques, and methods for uncertainty quantification.

The complexity of these energy and property landscapes originates from their simultaneous dependence on discrete degrees of freedom (e.g. number of atoms and species types) and continuous ones (e.g. position of atoms). The complexity is further exacerbated by the presence

of divergences (e.g. when atoms approach one another and at critical transition points) and non-trivial emergent phenomena that are due to collective interactions. Moreover, dynamical behavior governed by complex landscapes involves a rich hierarchy of timescales and is characterized by rare events that often are key to understanding function of the molecular structures under investigation. This complexity provides an ideal test bed for novel mathematical methods that characterize these functions and provide a description as well as optimal numerical methods.

This program will bring together researchers from pure and applied mathematics, computer science, materials science, chemistry, physics, and biomolecular science to advance the understanding of simulation, stochastic sampling and optimization methods for multidimensional energy landscapes and to develop a common language.

WORKSHOP: Complex High-Dimensional Energy Landscapes Tutorials. September 12 - 15, 2017

Part of the Long Program Complex High-Dimensional Energy Landscapes

Organizing Committee
Cecilia Clementi (Rice University, Physics)
Graeme Henkelman (University of Texas at Austin)
Richard Hennig, Co-chair (University of Florida)
Tony Lelièvre (Ecole des Ponts ParisTech)
Mitchell Luskin, Co-chair (University of Minnesota, Twin Cities, School of Mathematics)
Noa Marom (Carnegie-Mellon University, Materials Science and Engineering)
Petr Plechac (University of Delaware)
Christof Schuette (Freie Universität Berlin)

The 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 during the tutorials include: Minimization and saddle-point methods, surrogate models, stochastic sampling and rare event simulation techniques, and genetic algorithms.

Workshop I: Optimization and Optimal Control for Complex Energy and Property Landscapes. October 2 - 6, 2017

Part of the Long Program Complex High-Dimensional Energy Landscapes

Organizing Committee
Richard Hennig (University of Florida)
Noa Marom, Co-chair (Carnegie-Mellon University, Materials Science and Engineering)
Christof Schuette, Co-chair (Freie Universität Berlin)
Stephen Wright (University of Wisconsin-Madison, Computer Science)

Computational materials design requires simultaneous optimization with respect to a variety of target functions including energy and electronic properties in a vast configuration space of structure and composition. This workshop will focus on the mathematical foundations and efficient implementations of optimization methods, such as methods based on stochastic sampling like random searches, genetic algorithms, and particle swarm algorithms, and methods that overcome low-energy barrier to explore surrounding local minima like basin hopping, simulated annealing, and replica exchange. Specific methods for energy barriers and their use in dynamics are the topics of Workshop II.

These optimization methods will be applied to structure prediction and property-based design of diverse materials for energy conversion, electronic, magnetic, and optical materials, catalysts, and pharmaceuticals. The systems that will be discussed include atomic clusters, inorganic and organic crystals, biomaterials, interfaces, and functional nano-structures.

Some of the challenges we wish to address are:

- Formulating effective multi-objective optimization strategies for dealing with conflicting demands, such as low energy vs. desired electronic properties
- Finding efficient descriptors and surrogate models that reliably correlate with complex quantum mechanical collective behavior. Workshop III specifically focuses on the development of surrogate models and their effective use in optimization, sampling, and dynamics.
- Effective strategies for combining optimization methods with high-throughput screening and materials informatics
- Simulating the functionality of promising candidate materials under operating conditions
- Streamlining the interpretation of experiments by feeding, e.g., measured spectra or scattering pattern directly into the target function of an optimization engine

In this workshop, we will bring together experts on different optimization and stochastic optimal control methods and different types of materials applications from the fields of materials science, physics, chemistry, computer science, and applied mathematics.

There was a women’s luncheon during this workshop.

Here are a few anonymous comments from participants, collected via survey:

“The schedule of the workshop was excellent; there was ample time to discuss with other participants. I particularly appreciate the coffee breaks after each talk, which not only allowed for discussions but also for taking a break to digest and think about the content of the talk.”

“The women luncheon was very informative and "productive". We had a very good discussion, and the experiences shared by other women (either on career or on work-life balance) were very precious and supportive. I would like to mention that the speakers seemed to be very carefully chosen as all the talks were of high quality and clearly presented. Please keep up the good work

and the high quality! This was an excellent workshop and I cannot think of anything in the workshop that can be better organized!"

Workshop II: Stochastic Sampling and Accelerated Time Dynamics on Multidimensional Surfaces. October 16 - 20, 2017

Part of the Long Program Complex High-Dimensional Energy Landscapes

Organizing Committee
Kristen Fichthorn (Pennsylvania State University)
Graeme Henkelman (University of Texas at Austin)
Tony Lelièvre (Ecole des Ponts ParisTech)
Mitchell Luskin (University of Minnesota, Twin Cities, School of Mathematics)
Jörg Neugebauer (Max-Planck-Institut für Eisenforschung GmbH)
Danny Perez (Los Alamos National Laboratory, Theoretical Division T-1)

This is a Julian Schwinger Workshop on Multiscale Physics, with support from the Julian Schwinger Foundation for Physics Research (JSF).

In a multitude of research problems at the forefront of hard- and soft-matter simulation, adequate sampling of the energy landscape is a major challenge. Overcoming the energy barriers in the search for equilibrium states and accurately characterizing temporal evolution that occurs as a system evolves through a series of minima limit progress in understanding materials synthesis and processing, biology, colloidal engineering, and earth sciences. Despite advances in computing hardware, brute-force application of conventional molecular dynamics and Monte Carlo methods is not sufficient in many cases. Specialized algorithms and methods have been developed to navigate the energy landscape. In this workshop, we will discuss advances and challenges in methods such as transition-path sampling and transition-interface sampling, alchemical methods, umbrella sampling, identifying order parameters and collective variables, accelerated molecular dynamics, metadynamics, variational approaches, replica methods, and coarse-graining. We will bring together experts in sampling methods across disciplines including physics, chemistry, materials science, engineering, and mathematics.

We collected these anonymous comments from the workshop participants:

"I greatly appreciate and enjoy the workshops at IPAM, in particular the extended time for discussions."

"In my opinion, it is EXTREMELY difficult to have members of different communities communicate. IPAM is doing a great job, as always, in this enterprise. I want to stress that there are many different people present. The workshop also gives opportunities to the true actors, at the forefront of the research frontier (rather than have speak the "bigshots" who only go from conference to conference."

SPECIAL EVENT: Modern Math Workshop 2017. Oct 18 - 19, 2017

The Mathematical Sciences Diversity Initiative sponsored the 2017 Modern Math Workshop at SACNAS. This workshop is intended to encourage undergraduates, graduate students and recent PhDs from underrepresented minority groups to pursue careers in the mathematical sciences and build research and mentoring networks. ICERM was the lead organizer of the 2017 workshop, therefore, ICERM listed it as one of their programs. *The participants of this program are not included in IPAM's participant list for 2017-2018.*

PUBLIC EVENT: The Calculus of Comedy: Math in The Simpsons, Futurama, and The Big Bang Theory. October 25, 2017

While there is no mathematical formula for writing television comedy, for the writers of *The Simpsons*, *Futurama*, and *The Big Bang Theory*, mathematical formulas (along with classic equations and cutting-edge theorems) can sometimes be an integral part of those shows. In a lively and nerdy discussion, five of these writers (who have advanced degrees in math, physics, and computer science) will share their love of numbers and talent for producing laughter. Mathematician Sarah Greenwald, who teaches and writes about math in popular culture, will moderate the panel.

The event will begin with a lecture by bestselling author Simon Singh (*The Simpsons and Their Mathematical Secrets),* who will examine some of the mathematical nuggets hidden in *The Simpsons* (from Euler's identity to Mersenne primes) and discuss how *Futurama* has also managed to include obscure number theory and complex ideas about geometry.

Workshop III: Surrogate Models and Coarsening Techniques. October 30 - November 3, 2017.

Part of the Long Program Complex High-Dimensional Energy Landscapes

Organizing Committee
Cecilia Clementi (Rice University, Chemistry)
Gabor Csanyi, Co-chair (University of Cambridge)
Richard Hennig, Co-chair (University of Florida)
Frank Noe (Freie Universität Berlin)

The accurate description of the energy landscapes of molecular and condensed materials often requires expensive evaluations of quantum-mechanical models. On the other hand, a large number of energy evaluations are needed to explore the landscapes for structure optimization, thermodynamic sampling, and rate estimation. Several methods have been developed that aim to approximate energy landscapes. These methods range from physically motivated approximate quantum mechanical and fully empirical energy models that describe the bonding of materials, to approaches from computer science such as machine-learning that are agnostic to the underlying

chemical bonds. Ideally, a hierarchy of models with increasing and controllable accuracy is desirable to efficiently sample energy landscapes. Unfortunately, the origin of the current surrogate models in different scientific communities has led to a disconnect. As a result, knowledge about the different methods and their trade-offs have not penetrated the disconnected communities, hindering progress.

In this workshop, we will bring together researchers from the mathematics and computer science fields of optimization, optimal control and model development with chemists, physicists, and materials scientists working on model development and energy landscape optimization and sampling problems. The goal is to discuss future methods and algorithms for the development of surrogate models and parallel exploration and their application in structure optimization, sampling and dynamics.

We collected the following comments from participants on the survey:
"Great mix of lectures. I loved that later workshop speakers paid attention to early lectures and modified their talks/background as appropriate."
"This is hands-down the best workshop and the highlight of the year. I always leave with plenty of new things to try and a deeper understanding of the interconnectedness of the mathematical and physical approaches to our problems. The structure of the workshop is perfect, giving plenty of time for discussion and collaboration between talks. Thank-you for putting an excellent program together!"

Workshop IV: Uncertainty Quantification for Stochastic Systems and Applications.
November 13 - 17, 2017

Part of the Long Program Complex High-Dimensional Energy Landscapes

Organizing Committee
Virginie Ehrlacher, Co-chair (École Nationale des Ponts-et-Chaussées, CERMICS)
Markos Katsoulakis (University of Massachusetts Amherst, Mathematics & Statistics)
Tony Lelièvre (Ecole des Ponts ParisTech)
Petr Plechac, Co-chair (University of Delaware)
Andrew Stuart (University of Warwick, Computing and Mathematical Sciences)
Dallas Trinkle (University of Illinois at Urbana-Champaign)

In past decades, considerable effort has been devoted to first-principles modeling of materials and materials design. However, uncertainty quantification over multiple scales, especially when some of them are inherently stochastic, is not sufficiently understood despite having critical impact on guiding experimental efforts and design. The uncertainty in materials modeling and design can arise either from the stochastic nature of microscopic description, sampling and numerical errors or from improper modeling assumptions, inadequate or inaccurate parametrization of the system and/or the objective functionals that guide the design optimization. Principal mathematical, computational and modeling challenges stem from the multiscale and multi-physics nature of the materials models. Quantifying errors and uncertainties due to combining different models at different scales will be critical for obtaining computational

methods with sufficient predictive power to guide synthesis of new materials. For example, molecular simulations use force fields which are approximations of complex quantum mechanical free energy surfaces inducing uncertainty in mesoscopic processes. Similarly, rate constants in kinetic Monte Carlo simulations are subject to uncertainty due to errors in functionals of DFT, limits on the size of unit cells etc. The methods for quantifying the impact of such errors and uncertainties have been recently studied in different communities, including computational quantum chemistry, materials engineering, and mathematics.

Uncertainty quantification and sensitivity analysis for quantities governed by rare events is an area of particular importance in studies of molecular systems. The mathematical and computational methods for estimating sensitivities in these problems also connect directly to the topics of Workshop III. Uncertainty quantification has grown as a vital subject within the applied mathematics community, as witnessed by the emergence of a dedicated SIAM journal and regular SIAM conference. This workshop aims at fostering more interaction between different communities with a particular focus on mathematical tools for uncertainty quantification, sensitivity analysis and modeling error in high-dimensional stochastic systems, the role of rare and extreme events, computational tools and uncertainties due to model reduction and coarse-graining. It will offer an opportunity to discuss future developments in computational and mathematical techniques and transfer of methodologies developed by different communities. Interaction between participating domain scientists and mathematicians will also help stimulate new mathematical research.
Comment from a participant: "One of the best-organized workshops I have been to…I really enjoyed the workshop and got a number of interesting inputs (and hopefully could provide also a few) and some potential new collaborations have been initiated."

PUBLIC LECTURE: Green Family Lecture Series: "What's New In Two-Dimensional Topological Gravity" by Edward Witten. December 1, 2017

This lecture was part of the 2017 Green Family Lecture Series. It was open to the public. Registration was not required, so no participants are reported.

The talk will be devoted to explaining two relatively recent mathematical developments involving what physicists know as topological gravity in two dimensions. These results have not yet become well-known.

Among physicists, Maryam Mirzakhani, in her PhD work of roughly a decade ago, discovered a beautiful new proof of the Virasoro and KdV formulas for intersection theory on the moduli space of Riemann surfaces – formulas that reflect the relation of this intersection theory with matrix models of two-dimensional gravity. Much more recently, Pandharipande, Solomon, and Tessler (with later work by Buryak and Tessler) defined a version of intersection theory on the moduli space of Riemann surfaces with boundary and found a generalization of the Virasoro and KdV equations. Their results fit naturally in an extension of the matrix models to include vector degrees of freedom, as shown recently by Dijkgraaf and the speaker.

Workshop: Complex High-Dimensional Energy Landscapes Culminating Workshop. December 10-15, 2017

The culminating workshop was organized by the organizing committee of the long program.

The final workshop in the long program, Complex High-Dimensional Energy Landscapes, which was 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.

"The retreat continues to be one of the best experiences of the whole IPAM long program. I continue to think if there are ways to extend that experience for longer :-)"

"This was an excellent culminating workshop with plenty of opportunities to discuss the research all participants worked on throughout the program. The idea of putting together a whitepaper as a group activity worked very well. Everybody was engaged and the students had a great learning experience."

Reunion Conference: Culture Analytics Reunion Conference I. December 10-15, 2017

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

This was the first reunion conference for participants of the spring 2016 long program "Culture Analytics." 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.

Reunion Conference: Financial Mathematics Reunion Conference II. December 10-15, 2017

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

This was the second reunion conference for participants of the spring 2015 long program "Financial Mathematics." 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.

WORKSHOP: Algorithmic Challenges in Protecting Privacy for Biomedical Data. January 10 - 12, 2018

Organizing Committee:
Cynthia Dwork (Harvard University, SEAS)
Sriram Sankararaman (University of California, Los Angeles (UCLA))

Anand Sarwate (Rutgers University New Brunswick/Piscataway)
James Zou (Stanford University)

Genomics and digital phenotyping (electronic medical records, imaging, self-reported surveys, etc) have the potential to transform our understanding, diagnosis and treatment of human diseases. Realizing the potential of these rich data requires aggregating and sharing data across individual centers where the data is currently siloed. However, sharing data raises concerns about individual privacy. This workshop will explore the foundational algorithmic challenges of protecting individual privacy in this bio-medical context.

This workshop has a number of aims:

- To explore both the theoretical and implementation challenges of emerging techniques for protecting the privacy of genomic and phenotyping data. This will include frameworks such as differential privacy, homomorphic encryption, and multiparty computation, as well as key tasks such as computing summary statistics and associations.
- To bring together theorists and practitioners from industry, biobanks and hospitals in order to understand what are the real, actionable challenges in privacy and sharing of bio-medical data.
- To formulate key foundational questions about privacy raised through new and emerging technologies such as genome editing or DNA storage.
- To develop connections between privacy questions in -omics and notions of overfitting and fairness.

The workshop will be a mix of talks, posters, and breakout sessions centered around the different focus areas in which participants can work together to identify key challenges that need to be overcome, new theory or algorithms that may be needed, and how to delineate problem classes and solution frameworks. Specific initial focus areas include:

- Privacy-preserving analysis in GWAS and population genetics
- Adaptive data analysis and bioinformatics
- Storage, search, and querying in genomic databases

Additional topics and refinements will be made as the list of participants is finalized. This workshop will include a poster session; a request for posters will be sent to registered participants in advance of the workshop.

Quote from a participant: “The workshop brought together a diverse set of participants and I found the opportunity to interact with the other participants to be very valuable to my understanding of the field.”

WORKSHOP: New Methods for Zimmer's Conjecture. January 22 - 26, 2018

Organizing Committee:
Aaron Brown (University of Chicago)

Mikael De La Salle (École Normale Supérieure de Lyon)
Alex Eskin (University of Chicago, Mathematics)
David Fisher (Indiana University)
Sebastian Hurtado Salazar (University of Chicago)
Federico Rodriguez Hertz (Pennsylvania State University)
Ralf Spatzier (University of Michigan)
Amie Wilkinson (University of Chicago)

The purpose of this workshop is to bring focused attention on a recent breakthrough by Brown, Fisher and Hurtado on Zimmer's Conjecture. The conjecture concerns low dimensional actions of lattices in higher rank Lie groups and was made in 1983. Many approaches to the conjecture have been proposed in the intervening years, but progress has been minimal. The recent breakthrough both dramatically improves the state of knowledge and involves many novel ideas and contributions from various areas of mathematics. The main sources of techniques and ideas are:
(1) rigidity theory,
(2) smooth dynamics, particularly hyperbolic dynamics,
(3) homogeneous dynamics, particularly the study of invariant measures,
(4) operator algebras, particularly Lafforgue's strong property (T).

The workshop aims to explore topics related to these developments, to clear the ground for further progress on related questions, and to facilitate interaction between specialists in these four areas. Morning talks will focus on recent developments directly related to Zimmer's program, afternoon talks will concern related areas of research that may contribute to future developments.

The following quotes from workshop participants appeared in the workshop survey:

"This was a wonderful workshop. Nearly all the talks were well-delivered, and all represented significant breakthroughs or highly topical surveys."

"The consistent effort to force the speakers to clarify their statements (including definitions) in order to accommodate the diverse audience was a highlight of this workshop even if it was less necessary for me."

WORKSHOP: New Deep Learning Techniques. February 5 - 9, 2018

Organizing Committee:
Xavier Bresson (Nanyang Technological University, Singapore)
Michael Bronstein (USI Lugano, Switzerland, / Tel Aviv University, Israel / Intel Perceptual Computing, Israel)
Joan Bruna (New York University)
Yann LeCun (New York University, Canadian Institute for Advanced Research)
Stanley Osher (University of California, Los Angeles (UCLA), Mathematics)
Arthur Szlam (Facebook)

In recent years, artificial neural networks a.k.a. deep learning have significantly improved the fields of computer vision, speech recognition, and natural language processing. The success relies on the availability of large-scale datasets, the developments of affordable high computational power, and basic deep learning operations that are sound and fast as they assume that data lie on Euclidean grids. However, not all data live on regular lattices. 3D shapes in computer graphics represent Riemannian manifolds. In neuroscience, brain activity (fMRI) is encoded on the structural connectivity network (sMRI). In genomics, the human body functionality is expressed through DNA, RNA, and proteins that form the gene regulatory network (GRN). In social sciences, people interact through networks. Eventually, data in communication networks are structured by graphs like the Internet or road traffic networks.

Deep learning that has originally been developed for computer vision cannot be directly applied to these highly irregular domains, and new classes of deep learning techniques must be designed. This is highly challenging as most standard data analysis tools cannot be used on heterogonous data domains. The workshop will bring together experts in mathematics (statistics, harmonic analysis, optimization, graph theory, sparsity, topology), machine learning (deep learning, supervised & unsupervised learning, metric learning) and specific applicative domains (neuroscience, genetics, social science, computer vision) to establish the current state of these emerging techniques and discuss the next directions.

The following comments were collected through the workshop survey:

"The workshop was great and the only time people working on the same topic but from different disciplines came to meet. It was very enlightening to hear and see commonalities with other groups coming from different backgrounds."

"This workshop was ideal for a mathematician to learn about current developments in machine learning. The range and expertise of the speakers was excellent, and the presentations were much more technical (and therefore much more informative) than typical machine learning or computer science presentation. As a mathematician, I was very happy."

PUBLIC LECTURE: Green Family Lecture Series: "Deep Learning and the Future of Artificial Intelligence" by Yann LeCun. February 5, 2018

This lecture was open to the public. No registration was required, therefore, the attendees do not appear in our participant list.

Speaker Bio
Yann LeCun is Director of Facebook's Artificial Intelligence Research and Silver Professor at NYU, affiliated with the Courant Institute and the Center for Data Science. He received a PhD in Computer Science from Université Pierre et Marie Curie (Paris). After a postdoc at the University of Toronto, he joined AT&T Bell Labs, and became head of Image Processing Research at AT&T Labs in 1996. He joined NYU in 2003 and Facebook in 2013. His current interests include AI, machine learning, computer vision, mobile robotics, and computational

neuroscience. He has been a member of IPAM's Science Advisory Board since 2008 and has organized several IPAM programs.

Abstract
The rapid progress of AI in the last few years is largely the result of advances in deep learning and neural nets, combined with the availability of large datasets and fast hardware for numerical computing (GPUs). We now have systems that can recognize images with an accuracy that rivals that of humans. This will lead to revolutions in several domains such as autonomous transportation, medical image analysis and personalized medicine. Similarly dramatic progress have been achieved in speech recognition, natural language understanding, and language translation. AI will profoundly transform society and cause major shifts in many industries. But all of the current systems are trained through supervised learning, where the machine is trained with inputs labeled by humans. To make significant progress in AI, researchers are working on new forms of learning where machines learn like humans and animals, learning how the world works and building predictive models of the world by observation and action. Will future autonomous machines ultimately acquire "common sense" and learn how to behave like humans and other animals? What will be their impact on society?

PUBLIC LECTURE: Green Family Lecture Series; "AI Breakthroughs & Obstacles to Progress, Mathematical and Otherwise" by Yann LeCun. February 6, 2018

This lecture was open to the public. No registration was required, therefore, the attendees do not appear in our participant list.

Speaker Bio: See above.

Abstract:
Deep learning is causing revolutions in computer perception and natural language understanding. But almost all these successes largely rely on supervised learning, where the machine is required to predict human-provided annotations. For game AI, most systems use model-free reinforcement learning, which requires too many trials to be practical in the real world. But animals and humans seem to learn vast amounts of knowledge about how the world works through mere observation and occasional actions. Good predictive world models are an essential component of intelligent behavior: with them, one can predict outcomes and plan courses of actions. One could argue that prediction is the essence of intelligence. Good predictive models may be the basis of intuition, reasoning and "common sense", allowing us to fill in missing information: predicting the future from the past and present, the past from the present, or the state of the world from noisy percepts. After a brief presentation of the state of the art in deep learning, some promising principles and methods for predictive learning will be discussed.

SPECIAL EVENT: Latinx in the Mathematical Sciences Conference 2018. March 8 - 10, 2018

Organizing Committee:
Federico Ardila (San Francisco State University, Mathematics)
Ricardo Cortez (Tulane University)
Tatiana Toro (University of Washington, Mathematics)
Mariel Vazquez (University of California, Davis, Mathematics)

On March 8-10, 2018, IPAM hosted a conference showcasing the achievements of Latinx in the mathematical sciences. The goal of the conference was to encourage Latinx to pursue careers in the mathematical sciences, to promote the advancement of Latinx currently in the discipline, to showcase research being conducted by Latinx at the forefront of their fields, and, finally, to build a community around shared academic interests.

The conference included a pre-conference activity for undergraduate and graduate students, plenary talks, scientific sessions, a panel discussion, high school activities, career panels, and networking opportunities.

The conference was sponsored by the Mathematical Sciences Institutes Diversity Initiative, with funding from the National Science Foundation Division of Mathematical Sciences. Other sponsors included IPAM, UCLA, NSA, Elsevier, University of Washington, and Facebook. Additional support was provided by the Office of the Provost, Office of the Dean of the College of Letters and Science, and the Mathematics Department, UC Davis; the Department of Mathematics, UC Merced; and the Department of Mathematics, Purdue University. A total of 221 people attended the conference. In addition, about 26 high school students from two local charter schools attended a math circle activity on Friday morning.

The conference survey included the following anonymous quotes from some of the participants:

"This conference was cathartic for me. It was inspiring to hear the plenary speakers talk about their own lives, struggles, and the excellent mathematics they are doing. It has made me feel more capable and able to succeed as someone early in their career. Also, it was great to exchange ideas with other mathematicians who have similar interests to me. All in all, a wonderful, special, and unique conference that I will definitely want to attend again."

“Oh I can't even begin to cover all of this. I am used to conferences with a much more narrow focus so discussing math with people from different fields and specializations made me realize that the gulfs between us are not as huge as I had envisioned, and that building bridges is not just possible but essential. The plenary talks were beautiful, and opened my mind to the potential applications of the field. The networking events were extremely useful. The professional development was full of advice that made the next few career steps clearer and less overwhelming. In addition, being able to share lunch and dinner with my heroes and giants in the field felt like such an honor. Finally, the human connection was extremely important (more of this in the answer to problem 12). Mathematicians are people too, and we need to make sure not to forget that."

"It was the first time I felt I truly belong in Mathematics. I learned so much about how mathematics can lead to improving our society and lead to more equal opportunities for minorities, and it encouraged me to be a part of the solution and become involved myself. It was amazing to be among so many people who look like me, who had to go through so much hardship because of their origins (which are much like mine), and they still succeeded, and to realize I too can succeed, I too belong."

“I never thought I could have so much fun at a math conference!! This is by far the best one I've attended. I am looking forward to next year's. I am so happy and satisfied in regards to networking, as well as the opportunities I had to engage in amazing conversations. I made many new friendships, and I am eager to spread the word about my experience. There are not enough words of how happy I am!!! Thank you for all of your hard work and dedication, to each and every person that put together this wonderful conference, and to all whom attended.”

LONG PROGRAM: Quantitative Linear Algebra. March 19 - June 15, 2018

Organizing Committee:
Alice Guionnet (École Normale Supérieure de Lyon)
Assaf Naor (Princeton University, Mathematics)
Gilles Pisier (Texas A&M University - College Station)
Sorin Popa (University of California, Los Angeles (UCLA), Math)
Dima Shlyakhtenko (University of California, Los Angeles (UCLA))
Nikhil Srivastava (University of California, Berkeley (UC Berkeley))
Terence Tao (University of California, Los Angeles (UCLA), Mathematics)

The program lies at the juncture of mathematics and theoretical computer science in a quest for quantitative answers to finite-dimensional questions. The program brings together topics from a number of important directions, including discrepancy theory, spectral graph theory, random matrices, geometric group theory, ergodic theory, von Neumann algebras, as well as specific research directions such as the Kadison-Singer problem, the Connes embedding conjecture and the Grothendieck inequality.

A very important aspect of the program is its aim to deepen the link between research communities working on some infinite-dimensional functional analysis problems that occur in geometric group theory, ergodic theory, von Neumann algebras; and some quantitative finite-dimensional ones that occur in spectral graph theory, random matrices, combinatorial optimization, and the Kadison-Singer problem.

“The entire program was amazing and I am very happy to have been able to participate. I have learned many things and been able to work with senior mathematicians which would not have been possible without this long program. This had a tremendous impact on my research and my career in general.” (Comment from an anonymous participant)

WORKSHOP: Quantitative Linear Algebra Tutorials. March 20 - 23, 2018

Part of the Long Program "Quantitative Linear Algebra"

Organizing Committee:
Alice Guionnet (École Normale Supérieure de Lyon)
Assaf Naor (Princeton University, Mathematics)
Gilles Pisier (Texas A&M University - College Station)
Sorin Popa (University of California, Los Angeles (UCLA), Math)
Dima Shlyakhtenko (University of California, Los Angeles (UCLA))
Nikhil Srivastava (University of California, Berkeley (UC Berkeley))
Terence Tao (University of California, Los Angeles (UCLA), Mathematics)

The 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.

The following comments appeared in the survey of the participants:

"The posting of the tutorial videos online for those of us who missed or came late were INCREDIBLE value. I cannot recommend this enough as a great idea."

"All the lectures were amazing and were accessible to the non-experts of the specific fields."

WORKSHOP I: Expected Characteristic Polynomial Techniques and Applications. April 9 - 13, 2018

Part of the Long Program "Quantitative Linear Algebra"

Organizing Committee:
Adam Marcus (Princeton University)
Dan Spielman (Yale University)
Nikhil Srivastava (University of California, Berkeley (UC Berkeley))

A central goal of the program is to further connections between problems in infinite and finite dimensional linear algebra. This workshop will focus on the expected characteristic polynomials of finite-dimensional random matrices, which have played a crucial role in several recent results in this area (including the solution of the Kadison-Singer problem) and seem to offer a middle ground between the two settings. On one hand, their zeros turn out to be related to estimates in asymptotic random matrix theory, von Neumann algebras, and Free Probability theory; on the other hand, they can also be used to control the eigenvalues of the finite random matrices in question, which might come from another area such as spectral graph theory or frame theory.

In this workshop we will examine several occurrences of expected characteristic polynomials, with two goals: (1) to articulate a more rigorous understanding of the bridge between the infinite and the finite; and (2) to explore the consequences of recent applications of the method to concrete problems, and ideally uncover new applications.

SPECIAL EVENT: Infinite Possibilities Conference (organized by MSRI). April 14 - 15, 2018

The Infinite Possibilities Conference (IPC) is a national conference that is designed to promote, educate, encourage and support women of color interested in mathematics and statistics, as a step towards addressing the underrepresentation of African-Americans, Latinas, Native Americans, and Pacific Islanders in these fields. The conference is supported by the Mathematical Sciences Institutes Diversity Initiative. *MSRI was the lead organizer, therefore, the participants of this conference do not appear in IPAM's participant list.*

WORKSHOP II: Approximation Properties in Operator Algebras and Ergodic Theory. April 30 - May 5, 2018

Part of the Long Program "Quantitative Linear Algebra"

Organizing Committee:
Tim Austin (University of California, Los Angeles (UCLA))
Assaf Naor (Princeton University, Mathematics)
Gilles Pisier (Texas A&M University - College Station)
Sorin Popa (University of California, Los Angeles (UCLA), Math)
Stefaan Vaes (KU Leuven)

Modeling non-commutative phenomena in finite dimensional matrix algebras is a central theme of the program *Quantitative Linear Algebra*. This workshop will focus on a variety of concrete questions around this theme, coming from several directions, such as operator algebras, quantum information theory, geometric group theory, ergodic theory, etc. Topics will include:

- Connes approximate embedding conjecture, predicting that any II_1 factor can be approximated in moments ("simulated") by matrix algebras, with its numerous equivalent formulations in C*-algebras, quantum information, logic, etc.

- Related questions in combinatorial optimization, computational complexity and quantum games (e.g., the unitary matrix correlation problem).

- The sofic group problem, on whether any group can be "simulated" by finite permutation groups, and whether all free actions of a sofic group are sofic.

- Defining "good notions" of entropy for measure preserving actions of arbitrary groups (e.g., extending sofic entropy, etc).

- The commuting square problem for bipartite graphs, arising in subfactor theory.

The workshop survey results included these comments from participants:

"The program covered a broad range of topics that I found extremely interesting. I feel like a got a lot of exposure to new important trends in operator algebras and dynamics."

"This was by far one of the best workshops that I attended recently. The choice of speakers was rather bold – it involved researchers from more than one area – and the mix was excellent."

"The talks were spaced apart very cleverly which gave the participants ample opportunities to discuss various research topics with the speakers during the breaks. All the talks were excellent, the speakers were able to present their work eloquently to both specialists and non-specialists in their respective fields. I personally gathered some new ideas and specific problems from these talks that I intend to work on in the near future."

PUBLIC LECTURE: Green Family Lecture Series: "What is it about the Plane?" by Vaughan Jones. May 1, 2018.

This lecture was open to the public. No registration was required. The attendees do not appear in IPAM's participant list.

Speaker Bio:
Vaughan Jones is a mathematician known for his work on von Neumann algebras and knot polynomials. He obtained a BSc and an MSc at the University of Auckland and his PhD at the University of Geneva. In 1980, he moved to the United States, where he taught at UCLA and the University of Pennsylvania before being appointed as Professor of Mathematics at the University of California, Berkeley in 1985. Jones has been at Vanderbilt University as Stevenson Distinguished Professor of mathematics since 2011, while remaining Professor Emeritus at UC Berkeley and Distinguished Alumni Professor at the University of Auckland. Jones was awarded the Fields Medal in 1990 for his discovery of the quantization of the index of a subfactor, and what is now called the Jones polynomial of a knot.

Abstract:
We write and draw on paper, flat. We watch movies on screens, flat. We project 3 dimensional structures onto the plane, flat. From antiquity on, the plane has been key to our understanding of the world in all dimensions. I will introduce a notion of "planar algebra" and illustrate it in many ways, including some problems that are significantly harder in the plane than elsewhere, and explore the possibility of exploiting some strange physics in two dimensions.

Green Family Lecture Series: "God May or May Not Play Dice but He Sure Loves a von Neumann Algebra" by Vaughan Jones. May 2, 2018

This lecture was open to the public. No registration was required. The attendees do not appear in IPAM's participant list.

Speaker Bio: see above.

Abstract:
After reviewing the basic mathematics of quantum mechanics I will explain what a von Neumann algebra is and why it is as natural and necessary for understanding the quantum world as manifolds are for the classical world. An attempt to base quantum field theory on von Neumann algebras has, in the last 30 years, been extraordinarily successful in low dimensions. I will discuss a few of the high points of this theory.

WORKSHOP III: Random Matrices and Free Probability Theory. May 14 - 18, 2018

Part of the Long Program "Quantitative Linear Algebra"

Organizing Committee:
Alice Guionnet (École Normale Supérieure de Lyon)
Dima Shlyakhtenko (University of California, Los Angeles (UCLA))
Terence Tao (University of California, Los Angeles (UCLA), Mathematics)
Roman Vershynin (University of California, Irvine (UCI))
Jun Yin (University of California, Los Angeles (UCLA))

The workshop will explore large-N asymptotics of random matrices, in connection with the operator-algebra models of their limiting behavior that appear in free probability theory. The behavior or random matrices has found increasing applications in mathematics, with connections to combinatorics, analysis and probability theory, as well as fields outside mathematics such as physics and computer science.

Topics of the workshop include asymptotics behavior of various observables of random single-matrix and multi-matrix models, including behavior of eigenvalues and eigenvectors, as well as connections to properties of operators describing the large-N limit. Of particular emphasis will be links to applications, ranging from graph theory to statistical analysis of data.

"My compliments to the staff – very efficient and nice – and to the organizers for gathering so efficiently many relevant participants and speakers. It was a pleasure to be here, and very useful for my research."

"I have attended many workshops in my career and this one has been one of my favorite. The organizers did an excellent job."

WORKSHOP: Quantitative Linear Algebra Culminating Workshop at Lake Arrowhead. June 10 - 15, 2018

The culminating workshop was organized by the long program organizing committee.

The final workshop in the long program, Quantitative Linear Algebra, which was 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.

"The culminating conference was a great opportunity to speak with the other core participants one last time before we all head back to our respective institutions."

REUNION CONFERENCE: Many-Particle Systems with Machine Learning Reunion Conference I. June 10 - 15, 2018

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

This was the first reunion conference for participants of the fall 2016 long program "Many-Particle Systems with Machine Learning." 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.

"The ML for many-particle systems program has had a large impact on my career. I've met several physicists 1.5 years ago, started collaborations and we are now finishing up papers. Also, the program helped me to put together a research plan that helped me to win a major external grant."

REUNION CONFERENCE: Traffic Flow Management Reunion Conference II. June 10 - 15, 2018

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

This was the second reunion conference for participants of the fall 2015 long program "Traffic Flow Management." 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.

OUTREACH ACTIVITIES, 2017-2018

IPAM continues to strengthen its 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 the 2017 Research Industrial Projects for Students (RIPS) "Projects Day" and 2018 Green Family Lectures Series. In addition, IPAM supports 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 a K-12 educational event, their year-end banquet, and occasional other meetings and study sessions.

In the past year, IPAM representatives attended national diversity conferences to promote math programs to underrepresented groups. The assistant director and outreach coordinator attended the 2017 Modern Math Workshop and SACNAS National Conference in Salt Lake City to

advertise upcoming opportunities and network with faculty and students. A student from the RIPS 2017 program also participated in the conference. IPAM shared a booth at the 2017 SACNAS National Conference with three other math institutes (ICERM, SAMSI, and MSRI). In January of 2018, a representative of IPAM attended the Nebraska Conference for Undergraduate Women in Math (NCUWM) to promote the RIPS 2018 summer program and talk to undergraduate women about opportunities in math. Four RIPS students from the 2017 program also attended the conference and presented their research; IPAM paid for their travel.

IPAM hosted the second Latinx in the Mathematical Sciences Conference on March 8 – 10, 2018. The conference included a "math circles" activity aimed at Latinx high school students. 26 students and 2 teachers from the California Academy of Mathematics and Science and Lennox Academy participated in the activity. Both are public charter schools in Los Angeles that serve a large number of underrepresented students. See above for more information.

IPAM awarded Berland Foundation awards to 2 participants with family in the past year. The funds help pay for child care, housing, or other expenses necessary to allow them to fully participate in the workshop or long program.

Finally, IPAM advertised its RIPS (undergraduate) and GRIPS (graduate) programs through minority institutions and organizations, and announced its Associate Director search through the website and newsletters of the Association for Women in Mathematics and SACNAS.

K. PROGRAM CONSULTANT LIST

IPAM consulted a variety of scholars and practitioners in the scientific planning of its programs. The list below includes program organizers for the programs that took place during this reporting period or upcoming programs for which organizing committees have begun meeting. The list excludes IPAM's scientific staff (directors) and members of IPAM's Science Advisory Board and Board of Trustees, who are listed in section O, Committee Membership.

Name	Institution
David Ambrose	Drexel University
Federico Ardila	San Francisco State University
Tim Austin	University of California, Los Angeles (UCLA)
Ruzena Bajcsy	University of California, Berkeley (UC Berkeley)
David Balaban	AMGEN Inc
Nina Balcan	Carnegie Mellon University
Mirela Ben Chen	Technion - Israel Institute of Technology
George Biros	University of Texas at Austin
Mario Bonk	University of California, Los Angeles (UCLA)
Xavier Bresson	Nanyang Technological University, Singapore
Michael Bronstein	USI Lugano, Switzerland
Aaron Brown	University of Chicago
David Brown	Lawrence Berkeley National Laboratory
Joan Bruna	New York University
Joachim Buhmann	ETH Zürich

Hans-Joachim Bungartz	Technical University Munich (TUM)
Emmanuel Candes	Stanford University
Pierre Cardaliaguet	Université de Paris IX (Paris-Dauphine)
René Carmona	Princeton University
Marco Cavaglia	University of Mississippi
Jennifer Chayes	Microsoft Research
Matt Choptuik	University of British Columbia
Cecilia Clementi	Rice University
Ricardo Cortez	Tulane University
Gabor Csanyi	University of Cambridge
Elena Cuoco	Scuola Normale Superiore
Mikael De La Salle	École Normale Supérieure de Lyon
Claudia Draxl	Humboldt-Universität
Cynthia Dwork	Harvard University
Virginie Ehrlacher	École Nationale des Ponts-et-Chaussées
Alex Eskin	University of Chicago
Benson Farb	University of Chicago
Kristen Fichthorn	Pennsylvania State University
David Fisher	Indiana University
Jose Antonio Font	University of Valencia
Wilfrid Gangbo	University of California, Los Angeles (UCLA)
Paola Goatin	Institut National de Recherche en Informatique Automatique (INRIA)
Philipp Grohs	Universität Wien
Alice Guionnet	École Normale Supérieure de Lyon
Graeme Henkelman	University of Texas at Austin
Richard Hennig	University of Florida
Didier Henrion	Centre National de la Recherche Scientifique (CNRS)
Eriko Hironaka	American Mathematical Society
Jeffrey Hittinger	Lawrence Livermore National Laboratory
Sebastian Hurtado Salazar	University of Chicago
Ryan Hynd	University of Pennsylvania
Frank Jenko	University of California, Los Angeles (UCLA)
Chris Johnson	University of Utah
Markos Katsoulakis	University of Massachusetts Amherst
David Keyes	King Abdullah Univ. of Science and Technology (KAUST)
Ron Kimmel	Technion - Israel Institute of Technology
Mark Kisin	Harvard University
Jana Kosecka	George Mason University
Motoko Kotani	Tohoku University
Andreas Krause	ETH Zürich
Vipin Kumar	University of Minnesota, Twin Cities
Rongjie Lai	Rensselaer Polytechnic Institute
Yann LeCun	Facebook
Alan Lee	AMD
Joan Lind	University of Tennessee
Mitchell Luskin	University of Minnesota, Twin Cities
Senka Maćešić	University of Rijeka

Adam Marcus	Princeton University
Noa Marom	Carnegie Mellon University
Antonio Marquina	University of Valencia
Simon Masnou	Université de Lyon I
Marina Meila	University of Washington
Igor Mezic	University of California, Santa Barbara (UCSB)
Klaus-Robert Müller	Technische Universität Berlin
Assaf Naor	Princeton University
Frank Noe	Freie Universität Berlin
Danny Perez	Los Alamos National Laboratory
Benedetto Piccoli	Rutgers University
Gilles Pisier	Texas A&M University - College Station
Petr Plechac	University of Delaware
Sorin Popa	University of California, Los Angeles (UCLA)
Mihai Putinar	University of California, Santa Barbara (UCSB)
Zinovy Reichstein	University of British Columbia
Federico Rodriguez Hertz	Pennsylvania State University
Steffen Rohde	University of Washington
Martin Rumpf	Rheinische Friedrich-Wilhelms-Universität Bonn
Eero Saksman	University of Helsinki
Sriram Sankararaman	University of California, Los Angeles (UCLA)
Guillermo Sapiro	Duke University
Anand Sarwate	Rutgers University New Brunswick/Piscataway
Christof Schuette	Freie Universität Berlin
Benjamin Seibold	Temple University
Justin Solomon	Massachusetts Institute of Technology
Olga Sorkine-Hornung	ETH Zürich
Ralf Spatzier	University of Michigan
Dan Spielman	Yale University
Nikhil Srivastava	University of California, Berkeley (UC Berkeley)
Gabriele Steidl	TU Kaiserslautern
Andrew Stuart	California Institute of Technology
Arthur Szlam	Facebook
Terence Tao	University of California, Los Angeles (UCLA)
Tatiana Toro	University of Washington
Dallas Trinkle	University of Illinois at Urbana-Champaign
Matthias Troyer	Microsoft Research
Stefaan Vaes	KU Leuven
Mariel Vazquez	University of California, Davis (UC Davis)
Roman Vershynin	University of California, Irvine (UCI)
Fredrik Viklund	Royal Institute of Technology (KTH)
Zhenghan Wang	Microsoft Research
Tandy Warnow	University of Illinois at Urbana-Champaign
Amie Wilkinson	University of Chicago
Rebecca Willett	University of Wisconsin-Madison
Jesse Wolfson	University of California, Irvine (UCI)
Daniel Work	Vanderbilt University

Stephen Wright	University of Wisconsin-Madison
Jang-Mei Wu	University of Illinois at Urbana-Champaign
Jun Yin	University of California, Los Angeles (UCLA)
Hongkai Zhao	University of California, Irvine (UCI)
James Zou	Stanford University

L. PUBLICATIONS LIST

This report includes publications that resulted from the fall 2014 and spring 2015 long programs, as well as the publications of our Director, Deputy Director, Associate Director, and Director of Special Projects from the past year. We asked the participants of Traffic Flow Management (fall 2014), Computational and Combinatorial Geometry (spring 2015) to list their publications that were a result of or significantly influenced by the IPAM program. We also ask long program participants to report on recent publications at the reunion conferences. These publications were entered into the project reports "products" form in Research.gov. We chose not to include pre-prints. We confirmed that the publications in this report were not reported in our previous annual reports.

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)-Los Angeles. Companies and other organizations sponsor research projects and one or more representatives of the organization interact with the student team. Many of them are listed as participants of RIPS-LA and RIPS-LA Projects Day. Companies also sponsor projects in RIPS-Hong Kong and Graduate RIPS-Berlin; in these cases, the sponsors are recruited by our partners, Hong Kong University of Science and Technology, and MODAL (Berlin).

IPAM received some gifts and grants during this period from government and military agencies to support specific program, including:

- The 2017 Computational Genomics Summer Institute was entirely supported by a grant from the NIH. (IPAM was a cosponsor and did not administer the grant.)
- An IRES grant through NSF-OISE supports RIPS-Hong Kong
- Research in Industrial Projects for Students (RIPS) collects sponsorship fees from its corporate and other sponsors, which cover some of the program expenses
- A generous gift from AMD supported RIPS and other IPAM programs (part of the Director's Endowment Fund in Table N)
- Facebook, Elsevier, and the NSA sponsored the Latinx in Mathematical Sciences Conference at varying levels
- ONR supported the workshop on Mean Field Games

We seek the advice of government and industry by recruiting corporate and government leaders to serve on our Science Advisory Board and Board of Trustees. See section O for a complete list of members and their affiliations.

Out of all of IPAM's participants during this reporting period, 78 of them held positions in government or military organizations, and 49 worked in industry. Eight of our workshops speakers came from companies such as Genentech, Facebook, IBM, Navigate BioPharma, Microsoft Research, and Quantitative Brokers. 18 speakers came from government or military labs, half of which came from Los Alamos, Argonne, and Oak Ridge National Labs.

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 by IPAM from June 1, 2017 through May 31, 2018. *Support from Foundations are generally endowments and only the earnings are available for spending.*

Table N: Other Funding Support	
Federal Funding	
NSF-IRES: RIPS-Hong Kong	$75,015
Office of Naval Research (Mean Field Games)	$58,477
Mathematical Science Research Institute (NSF)	$50,230
National Security Agency	$18,000
Sub-total	$201,722
Support from Foundations and Endowments	
Schwinger Foundation - Endowment	$375,000
UC Regents Matching - Schwinger Foundation Endowment	$750,000
Simon's Foundation - Current Spending	$192,985
IPAM Director's Endowment Fund	$180,850
Green Family Foundation Endowment	$75,000
Los Angeles Police Foundation - Current Spending	$4,000
Sub-total	$1,577,835
UCLA Funding	
Dean Physical Sciences	$136,253

Vice Chancellor for Research	$133,378
Graduate Division	$10,000
Equity, Diversity, and Inclusion Office	$4,000
Sub-total	$283,631
Industrial Affiliates and Other Support	
Aerospace Corporation	$25,000
Air Force	$25,000
Elsevier	$5,000
Facebook, Inc	$10,000
Google, Inc	$50,000
Gum Gum, Inc	$50,000
HRL	$25,000
Microsoft	$10,000
UNC Lineberger Comprehensive Cancer Center	$28,500
Sub-total	$228,500
Others	
Hyperloop Advanced Research Partnership	$5,348
Scalia Giusy	$9,751
University of Washington	$6,000
Other Donors	$7,055
Sub-total	$28,154
TOTAL	$2,319,842

O. COMMITTEE MEMBERSHIP

IPAM's committees include the Board of Trustees and Science Advisory Board. The members during the reporting period are listed below. The IPAM directors are *ex officio* members.

Board of Trustees, 2017-2018 Membership

Name	Institution	Department or title
David Balaban	Amgen	
Tanya Beder	SBCC Group Inc.	Chairman & CEO
Russel Caflisch	New York University	Director, Courant Institute
Tony Chan	KAUST	President
Brenda Dietrich	Cornell University	Professor
Karina Edmonds	Google	Google Cloud University Relations Lead
Mark Green	UCLA	Mathematics
Alfred Hales	CCR West	

Sallie Keller	Virginia Tech University	Professor of Statistics, Director
Steven Koonin	New York University	
Alan Lee	AMD Research	Corporate Vice President of Engineering Research
Monique Miller	Wilshire Funds Management	Managing Director
Nancy Potok	US Government	Chief Statistician
Ronald Stern	UC Irvine	
Tatiana Toro	University of Washington	Mathematics
Leland Wilkinson	H2O.ai	Chief Scientist
Jeannette Wing	Columbia University	Director, Data Science Institute

Science Advisory Board, 2017-2018 Membership

Name	Institution	Discipline or department
Alexei Borodin	MIT	Mathematics
Michael Brenner	Harvard	School of Engineering and Applied Sciences
Emery Brown	MIT	Professor of Medical Engineering and of Computational Neuroscience
Robert Calderbank	Duke University	Director of the Information Initiative
Emmanuel Candes	Stanford University	Professor of Mathematics and of Statistics
Cecilia Clemente	Rice	Chemistry
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Jordan Ellenberg	Univ of Wisconsin	Mathematics
Peter Wilcox Jones	Yale University	Mathematics
Michael Kearns	University of Pennsylvania	Computer and Information Science
Yann LeCun	New York University/Facebook	Computer Science
David Levermore	University of Maryland	Applied Math
Xihong Lin	Harvard	T H Chan School of Public Health.
Assaf Naor	Princeton	Mathematics
Stanley Osher	UCLA-IPAM	Applied Math
Pablo Parrilo	MIT	Electrical Engineering and Computer Science
Christian Ratsch	UCLA-IPAM	Physics
Dima Shlyakhtenko	UCLA-IPAM	Pure Math
Terence Tao	UCLA	Mathematics
Luca Trevisan	UC Berkeley	Electrical Engineering and Computer Science
Amie Wilkinson	Univ. of Chicago	Mathematics