Institute for Pure and Applied Mathematics, UCLA
Annual Progress Report for 2016-2017
Award #1440415
August 7, 2017

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EXECUTIVE SUMMARY

This report covers our activities from June 1, 2016 to June 10, 2017 (which I will refer to as the *reporting period*). Last year the reporting period ended on May 31. This year, we decided to extend the reporting period to June 10, so 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 our 2016 "RIPS" programs, but not 2017.

IPAM held two long program in the reporting period:

- Understanding Many-Particle Systems with Machine Learning
- Computational Issues in Oil Field Applications

IPAM held the following workshops in the reporting period:

- Turbulent Dissipation, Mixing and Predictability
- Beam Dynamics
- Emerging Wireless Networks
- Big Data Meets Computation
- Regulatory and Epigenetic Stochasticity in Development and Disease
- Gauge Theory and Categorification

IPAM 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 six second reunion conferences during this reporting period.

IPAM offered one public lecture, presented by Edward Witten during the reporting period. His second public lecture was cancelled and is rescheduled for late 2017.

This report includes three 2016 student research programs: Research in Industrial Projects (RIPS) in LA and Hong Kong, and Graduate RIPS in Berlin. We also held a one-week summer school entitled "Putting the Theory Back in Density Functional Theory" and cosponsored the Computational Genomics Summer Institute.

Finally, IPAM held two events aimed at underrepresented groups in mathematics:

- The annual Modern Math Workshop (at SACNAS; IPAM was the lead institute)
- The second National Meeting of Women in Financial Mathematics

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, 2016 and August 31, 2017.

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, 2016 and August 31, 2017.

C. INCOME AND EXPENDITURE REPORT

This table shows appropriations and expenses for the twelve-month period June 1, 2016 through May 31, 2017 for grant #1440415.

	A	B	C	D	E	F
			A-B=C		B+D=E	A-E=F
Budget Category	Appropriation Year 2	Actual Expenses for the 12 months	Balance for the 12 months	Encumbered Expenses as of May 2017	Total & Encumbered Expenses at May 2017	Encumbered Balance as of May 2017
A. Operations Fund	$1,705,822	$1,680,666	$25,156	$134,333	$1,814,999	<$109,177>
B. Participant Costs	$2,020,000	$1,811,603	$208,397	$28,053	$1,839,656	$180,344
C. Indirect Costs	$784,178	$750,662	$33,556	$0	$750,622	$33,556
Totals	$4,510,000	$4,242,891	$267,109	$162,386	$4,405,277	$104,723

IPAM received an appropriation of $4,510,000. Total expenses were $4,405,277, leaving a balance of $104,723.

A. The Operational Fund (salaries, benefits, equipment, and supplies) for the twelve-month period has an appropriation budget of $1,705,822 with total expenditures of $1,814,999 leaving a balance of <$109,177>.

   Included in the encumbered expenses is $133,526 for the sub-award with California State University, Northridge for Associate Director Jorge Balbas.

B. Participant Support Costs include stipends, travel, housing, and subsistence for the scientists participating in IPAM Programs. Participant Support Costs for the twelve-month period has an appropriation budget of $2,020,000 with total expenditures of $1,839,656 leaving a balance of $180,344.

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 $784,178 with total expenditures of $750,662 leaving a balance of $33,556.

Program Income: Registration fees for NSF-supported conferences are accounted for as program income. IPAM charges modest registration fees primarily to discourage non-serious registrations. Registration fees for workshops are $75 for faculty and government/military participants, $100 for industry participants, $50 for post-doctoral scholars and $25 for graduate students. Program income received was $22,529 for the twelve-month period and is spent entirely on participant support expenses.

D.POSTDOCTORAL PLACEMENT LIST

IPAM did not appoint postdoctoral fellows in 2016-17, so we have no data to report in this section.

E. MATH INSTITUTE DIRECTORS' MEETING REPORT

2017 Math Institute Directors Meeting
April 28-29, 2017, at SAMSI

Meeting Chair: Robert Calderbank (Duke University; Chair of SAMSI Governing Board)

Attendees:
AIM: Brian Conrey and Estelle Basor
IAS: Richard Taylor
ICERM: Brendan Hassett
IMA: Daniel Spirn
IPAM: Russ Caflisch and Christian Ratsch
MBI: Tony Nance, Greg Rempala,
MSRI: David Eisenbud and Hélène Barcelo
SAMSI: Richard Smith and Sujit Ghosh

Additional Guests: Ilse Ipsen and Thomas Witelski (SAMSI), Peter Mucha (UNC), Mike Reed (MBI, Duke University)

NSF: Christopher Stark, Joanna Kania-Bartoszynska, Nandini Kannan, Tie Luo, Henry Warchall and Michael Vogelius *(day two only)*

DAY 1

1. Introductions

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

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

   - Online Colloquium at MBI: A new MBI activity was described by Mike Reed: the National Mathematical Biology Colloquium initiated in the Fall of 2016. Talks by prominent speakers are broadcast over the web on a regular monthly schedule. The Bluejeans web-conferencing system is used and allows for questions to be texted or voiced live by the real-time audience (handled by a moderator). MBI purchased time on the company's webservers to ensure good bandwidth for high-quality broadcasting. Scheduling at noon Eastern Time (ET) allows for viewers on the west coast and in Europe as well. The speakers can present from their home-institution office (avoiding the need for travel makes it easier to get high profile speakers). The web-broadcast makes it possible for the talk to reach students and faculty at a very broad range of schools that might otherwise not be able to attract the speakers to visit. The series will continue in Fall 2017. The Bluejeans system has also been used by other institutes for some of their meetings. Folks interested to use such web-based facilities are encouraged to contact MBI.
   - Unique identifiers for participants: ORCID (https://orcid.org/) was discussed as system for uniquely identifying participants in MI activities. ORCID ID numbers will soon be a requirement for reimbursement for participants from NSF funds. Questions were raised about ease of use and whether the system can avoid duplicate records. The fundamental question of interest was identified as understanding NSF's interests and goals in making use of ORCID for evaluating MI activities. It was also pointed out that some journals in mathematical sciences and other interdisciplinary sciences are also requesting authors to provide ORCIDs.
   - Evaluation Metrics for MIs: Further discussion relating to evaluating MI activities touched on MI's missions in core research programs and being one of NSF's mechanisms for reaching the broader mathematics community (people not having their own NSF funding) (including outreach to under-represented groups). For several years, DMS contracted with the Science and Technology Public Institute (STPI) to coordinate an evaluation of the full institutes portfolio, but this effort had been abandoned after the attempt to conduct randomized surveys did not produce useful results. Nevertheless, it's possible that the next DMS director will want to revive the process. It was pointed out that highlighted case study stories and notable anecdotal descriptions or blogs (e.g., SAMSI regularly posts blogs written by its participants) might be of more impact value

than tabulated statistics on participants. There were some concerns raised about how effective the MathInstitutes.org website might be at presenting these activities.

- Coordination among Math Institutes Activities: Cooperation and coordination among the MI's included activities for the Math of Planet Earth, the Institutes Postdoc program, the MI Diversity committee and the MIDS meeting itself. It was noted that the idea for an annual MIDS meeting originated with former DMS Director Philippe Tondeur, who envisioned that it would serve as a leadership council for the US Mathematics community, but the role has evolved and become more specialized over the years. However avoiding scheduling of similar programs seemed a sensitive topic which has previously received criticism (and has practical issues in terms of burning out the key researchers in given topic areas). MSRI and the Fields Institute maintain lists of recent/upcoming programs shared among NSF-MI's (MSRI) and other North-American MI's (Fields).
- Overall, DMS seem to support the idea of institutes working together (the whole being bigger than the sum of its parts) but the message has been mixed. For example, there was a proposed collaboration among IPAM, IMA and ICERM that would have looked at inverse problems with oil industry funding, but DMS did not support this.
- Funding Raising Activities: Discussion of partnerships that the MI's can have with industry and other funding sources was raised in light of concerns about flat or decreasing NSF funding. Challenges in raising money arise from seeking to fit in with parent university's strategic plans while maintaining focus serving the public-good at the national level for the mathematics community. Building endowments allowing for the MI's to become independent of NSF funding feels out of reach for almost all MI's.
- Discussion continued on whether NSF might help facilitate MI's forming partnerships with outside entities (industry, others?). Background was given about past NSF views on providing finite-term seed money with goals of MI's becoming self-sustaining in the long term. This seems challenging to achieve in the current financial climate. With some exceptions (e.g., IMA), support from companies is becoming more difficult to secure and issues like ownership of intellectual property can be significant problems.

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

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

5. The MI Diversity Committee report: Helene Barcelo provided overview of the MI diversity activities and following items were discussed:
   - The 2012-16 NSF supplement managed by MSRI supported various conferences and activities coordinated by the Diversity Committee including the Modern Math Workshop, the Blackwell-Tapia Conference, the Infinite Possibilities Workshop and the Spring Opportunities Workshops (a complete list is available on the MI diversity website: https://mathinstitutes.org/diversity/)
   - The supplement was extended by only one year during 2016-17 while MSRI went through its renewal process, but after that was completed, the Diversity Committee put together a proposal for a further 4-year supplement. The first version of the proposal was asked to be withdrawn and NSF asked for more detailed documentation of prior MI diversity activities. The MI diversity committee coordinated with each of the MIs in collecting more details of about the diversity workshops and activities, the proposal was revised and resubmitted and subsequently funded at the requested level.
   - In anticipation of the uncertain amount of funding available for 2016 (while the proposals were being evaluated by NSF), some of the major diversity workshops in 2016 (e.g., Spring Opportunities, MMW, Blackwell-Tapia) spent less amount than those originally allocated, which resulted into a surplus. The diversity committee finds that if we take into account the surplus from previous grant and keep underspending throughout the next 4-year cycle, the projected amount of surplus will be close to $100K. So, the diversity committee solicited ideas for including new diversity initiatives
   - There has been dissatisfaction with holding the MMW at SACNAS due to the logistics of supporting students which is partly managed by SACNAS, but after fruitful coordination between the current SACNAS annual conference management team and MI diversity committee, this has now been resolved and the 2017 MMW will continue to be part of the SACNAS meeting.
   - Russ Caflisch reported on IPAM's organization of the "Latinos in the Mathematical Sciences Conference," informally known as Lat@Math. The first installment of this conference took place in 2015 and the second is scheduled for March 8 - 10, 2018. The earlier conference had an organizing committee led by Alejandro Adem, Ricardo Cortez and Tatiana Toro, though Alejandro has since left the committee. There was an excellent line-up of speakers including Ana Mari Cauce (President of the University of Washington), Terrence Tao and Erika Camacho. However, it's not so easy to find funding because companies don't seem very interested in sponsoring this kind of activity. For example, it was pointed out that Google has funding for societal projects but not for science. The long-term plan is to repeat the conference at 3-year intervals at rotating locations. After further discussion the following motion was proposed and approved: the Diversity Committee is authorized to spend $50,000 from the current Diversity Grant budget to fund the 2018 conference. It was decided to forward this request to NSF IMT for their approval on the Day 2 of the meeting.

6. Other items:

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

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

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

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

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

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

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

DAY 2

Representatives of NSF-DMS joined the meeting.

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

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

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

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

1. There was interest in projections for the NSF and DMS budgets in the upcoming Federal

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

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

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

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

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

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

7. Questions arose about partnerships and expectations for cost-sharing.
   (i) NSF's rules on cost-sharing are to prevent wealthier universities from having strong advantages over smaller schools.
   (ii) There will be MOU's defining firewalls on activities being supported from NSF budgets vs activities from private foundation funding and their rules. Budgets and funding will not get co-mingled.
   (iii) Dollar amounts of any cost-sharing can NOT be included in proposals or letters of support, or anywhere in the budget justification. Some general terms about cost-

sharing can be mentioned in the proposal but no specifics should be included. The tone was "Don't brag about money, brag about activities, successes, and output." Avoid issues connecting to Federal spending rules.

(iv) The new MI CFP has no rule changes in this area from the previous call for proposals.

8. Changes in the new solicitation for MI's were noted:
   - Language is included to ensure that the MI won't be just of narrow interest to one university. It needs to serve the broad national interest and have nationwide recruiting. All current MI's are fully compatible.
   - There's a new list included of strengths for MI's – not ALL things are expected to be covered by a single MI, they are just examples of typical traits being sought.
   - Participant expenses cannot be reimbursed from NSF funds without ORCIDs. The purpose is to help manage participant data collection.
9. There was an extended discussion about ORCID and participant data collection:
   - A DMS working group with representatives from MIs will be formed to discuss issues and logistics on collecting participant data: how to feasibly collect data and what data is being asked for that can be done across all institutes. It was concluded that we really need to ask all current items about participants in order to continue various metrics of impact. The number of questions can't be reduced, but at least no new questions are being added.
   - Collection of data has been recognized as a challenge, it is also a challenge for NSF to process the spreadsheets by MI's in annual reports. This has motivated exploring options for better data management, but there has been slow progress on selecting a system.
   - One option is to copy the approach from REU sites: undergraduate students applying for any REU program will register at a central NSF web portal.
   - At the Institutes level, people who want to attend a program at one MI, say IPAM, would be directed to the mathinstitute.org website and use a centralized system to fill in the data that NSF wants and then the site send them back to IPAM to fill in further information (housing, dates, etc) needed by IPAM. This kind of common portal system lets NSF get data directly without intermediate steps of MI's needing to report data. MI's workload would be reduced to just financial reporting in each annual report.
   - A mock-up of a registration portal was set up as a Google Docs form: https://goo.gl/forms/RCfI5FB1lz6gV6sy1 was illustrated by Hank Warchall.
   - There was a very lively discussion of various practical considerations:
     - Walk-in participants at workshops could register on-site at a computer at the registration desk.
     - People that applied but end up not attending should not be registered.
     - A question was raised: Doesn't this system add more stages to the registration process? It seems to add to the burden involved for participants while only making work for MI's slightly easier.
     - If participants' information is saved in the system, it means they would only have to enter it once (or occasionally edit it), which should overall save time for

participants.
- There were concerns expressed about participants forgetting ORCID accounts or having multiple accounts. It was shown that the ORCID registration process was very short and thereafter, one's ID number is information publicly available on the ORCID system.
- There were still concerns about MI's efforts and use of IT employees to ensure data integrity.
- NSF's participant registration data would be made available to all MI directors.
- ORCID will become required for NSF reimbursement of participants. It is currently optional for PI's but may become required in the future. A similar requirements are also being demanded by some of the journal publishers.
- Tracking ORCID IDs is separate from the idea of having a centralized MI registration portal.
- DMS has an interest in doing long-term tracking of people's involvements in programs over the years.
- DMS recognizes the need to clean up the data that will be collected.
- The imagined registration portal will be supported by a grant supplement from the NSF to one of the MI's.
- NSF is less concerned about the data of foreign participants.

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

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

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

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

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

Hank Warchall was noted for his efforts in creating the EDT program. There will be a new DMS-funded internship program with a new portal from the Oak Ridge institute for science education to enable graduate students to apply for internships at national labs. Later it may be expanded to connect to opportunities at private companies too. It will include matching/screening mechanisms. It has received a lot of interest from grad students. The internships are very good broadening experiences for students, beyond just working with an advisor. This program will also try to reach pure math students. That will be a bit harder to make that work, but we are trying to show people more career options and paths forward.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

16. The schedule for the 2018 MIDS meeting was briefly discussed. It will be next held at

AIM. A poll will be conducted by AIM representative via email or other means. Potential dates are April 26-27, 2018 or the first weekend in May.

F. PARTICIPANT SUMMARY

In this report, we are reporting on participants of programs that took place between June 1, 2016 and June 10, 2017. (This year, 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 4-9, 2017. This report does not include the participants of our summer programs, RIPS-Hong Kong and RIPS-LA, which start after June 10.)

Table F-1: All Participants' Gender and Ethnicity by Program Type (June 1, 2016 - June 10, 2017)

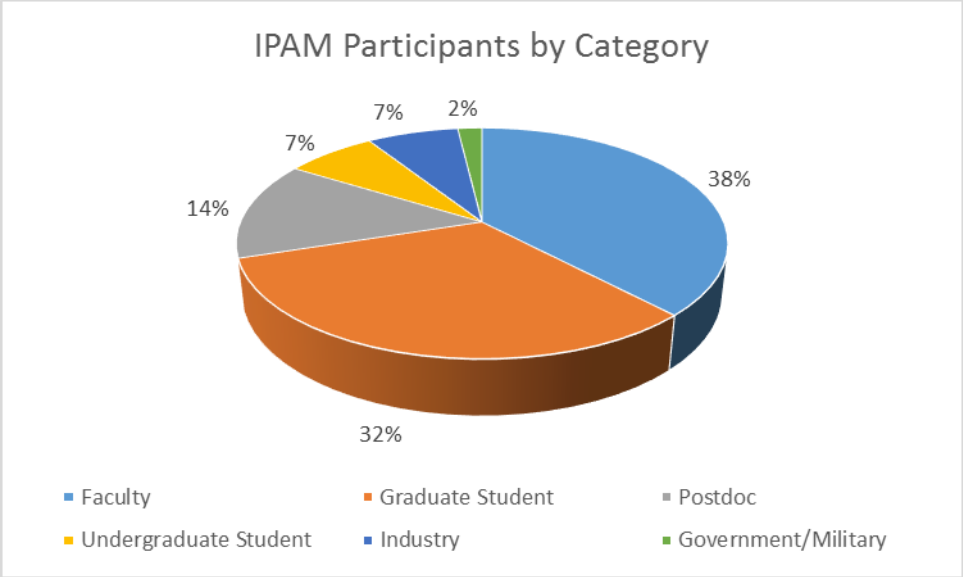
		Gender		Underrepresented Ethnic Groups			
Program Type	**Total Participants**	**Female**	**No. Reporting Gender**	**Amer. Indian**	**Black**	**Hispanic**	**No. Reporting Ethnicity**
Long Program	94	18	91	0	1	8	86
Workshops	1194	212	1170	1	19	74	1051
Summer School	194	50	190	1	2	15	171
Student Research Programs	80	31	80	0	3	10	72
Special Events and Conferences	188	119	185	4	15	62	183
Reunion Conferences	122	24	119	0	2	8	100
Total	1872	454	1835	6	42	177	1663
Percent of No. Reporting		24.7%		0.4%	2.5%	10.6%	
		All underrepresented ethnic groups:			*225*	*13.53%*	

There were 1,358 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, 25.6% were women. Out of those reporting ethnicity, 13.9% of 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 1, 2016 to June 10, 2017)			
Program Type	**U.S. Citizens & Permanent Residents**	**No. Reporting Citizenship & Residency**	**percent**
Long Programs	23	91	25%
Workshops	538	1145	47%
Summer School	97	186	52%
Student Research Programs	57	78	73%
Special Events and Conferences	134	171	78%
Reunion Conferences	69	118	58%
Total	895	1698	53%

98% of participants reported their participant category. The majority of IPAM participants are faculty and graduate students. See the pie chart below for the percentage of participants in each category.



The following sections provide summary data for the requested sub-groups: postdocs, graduate students, and undergraduate students.

G. POSTDOCTORAL PROGRAM SUMMARY

Postdocs participated in all of IPAM's programs during the reporting period (June 1, 2016 to June 10, 2017). Three postdocs participants in IPAM"s student research programs as academic mentors. See tables G-1 and G-2.

Table G-1: Postdocs' Gender and Ethnicity by Program Type (June 1, 2016 - June 10, 2017)							
		Gender		Underrepresented Ethnic Groups			
Program Type	Total Participants	Female	No. Reporting Gender	Amer. Indian	Black	Hispanic	No. Reporting Ethnicity
Long Program	21	3	21	0	0	3	18
Workshops	164	32	163	0	3	14	142
Summer School	34	13	33	0	1	1	28
Student Research Programs	3	1	3	0	0	1	2
Special Events and Conferences	12	6	12	0	3	3	12
Reunion Conferences	20	6	20	0	0	2	13
Total	254	61	252	0	7	24	215
Percent of No. Reporting		24.2%		0.0%	3.3%	11.2%	
		All underrepresented ethnic groups:			*31*	*14.42%*	

Table G-2: Postdocs' Citizenship by Program Type (June 1, 2016 to June 10, 2017)			
Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency	percent
Long Programs	2	21	10%
Workshops	50	164	30%
Summer School	16	33	48%
Student Research Programs	1	3	33%
Special Events and Conferences	9	10	90%
Reunion Conferences	8	20	40%
Total	84	251	33%

H. GRADUATE STUDENT PROGRAM SUMMARY

Graduate students participated in IPAM's workshops and long programs during the reporting period. 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 and Ethnicity by Program Type (June 1, 2016 - June 10, 2017)							
		Gender		Underrepresented Ethnic Groups*			
Program Type	Total Participants	Female	No. Reporting Gender	Amer. Indian	Black	Hisp.	No. Reporting Ethnicity
Long Program	30	7	30	0	1	2	28
Workshops	358	75	356	1	5	25	325
Summer School	104	26	102	1	0	7	94
Student Research Programs	12	4	12	0	0	1	11
Special Events and Conferences	59	38	58	3	2	19	58
Reunion Conferences	28	7	28	0	0	4	25
Total	591	157	586	5	8	58	541
Percent of No. Reporting		26.8%		0.9%	1.5%	10.7%	
			All underrepresented ethnic groups:		*71*	*13.1%*	

Table H-2: Graduate Students' Citizenship by Program Type (June 1, 2016 to June 10, 2017)			
Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency	percent
Long Programs	5	30	17%
Workshops	108	357	30%
Summer School	45	104	43%
Student Research Programs	8	12	67%
Special Events and Conferences	29	59	49%
Reunion Conferences	8	26	31%
Total	203	588	35%

I. UNDERGRADUATE STUDENT PROGRAM SUMMARY

Undergraduate students participated in the Modern Math Workshop (under "special events and conferences"), RIPS-LA and RIPS-Hong Kong (2016 student research programs), and RIPS Projects Day (workshop, 2016).

Table I-1: Undergraduate Students' Gender and Ethnicity by Program Type (June 1, 2016 - June 10, 2017)							
		Gender		Underrepresented Ethnic Groups			
Program Type	Total Participants	Female	No. Reporting Gender	Amer. Indian	Black	Hispanic	No. Reporting Ethnicity
Workshops	37	18	37	0	2	8	35
Student Research Programs	44	22	44	0	2	8	43
Special Events and Conferences	50	27	50	1	3	28	49
Total	131	67	131	1	7	44	127
Percent of No. Reporting		51.1%		0.8%	5.5%	34.6%	
	All underrepresented ethnic groups:				*52*	*40.94%*	

Table I-2: Undergraduate Students' Citizenship by Program Type (June 1, 2016 to June 10, 2017)			
Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency	percent
Workshops	23	35	66%
Student Research Programs	32	44	73%
Special Events and Conferences	43	47	91%
Total	98	126	78%

J. PROGRAM DESCRIPTION

The programs are listed in chronological order by start date. The list includes all IPAM programs from **June 1, 2016 through June 10, 2017**.

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.

WORKSHOP: Culture Analytics Culminating Workshop, June 5 - 10, 2016

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

The final workshop in the long program, Culture Analytics, 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.

REUNION CONFERENCE: Mathematics of Turbulence Reunion Conference I, June 5 – 10, 2016

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

This was the first reunion conference for participants of the fall 2014 long program "Mathematics of Turbulence." 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.

REUNION CONFERENCE: Materials for Sustainable Energy Reunion Conference II, June 5 - 10, 2016

The reunion conference was organized by the original long program organizing committee. This was the second reunion conference for participants of the fall 2013 long program "Materials for Sustainable Energy." 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.

STUDENT RESEARCH PROGRAM: Research in Industrial Projects for Students (RIPS)-Hong Kong 2016. June 11 - August 12, 2016

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 $3,000. Housing and most meals are also included. (These terms apply to U.S. students recruited by IPAM.)

U.S. citizens are eligible for RIPS-Hong Kong. English is the only language required for participation. The local students, academic mentors and industry mentors will speak English. The Director of the program was Dr. Albert Ku.

Students stay in residence halls and eat most meals in the campus dining halls. The HKUST math department provides technical support and offices, and offers some cultural activities and Cantonese lessons. There are four projects. Projects vary, but all involve some math, statistics, data, and computing.

The beautiful HKUST campus overlooks beautiful Port Shelter on the Clear Water Bay peninsula, several miles east of the city center.

The 2016 sponsors, projects and academic mentors (recruited by HKUST) were:

Company	Project Title	Academic Mentor
AECOM	Flow and Dispersion Patterns by OpenFOAM and FLUENT	Dr. Chi Wai Wu
ePropulsion	Optimization of an Acoustic Communication Protocol for Underwater Wireless Communication	Dr. Haixia Liu
Ant Financial	Forgery Detection in Alipay	Dr. Avery Ching
Huawei	Churn Prediction and Retention Systems	Dr. Meng Wang

STUDENT RESEARCH PROGRAM: Research in Industrial Projects for Students (RIPS) 2016. June 20 - August 19, 2016

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 $3,000. Housing and most meals are also included.

RIPS-LA students will live in residence halls on the UCLA campus and will work at IPAM. We expect to have nine projects. The project sponsors are announced in March. Projects vary, but all involve some math, statistics, data, and computing.

International students, including students attending a university outside the U.S., are eligible to apply for RIPS-LA, as are graduating seniors.

Susana Serna served as RIPS Director. The sponsors and projects in 2016 were:

RIPS Sponsor	*Project*
Aerospace Corp	Space Debris Detection and Characterization using CubeSat Constellations
AMD	Side-Channel Leakage and Countermeasure Characterization with Mutual Information
Arete	DNA Statistics and the Null Hypothesis
CSX	Ballast cleaning scheduling optimization
Google	Ways to improve classifier performance where the training data is labeled by human raters
Gum Gum	Bid Stream Filtering
HRL Laboraties	Automated Tuning of Electrostatically Defined Quantum Dots: Navigating Through High-Dimensional Potential Energy Landscapes
LAPD	Change-point Detection for Police Body-Worn Video
LLNL	Adaptive polynomial expansion method for the numerical solution of the Lenard-Balescu equation

We collected the following comments from students in RIPS2016 on the post-program survey:

- RIPS was exactly what I hoped it would be, and more. It introduced me to what a career in science/math research would be like. Particularly, a career in industry, where the problems aren't always so clearly defined. I learned whole new concepts and techniques, both from my industry mentors, team mates and even other participants in RIPS.

- I enjoyed [the] ability to self-direct research, thought it was very enjoyable and also an excellent learning experience, good preparation for directing our own research or the research of others in a lab. It was interesting to learn how to break down a problem in a group context.

- This program was a great way for me to learn and use mathematics in a real world application. I had a wonderful time learning and applying my knowledge in a non-academic sense. This was such a great learning experience.

- This program boosted my confidence in terms of pursuing a masters and PhD, and a career in mathematics/science. I also improved my presentation and speaking skills immensely.

- This program opened my eyes to the extent of applications of math in industry. This is encouraging to me in possibly pursuing a career outside of academia. I also realize the power of team work. Problems get solved [more] efficiently through sharing ideas and skills.

- Overall, RIPS was the best experience of my life! I will definitely be recommending it to other students.

WORKSHOP: RIPS Projects Day, August 18, 2016

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 2016.
June 27 - August 19, 2016

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

Round-trip travel to Berlin and accommodations in Berlin are included. Students also receive a meal allowance and a stipend. (These terms apply to U.S. participants recruited by IPAM.)

Partner:
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).

Sponsors and Projects:

1. Train Planning – Deutsche Bahn (DB)

Hosting Lab:
The MODAL:RailLab cooperates with DB Fernverkehr to develop an optimization core that helps to operate the Intercity-Express (ICE), Germany's fastest and most prestigious train, in the most efficient way. This is achieved by determining how the ICEs should rotate within Germany and, thereby, reducing the number of empty trips. The software has now been deployed in production at DB Fernverkehr for two years.

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

Project:
You will learn to think about the railway network at DB from a planner's perspective. Making up ICE rotations sounds easy at first, but you will soon find out that a lot of constraints have to be taken into account and do not forget about the size of Germany's rail network! This makes finding and understanding suitable mathematical programming models a difficulty of its own. It will be your daily business to deal with huge data sets. You will write scripts to process the data and extract useful information. At your option you can come up with your own ideas and propose and implement extensions for our optimization core. The past project assignments included to find out how robust optimization methodology can be incorporated in the optimization process and to develop a rotation plan for the situation that a restricted amount of train conductors is available, e.g. in a strike scenario.

2. Large Medical Data Analysis – MODAL AG (MAG)

Hosting Lab:
Changes in cells while they are undergoing transformation from "normal" to malignant cells (e.g. during infections) happen on many biological levels, such as genome, transcriptome, proteome and metabolome. Following the central dogma of molecular biology and its extensions these levels are highly interconnected and depend on each other. Within the MODAL:MedLab, we develop new mathematical methods that allow (1) identification of multivariate disease signatures that describe changes in multiple data-sources and (2) development of multi-level models that embeds these findings into the actual biological context. Both parts combined will eventually lead to a thorough understanding of the modeled process and open up the opportunity to use the respective model for diagnostic purposes for individuals, thus allowing high-throughput classification of biological samples. These techniques can then be adjusted to an individual by using its -omics data and thus allows to derive information about the individual's state, for example, as a diagnostic tool for a certain disease that is captured by the data and the model. All algorithms will be implemented using state-of-the art software frameworks that can cope with the very large data volumes.

Sponsor:
The MODAL AG (MAG) is a ZIB spin-off that works as a bridge between research and industry. MAG offers the students in this project access to real world data and expertise from leading hospitals and companies working in this field. Within the MAG infrastructure, students will have the opportunity to experience creation of industry-strength technology and software solutions.

Project:
Building on state-of-the-art database technology, students will develop new machine-learning techniques to analyze medical massive data sets. First, students will learn the necessary biological foundation needed to successfully complete the project. They will then use data from a large clinical trial to model medical phenomena based on ideas from the areas of compressed sensing, machine learning, and network-of-networks theory.

3. Therapy Planning – 1000shapes GmbH

Hosting Lab
Within the therapy planning group at ZIB we are dealing with a variety of medical data. To tackle the challenges of analyzing an always increasing amount of data and to provide software tools to automatically extract the relevant information out of it, we are investigating model based approaches (statistical shape and appearance models) as well as machine learning techniques (regression, classification, and semi-supervised learning), which can then be used in a number of applications such as scene recognition from photographs, object recognition in images, or automatic diagnosis from medical image data.

Sponsor:
The project is in close collaboration with 1000shapes GmbH, a ZIB spin-off that transfers research in life sciences into products for clinical applications. Within the project, algorithms are to be developed within an existing software framework and tested on clinical image data. The successful applicant will have the opportunity to perform research in medical image computing within the ZIB research group therapy planning while obtaining professional support from 1000shapes in software development and implementing algorithms within existing software frameworks. Within the project, students will have the opportunity to experience medical research in combination with industry-strength software development.

Project:
Building on a large medical image database, students will investigate new machine-learning techniques, i.e. the application of regression forests, to analyze and classify features or disease patterns in medical image data.

SUMMER SCHOOL: Computational Genomics Summer Institute. July 18-22, 2016 (with UCLA computational genomics, NIH grant)

Organizing Committee:
Eleazar Eskin, University of California, Los Angeles, CGSI Director
Russ Caflisch, University of California, Los Angeles, IPAM Director
Eran Halperin, Tel Aviv University
John Novembre, University of Chicago
Ben Raphael, Brown University

Biological sciences have been transformed over the past two decades by the development of technologies capable of performing large-scale measurements of cellular states. In particular, DNA sequencing instruments have undergone an extraordinary increase in efficiency during the past few years that has reduced the time and cost required to sequence billions of bases by several orders of magnitude. This is revolutionizing the scale and potential applications of genomic studies, and creating an enormous need to develop mathematical and computational infrastructures to meet emerging data analysis challenges. To name just a few examples, applications requiring the development of novel mathematical and statistical frameworks include the reconstruction of RNA transcript populations, identifying sequence variations (both single-nucleotide and segmental) and exploring their disease associations, locating the sites of protein-DNA interactions, elucidating population histories, and reconstructing microbial communities that colonize particular hosts or environmental niches. The goal of this long program is to bring together mathematical and computational scientists, sequencing technology developers in both industry and academia, and the biologists who use the instruments for particular research applications. This presents a unique opportunity to foster interactions between these three communities over an extended period of time and advance the mathematical foundations of this exciting field.

The development of high-throughput genomic technology has transformed biomedical sciences and provides limitless potential for developing new treatments for disease. However, analyzing the data generated by these technologies requires tremendous computational resources and significant computational expertise by the researchers.

SUMMER SCHOOL: Putting the Theory Back in Density Functional Theory. August 22 - 26, 2016

Organizing Committee:
Kieron Burke (University of California, Irvine (UCI))
Attila Cangi (Max Planck Institute of Microstructure Physics, Theory)
Hardy Gross (Max Planck Institute of Microstructure Physics)

Last year, at least 30,000 scientific papers reported the results of DFT calculations. Many workshops and schools teach how to run a specific code. The purpose of this school is to teach the theory behind DFT. Lectures will be pedagogical and range from fundamentals (Hohenberg-Kohn theorem) to the latest approximations, and will help connect DFT to other areas of mathematics and theory.

The school is primarily targeted at junior researchers (Ph.D. students and postdocs) who are currently running DFT calculations and/or developing DFT or are interested in learning more about DFT. Internationally renowned experts in DFT will provide a thorough training in the fundamental theory through lectures and pedagogical research talks that connect themes of the lectures to the lecturers' own cutting-edge research. All participants are encouraged to submit an abstract to present a poster, and a limited number will be selected for oral presentation to the entire school.

Support for this summer school includes a grant from the Office of Naval Research.

Here are a few of the anonymous comments from participants, collected through the survey:

- I really like this place. It is a good effort by the center and I hope that I can visit again. It is especially nice that it is a waste-free facility. Staff are very nice.

- I was incredibly impressed and pleased by IPAM and my experience. I would attend another workshop.

LONG PROGRAM: Understanding Many-Particle Systems with Machine Learning
September 12 - December 16, 2016

Organizing Committee:
Alán Aspuru-Guzik (Harvard University)
Gabor Csanyi (University of Cambridge)
Mauro Maggioni (Duke University, Mathematics and Computer Science)
Stéphane Mallat (École Normale Supérieure)
Marina Meila (University of Washington)
Klaus-Robert Müller (Technische Universität Berlin)
Alexandre Tkatchenko (University of Luxembourg, Theory)

Interactions between many constituent particles (bodies) generally give rise to collective or emergent phenomena in matter. Even when the interactions between the particles are well defined and the governing equations of the system are understood (for example the Coulomb interaction between protons and electrons and the Dirac/Schroedinger equation in quantum mechanics), the collective behavior of the system as a whole does not trivially emerge from these equations. Examples of collective behavior are abundant in nature, manifesting themselves at all scales of matter, ranging from atoms to galaxies. Machine learning methods have been used extensively in a wide variety of fields ranging from, for example, the neurosciences, genetics, multimedia search to drug discovery. Machine learning models can be thought of as universal approximators that learn a (possibly very complex) nonlinear mapping between input data (descriptor) and an output signal (observation). It is the goal of this IPAM long program to bring together experts in many particle problems in condensed-matter physics, materials, chemistry, and protein folding, together with experts in mathematics and computer science to synergetically address the problem of tackling emergent behavior and understanding the underlying collective variables in many particle systems.

We conducted an evaluation survey at the end of the program. Here are some anonymous comments from program participants:

- IPAM program overall was a wonderful experience! The synergy created during the program is emerging into to various collaborations and promising future work. Further, I believe the reunion of the IPAM program will positively impact these collaborations between the mathematicians and material scientists. I thank all the organizers for their vision and efforts making this IPAM program a success.

- I was very happy with the program, and it was a pleasure to participate. What I liked most about the program was the fact that the majority of the talks were by non-mathematicians who been exploring the use of relatively new mathematical techniques in [machine] learning on problems of significant practical interest. While the talks presented positive results, most included frank comments about the difficulties and problems that remain in the effective application of machine learning techniques. Many of [the] difficulties are mathematical and/or computational in nature, and have led me (and hopefully a few graduate students) to a large number of interesting mathematical problems to work on. What's particularly valuable about identifying this collection of [problems] is that research on them isn't just "curiosity driven research" whose aim is to increase ones publication list, but research on problems where results can have a significant impact on those applying machine learning.

- As a mathematician, I hugely benefited from communicating with non-mathematicians, both long-term participants and workshop participants.

- Very strong scientific program and exceptional selection of speakers. I learned a lot and initiated several new projects.

- The seminar were a good way to make participants aware of each other work and provided a good environment for discussions. I hope IPAM keep doing this.

- IPAM program provided me with really unique opportunities, otherwise not possible. I started several projects with mathematicians and computer sciences. Several ideas we jointly developed are posit to leapfrog application of ML in chemical sciences.

WORKSHOP: Understanding Many-Particle Systems with Machine Learning Tutorials
Part of the Long Program Understanding Many-Particle Systems with Machine Learning
September 13 - 16, 2016

The organizing committee of the long program is also responsible for the scientific organization of Tutorials.

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

WORKSHOP I: Machine Learning Meets Many-Particle Problems. September 26 - 30, 2016

Organizing Committee:
Alán Aspuru-Guzik (Harvard University)
Klaus-Robert Müller (Technische Universität Berlin)
Alexandre Tkatchenko (Fritz-Haber-Institut der Max-Planck-Gesellschaft, Theory)

This workshop will set the stage and define research directions for the rest of the program. The idea is to achieve a healthy mix of mathematicians, computer scientists, physicists, and chemists and establish common grounds that will enable rational applications of machine learning techniques to many-particle problems. One prominent outcome of this workshop will be the establishment of a common repository of datasets corresponding to different many-particle problems (structures and energies of molecules and materials, protein structures and dynamics, spectroscopic signatures of complex systems, etc.). These datasets can be used to assess the performance of different ML techniques during the IPAM program and beyond.

SPECIAL EVENT: Modern Math Workshop, October 12-13, 2016

Organizing committee:
Hélène Barcelo (Mathematical Sciences Research Institute)
Sujit Ghosh (Statistical and Applied Mathematical Sciences Institute)
Christian Ratsch (Institute for Pure and Applied Mathematics)*
Ulrica Wilson (Institute for Computational and Experimental Research in Mathematics)

*IPAM was the lead institute for the 2016 workshop.

As part of the *Mathematical Sciences Collaborative Diversity Initiatives*, the nine mathematics institutes offer an annual SACNAS pre-conference event, the Modern Math Workshop (MMW). The Modern Math Workshop is intended to encourage minority undergraduates to pursue careers in the mathematical sciences and to assist undergraduates, graduate students and recent PhDs in building their research networks. The Modern Math Workshop is part of the SACNAS National Conference; the 2016 workshop and the conference took place in the Long Beach Convention Center in Long Beach, CA. The Modern Math Workshop consists of a "research session" for graduate students and recent PhDs, and two undergraduate mini-courses, offered concurrently, described below. In addition, there was a keynote lecture by Joseph Teran, professor of mathematics at UCLA, and a reception on Wednesday evening that included information booths for each institute and poster presentations by workshop participants.

Undergraduate Mini-Course 1: Concave Monotone Mappings in Higher Dimensions**,** taught by Selenne Bañuelos (CSU Channel Islands)

In this session, we will motivate the discussion of concave monotone mappings in higher dimension in the context of population dynamics. Concave monotone mappings form the real line to itself receive much attention because of this application. One of the interests in studying these mappings in higher dimensions arises in analyzing multi-patch populations – populations of the same species in adjacent locations. We will take an inquiry-based learning approach to define concavity and monotonicity in higher dimensions. We will also show that these mappings form a semigroup under composition. The semigroup property allows us to discuss periodic mapping systems; in the context of population dynamics – populations that rise and fall over a predictable period of time. Finally, students will apply this knowledge and study the stability of a structured two-stage population model with migration.

Undergraduate Mini-Course 2: Mathematical Modeling in Ecology: Applications of Graph Theory**,** taught by Amanda Ruiz (University of San Diego) and Jennifer Prairie (University of San Diego)

The field of ecology addresses fundamental problems concerning how organisms interact with their environment. Two particularly interesting areas of study include population connectivity and food web dynamics, both of which involve ecological concepts that can be viewed through a mathematical lens. In this workshop, we will explore how applications of graph theory can help us gain insight into these complex interactions to address ecologically relevant problems. We will begin by providing a background in metapopulational and food web theory from an ecological perspective. We will then introduce the basics of graph theory. Finally, students will work in teams to integrate this knowledge and investigate specific questions at the interface of these two topics. For example, how can weighted graphs be used to evaluate the impact of subpopulation extinctions, and how can the effect of individual species on food web dynamics be determined with directed graphs?

Anonymous comments from survey:

- Really love the outcome of the event hosted by IPAM. It has inspired me to continue with my dream to become a mathematician. It helps reinforce my growth mindset to dig deeper into more mathematics given by great mathematicians during and after the workshop.

- I liked that we worked in groups and that there was diversity in the crowd because not all the students were from Mathematics (some of the students had a different background) and that contributed to a different perspective in the examples of problems that we resolved during the mini course.

WORKSHOP II: Collective Variables in Classical Mechanics. October 24 - 28, 2016

Organizing Committee:
Cecilia Clementi (Rice University, Chemistry)
Leslie Greengard (New York University, Mathematics)
Mauro Maggioni (Duke University, Mathematics and Computer Science)

Susan Sinnott (Pennsylvania State University)

Atomistic simulations based on classical mechanics are nowadays routinely employed to investigate the behavior of chemical and biological systems. Large amounts of high-dimensional data can be produced in atomistic simulations (atomic positions, forces, etc.). Often, however, only a few macroscopic observables are recorded during these simulations. Deciding which data to keep, in a principled fashion, and how to best utilize the giant amount of generated data to produce useful results and learn about the important collective variables that determine the macroscopic behavior of proteins and chemical systems are key questions which will be discussed in this workshop.MPSWS2 Image

The simulations are often stochastic or approximated by stochastic systems, and important features of the dynamics include rare events. Designing better adaptive sampling algorithms in these situations, leveraging data from long or short simulations, is often tied to the problem of learning good collective variables. Finally, the dimensionality reduction problems underlying the questions above require a robust quantitative understanding of the geometry of the effective spaces of configurations of a molecule, or of family of molecules in chemical compound space. This will permit better understanding of collective variables and the ability to navigate and explore molecular and chemical compound space. Since robust dimensionality reduction techniques and fast computational methods tend to be multiscale (in space, time, molecular resolution, etc.), a key aspect of the workshop will be to develop a better understanding of the ways in which “multiscale” reasoning can have the greatest impact in the context of molecular simulations.

This workshop will bring together a mix of mathematicians, physicists, chemists, computer scientists, and biologists to address some of the following questions: Is it possible to generate a low-dimensional representation for (a subset of) the chemical compound space (CCS)? What are the appropriate descriptors for different molecular properties in CCS? How can we deal with the permutational space of many-component alloys? How does the choice of descriptors affect the efficiency and faithfulness of a model constructed with Machine Learning (ML) techniques? Are current coarse-graining approaches that represent proteins as collections of functional groups or backbone degrees of freedom optimal in any sense? What are other possibilities? Can ML techniques be trained on long or short molecular dynamics (MD) trajectories and condense these complicated trajectories into a reduced representation? How can accurately determined macroscopic observables from MD simulations be obtained from such reduced (collective) representations?

Anonymous comments from survey:

- IPAM is (now) my favorite focused-workshop venue for maximizing overlap with other speakers and generating productive ideas -- surpassing CECAM and Gordon conferences. Congratulations on running an excellent conference series.

- Some things that are absolutely great: (1) the room - don't change a thing, (2) the staff - always very courteous and professional, (3) the new Luskin Center - fantastic accommodation, (4) the sunshine--all my vitamin D for a year in one brief period.

- I think this workshop is excellent! Sincerely look forward to joining this again in the future!

WORKSHOP III: Collective Variables in Quantum Mechanics. November 14 - 18, 2016

Organizing Committee:
Eric Cances (École Nationale des Ponts-et-Chaussées, Applied Mathematics)
Gabor Csanyi (University of Cambridge)
Stéphane Mallat (École Normale Supérieure)
Noa Marom (Tulane University, Physics and Engineering Physics)
Alexandre Tkatchenko (Fritz-Haber-Institut der Max-Planck-Gesellschaft, Theory)

Many-particle quantum systems can be completely described by N-body wave functions or density matrices. However, such objects are high-dimensional and extremely difficult both to compute and to apprehend with physical intuition, especially for extended systems. In most applications, though, only a tiny part of the information available in many-particle quantum states is really useful. For instance, the requested output of an electronic structure calculation are often simply the effective forces experienced by the atoms of the molecular system. Such quantities could be obtained at a much lower cost using reliable interatomic potentials. Likewise, collective quasiparticle states (molecular or crystalline orbitals, plasmons, phonons, polarons, excitons, etc.) allow one to describe the properties of many-particle quantum systems with lower-dimensional objects, which are easier to visualize and can be computed accurately enough for most physical systems, by means of effective one-particle (Kohn-Sham, TDDFT, GW, …) or two-particle (Bethe-Salpeter equation, …) models. For these reasons, such states play an essential role in condensed matter physics and materials science.

This workshop will bring together a mix of mathematicians, physicists, chemists, computer scientists, and biologists to address some of the following questions: Can machine learning (ML) techniques be used to create ab-initio accurate interatomic potentials? Can they generate quasiparticle states or approximations thereof given only the molecular Hamiltonian as an input and macroscopic observables as an output? On a larger scale and going towards materials design (materials genomics): how can one generate the necessary and sufficient data to use ML approaches to infer the important collective variables ("materials genes", scaling relations, etc.)?

Anonymous comment from the survey:

- As always, an excellent meeting. IPAM probably belongs to the most informative, crosscutting conference series in my academic experience. Thank you so much for putting together these amazing series over all these years!

WORKSHOP IV: Synergies between Machine Learning and Physical Models. December 5 - 9, 2016

Organizing Committee:
Alán Aspuru-Guzik (Harvard University)
Gabor Csanyi (University of Cambridge)
Marina Meila (University of Washington)
Klaus-Robert Müller (Technische Universität Berlin)
Sadas Shankar (Harvard University)

The application of machine learning (ML) to the computer simulation of materials has features that are somewhat uncommon in ML: the data is often free of noise, in principle unlimited amounts of data are available at known unit cost, and there is often considerable freedom in choosing data locations. This calls for the close examination of which ML strategies are best, and what their ultimate limitations are in practice. Can we create ML models of arbitrary accuracy? How can recent advances in on-line or active learning be utilized? What can more classical statistical interpolation methods contribute?

Traditional, non-data-intensive models in the physical sciences are "extrapolative", i.e. the parameters are determined by observing limited data in some domain, and the models are tested in extended or even wholly different domains, and the performance of such models is evaluated according to how well they do in such a situation. In contrast, high dimensional ML models are best at interpolation. What are the best criteria for assessing the quality of such models? Do they only give back what they were "taught"? What new discoveries of structures or processes could ever result from an interpolative ML model?

This workshop will broadly address the reaches and limitations of ML as applied to the modeling of physical systems and highlight examples where physical models can be successfully combined or even derived from ML algorithms.

WORKSHOP: Understanding Many-Particle Systems with Machine Learning Culminating Workshop, December 11-16, 2016

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

The final workshop in the long program, Understanding Many-Particle Systems with Machine Learning, 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.
Anonymous comments from the survey:

- The Lake Arrowhead culminating workshop was great. Scientifically, I very much enjoyed seeing what core participants had done over the past three months, and where they thought things are going. I think this really stimulated a burst of discussion in this last week. The staff were super nice and helpful, and of course the facility itself is amazing. I also very much enjoyed the opportunity to interact with participants of previous IPAM long programs.

- IPAM program overall was a wonderful experience! Specifically, the culminating workshop shed a light on the current challenges in the field of computational materials science and machine learning, and different ways of bridging the gap between these two fields. The synergy created during the program is emerging into to various collaborations and promising future work. Further, I believe the reunion of the IPAM program will positively impact these collaborations between the mathematicians and material scientists. Also, the participants (other than the core participants) of individual workshops could be promising candidates for future events of IPAM, including the reunions. I thank all the organizers for their vision and efforts making this IPAM program a success.

REUNION CONFERENCE: Financial Mathematics Reunion Conference I, December 11-16, 2016

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

This was the first 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.

REUNION CONFERENCE: Combinatorial and Computational Geometry Reunion Conference II, December 11-16, 2016

The reunion conference was organized by the original long program organizing committee. This was the second reunion conference for participants of the spring 2013 long program "Combinatorial and Computational Geometry." It was a timely get-together to continue some of the collaborations that were started during the long program. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations.

WORKSHOP: Turbulent Dissipation, Mixing and Predictability. January 9 – 13, 2017

Organizing Committee:
Jacob Bedrossian (University of Maryland)
Gregory Eyink (Johns Hopkins University)
Yves Le Jan (Université d'Orsay)
Katepalli Sreenivasan (New York University)
László Székelyhidi (Universität Leipzig)

Turbulence is a subtle and multi-faceted phenomenon which touches many related areas and its study is widely considered one of the most important fields in classical physics. Recently, rapid progress has been made in the mathematical community towards understanding Onsager's conjecture and anomalous dissipation. Meanwhile, new ideas have emerged from the turbulence physics community regarding spontaneous stochasticity, or breakdown of uniqueness of Lagrangian particle trajectories. Both of these developments are intimately related to applied

topics, such as large-eddy simulation of turbulent flows, predictability of turbulent flows, and enhanced mixing by turbulence.

Any significant progress towards true understanding requires close, cross-disciplinary collaboration and communication between the different areas involved. This workshop will bring together various communities working on the topics of turbulence, anomalous dissipation, and spontaneous stochasticity in incompressible fluid mechanics at high and infinite Reynolds number. The goal of this workshop is to increase the dialogue between these communities as the various fields are rapidly developing.

WORKSHOP: Beam Dynamics. January 23 - 27, 2017

Organizing Committee:
Rafael de la Llave (Georgia Institute of Technology)
Vadim Kaloshin (University of Maryland)
Young-Kee Kim (University of Chicago)
Amie Wilkinson (University of Chicago)

Particle beams, from heavy ions to electrons and photons, are used to explore matters at the molecular, atomic and subatomic level, and in many industrial and medical applications. Accelerators were invented in the 1930s to provide high-energy particles to investigate the structure of the atomic nucleus. Since then, high-energy accelerators led to the discovery of the fundamental building blocks of the Universe and the exploration of the forces acting between them. From the 1970s, the field of accelerator science widened in scope from elementary particle physics to sciences exploring the structure and dynamics of organic and inorganic aggregates of atoms and molecules through the use of neutrons, synchrotron radiation, and free electron lasers. Approximately 30,000 accelerators are currently used to diagnose and treat cancer and other diseases, improve manufacturing processes, and study energy, environmental and security issues. The operation and future improvement of particle accelerators requires the solutions to challenging mathematical problems related to single particle nonlinear dynamics and collective phenomena in high intensity particle beams interacting with electromagnetic fields and plasmas. These challenges include the effects of linear and nonlinear resonances and KAM dynamics in particle accelerators, regular and chaotic effects in many body systems, collective effects, particle beam instabilities and Landau damping.

The workshop is dedicated to better understand and extend the mathematical methods available to accelerator physicists to make progress in understanding and controlling the physics and technology of these systems.

During this workshop, one of the speakers had a heart attack and was admitted to the emergency room. A participant wrote this comment on his or her survey, in reference to this: "Thanks to the staff for organizing a wonderful and friendly workshop. Everyone involved deserves recognition for handling a very difficult situation with grace."

WORKSHOP: Big Data Meets Computation. January 30 - February 3, 2017

Organizing Committee:
Rick Archibald (Oak Ridge National Laboratory, Mathematics)
Hans-Joachim Bungartz (Technical University Munich (TUM))
Frank Jenko (University of California, Los Angeles (UCLA), Physics and Astronomy)
Stan Osher (Institute for Pure and Applied Mathematics, Mathematics)

In High Performance Computing (HPC), one of the key challenges toward exascale computing is to overcome the communication bottleneck. Data motion tends to clearly limit the overall performance and determine the (enormous) energy consumption of future supercomputers; some even say "flops are for free." Therefore, it is crucial to develop novel ways of efficiently representing, reducing, reconstructing, and transferring huge amounts of data. At the same time, the analysis of large sets of (simulation) data requires sophisticated data analytics, which, in return, turns more and more compute-intense itself and, thus, becomes a major customer for HPC. Hence, computing technology and Big Data technology are intrinsically linked, and latest insights, methods, and algorithms have to be considered jointly within that context. The fusion of HPC and Big Data is a young field with an endless number of applications and huge potential. The present workshop aims at being a catalyst at this frontier and bringing together leading innovators and pioneers from applied mathematics, computer science, and various applications areas.

Anonymous comment from the survey:

- This workshop had a wider range of mathematical topics and application topics than in previous workshops I've attended. I liked this very much, and my thanks to the organizers for putting it together.

WORKSHOP: Emerging Wireless Networks. February 6 - 10, 2017

Organizing Committee:
Francois Baccelli (University of Texas at Austin, Mathematics and Electrical and Computer Engineering)
Suhas Diggavi (University of California, Los Angeles (UCLA), UCLA Electrical Engineering)
Christina Fragouli (University of California, Los Angeles (UCLA))
Shyam Gollakota (University of Washington)
Zhu Han (University of Houston, Dept. of Electrical & Computer Engineering)
Alejandro Ribeiro (University of Pennsylvania)

There is a strong need for more efficient bandwidth use and higher mobile speeds today, given that the global mobile traffic is projected to increase nearly 11-fold between 2013 and 2018. The number of wireless devices has already reached 7 billion, while smart devices that have high computing resources and network connection capabilities increasingly dominate the market. This number is set to increase by an order of magnitude as we enter into the age of Internet-of-things (IoT), where smart sensing and machine-to-machine communication is envisaged to explode in

the coming decade (with applications to smart health, smart environments etc.). All this points to fundamental new challenges which will require insights from mathematics, information theory, computer science as well as economics to resolve.

In order to address these challenges, over the next 5 years, there will be a new wireless standard developed ("5G") which has a target of orders-of-magnitude increase in system capacity. In order to enable this, as well as to deal with the envisaged proliferation of IoT devices, current technologies will be insufficient, and fundamental new ideas need to be developed. This workshop will explore fundamental new ideas in wireless networks and its connections to mathematics. There are several workshops and conferences devoted to wireless systems and implementations, but there are none as far as we know that will connect traditionally disparate areas such as wireless network information theory, applied mathematics, economics and computer science.

The workshop will bring together researchers working on several fundamental aspects which could have an important impact in future wireless networks. The mathematical tools that will be involved include information theoretic and entropy inequalities, coding theory, probabilistic analysis including analysis of (randomized) algorithms, convex optimization, stochastic geometry, random matrices etc.

Anonymous comment from a participant: "Thank you to the IPAM staff for hosting the WN2017 workshop. It went extremely smoothly and I really appreciate the excellent facility that made it very easy to interact with the other participants in a comfortable atmosphere. In addition to the food, lecture room, and break/poster room, I borrowed a guest office one morning to do a thesis defense via videoconference and that was very convenient."

WORKSHOP: Regulatory and Epigenetic Stochasticity in Development and Disease. March 1 - 3, 2017

Organizing Committee:
Adam Arkin (University of California, Berkeley (UC Berkeley))
Andrew Feinberg (Johns Hopkins University)
Don Geman (Johns Hopkins University, Applied Mathematics and Statistics)

Epigenetics refers to information transmitted during cell division other than the DNA sequence per se, and it is the language that distinguishes stem cells from somatic cells, one organ from another and even identical twins from each other. In contrast to the DNA sequence, the epigenome is relatively susceptible to modification by the environment as well as stochastic perturbations over time, adding to phenotypic diversity in the population. Despite its strong ties to the environment, epigenetics has never been well reconciled to evolutionary thinking, and in fact there is now strong evidence against the transmission of so-called "epi-alleles," i.e. epigenetic modifications that pass through the germline.

However, genetic variants that regulate stochastic fluctuation of gene expression and phenotypes in the offspring appear to be transmitted as an epigenetic or even Lamarckian trait. Furthermore,

even the normal process of cellular differentiation from a single cell to a complex organism is not understood well from a mathematical point of view. There is increasingly strong evidence that stem cells are highly heterogeneous and in fact stochasticity is necessary for pluripotency. This process appears to be tightly regulated through the epigenome in development. Moreover, in these biological contexts, "stochasticity" is hardly synonymous with "noise", which often refers to variation which obscures a "true signal" (e.g., measurement error) or which is structural, as in physics (e.g., quantum noise). In contrast, "stochastic regulation" refers to purposeful, programmed variation; the fluctuations are random but there is no true signal to mask.

This workshop will serve as a forum for scientists and engineers with an interest in computational biology to explore the role of stochasticity in regulation, development and evolution, and its epigenetic basis. Just as thinking about stochasticity was transformative in physics and in some areas of biology, it promises to fundamentally transform modern genetics and help to explain phase transitions such as differentiation and cancer.

Anonymous comment from the workshop survey: "An excellent and very productive workshop that maintained an atmosphere encouraging scientific discussions."

WORKSHOP: Gauge Theory and Categorification. March 6 - 10, 2017

Organizing Committee:
Mohammed Abouzaid (Columbia University)
Ciprian Manolescu, Chair (University of California, Los Angeles (UCLA))
Rafe Mazzeo (Stanford University, Mathematics)
Andrew Neitzke (University of Texas at Austin)
Catharina Stroppel (Rheinische Friedrich-Wilhelms-Universität Bonn)

The equations of gauge theory lie at the heart of our understanding of particle physics. The Standard Model, which describes the electromagnetic, weak, and strong forces, is based on the Yang-Mills equations. Starting with the work of Donaldson in the 1980s, gauge theory has also been successfully applied in other areas of pure mathematics, such as low dimensional topology, symplectic geometry, and algebraic geometry.

More recently, Witten proposed a gauge-theoretic interpretation of Khovanov homology, a knot invariant whose origins lie in representation theory. Khovanov homology is a "categorification" of the celebrated Jones polynomial, in the sense that its Euler characteristic recovers this polynomial. At the moment, Khovanov homology is only defined for knots in the three-sphere, but Witten's proposal holds the promise of generalizations to other three-manifolds, and perhaps of producing new invariants of four-manifolds.

This workshop will bring together researchers from several different fields (theoretical physics, mathematical gauge theory, topology, analysis / PDE, representation theory, symplectic geometry, and algebraic geometry), and thus help facilitate connections between these areas. The common focus will be to understand Khovanov homology and related invariants through the lens of gauge theory.

We collected the following anonymous comments from participants:

- All the best people in the field. Outstanding recruitment of speakers.

- The workshop was outstanding in terms of quality of speakers and the lectures given. It was well organized and I found it to be a wonderful experience.

- This workshop gave me a great opportunity to meet with some of the best professors and researchers who are working on, broadly, Mathematical Physics and since I have been learning these topics, the lectures gave me a great motivation to work harder. I liked the mixture of different topics presented, for example, the applications of Gauge Theory to settle other mathematical questions and Prof. Khovanov's lecture on the categorification of Z[1/2]. I became very fond of Prof. Gukov's demonstrations and was amused by Prof. Taube's sense of humor. The workshop was a very thrilling experience for me.

- I really liked this workshop. I am in second year of my Ph.D program and this program turned out to be very useful for me. I learnt a great deal not only from the lecturers but also by discussing with fellow attendees during the breaks. The accommodation at the Luskin Conference Center was excellent and the overall organization was very satisfactory.

LONG PROGRAM: Computational Issues in Oil Field Applications. March 20 - June 9, 2017

Organizing Committee:
Lou Durlofsky (Stanford University, Earth Sciences)
William W. Symes (Rice University)
Mary Wheeler (University of Texas at Austin)

The world is increasingly reliant on unconventional (e.g., shale gas, heavy oil) and deep offshore resources that are difficult and expensive to find and produce. The computational challenges associated with these exploration and production operations are substantial. Specific issues include reliably imaging and characterizing deep subsurface oil and gas reservoirs, accurately simulating flow through these highly heterogeneous systems, and applying these modeling capabilities to quantify uncertainty and optimize field performance. Complications arise from the multiphysics and multiscale character of the wave propagation and fluid flow problems, from the need to perform data assimilation for different properties over a range of scales, and as a result of the challenging model-based optimization problems associated with maximizing reservoir performance.

This program will focus on the key modeling and computational challenges in these areas. Cross-cutting issues and themes will be emphasized throughout. The issues and approaches addressed in this program are directly relevant for other subsurface flow applications such as geological carbon storage and hydrogeological modeling.

Anonymous comments from long program participants:

- You've done a good job providing opportunities that foster meaningful interactions and collaborations.
- I learned a lot, and I think I can apply my experience here with my research in the future.

WORKSHOP: Computational Issues in Oil Field Applications Tutorials. March 21 - 24, 2017

Organizing Committee:
Lou Durlofsky (Stanford University)
William W. Symes (Rice University)
Mary Wheeler (University of Texas at Austin)

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

- Introduction to multiscale modeling
- Introduction to numerical methods for geomechanics and flow
- Data fitting in the presence of uncertainty in data acquisition
- Data driven optimization
- Introduction to uncertainty quantification and reduction

Registration for tutorials is free, to encourage broad participation.

Anonymous comment: "Excellent workshop! Thank you for hosting such a great opportunity to expand my knowledge."

WORKSHOP I: Multiphysics, Multiscale, and Coupled Problems in Subsurface Physics. April 3 - 7, 2017

Organizing Committee:
Yalchin Efendiev (Texas A&M University - College Station, Mathematics)
Tom Hou (California Institute of Technology, Applied and Computational Mathematics)
Knut--Andreas Lie (SINTEF)
Fredrik Saaf (Shell)
Hamdi Tchelepi (Stanford University)
Mary Wheeler (University of Texas at Austin)

In the past decades computing power has made possible simulations of unprecedented sophistication and detail, and allowed the resolution of coupled phenomena that occur on many different spatial and temporal scales. Paradoxically, as computational power increases, we become aware of finer scale effects and the consequent limits of our physical models. Moreover, we are more sensitive to the propagation of errors and uncertainties. Therefore, in spite of vastly

expanded limits on computational power, we will continue into the foreseeable future to be thwarted in our efforts to understand the most complex coupled Multiphysics and multiscale phenomena. To this end, mathematical and computational modeling will remain a key enabling technology that must be developed and exploited.

A primary challenge in the modeling of complex systems is to determine the scale, accuracy, and model complexity that are necessary to achieve acceptable predictive capabilities, and to reflect these requirements in a stable, efficient computational framework. In this workshop we will discuss these problems on several interrelated topics:

- Physics-preserving discretizations leading to numerical models that preserve basic physical principles, such as conservation, on and across appropriate scales.
- Multiscale modeling techniques for handling multiscale systems in both time and space and provide high-fidelity and fine-scale detail by either describing the system by a macromodel based on theoretical or numerical upscaling from a physically correct, but overly detailed model; or by incorporating into the numerical model a reduced physics, coarse-grain approximation.
- Multiphysics couplings of phenomena occurring on multiple temporal and spatial scales. Some algorithms that combine existing codes through software often fail to adequately address the coupling physics as one code may violate basic physical principles assumed to hold by the other code, and other algorithms suffer from issues related to disparate temporal and/or spatial scales between coupled physical processes
- Approximation of continuum and discrete models. Continuum systems may contain discrete components, such as a well or fault in a porous geological formation; and on fine scales, some systems are naturally discrete, such as interacting molecules or biological cells. These systems require special techniques such as microstructure models and network and other techniques for their simulation.
- Additional topics will include estimational and control of errors and mesh generation.

Anonymous comment from a participant: “The workshop provided a unique opportunity for me to present my work to audience from industry. The workshop also provided a platform for me to network and exchange ideas with the experts in the field. It was also an incredibly valuable experience providing ample time and opportunities to meet with peers in a relaxing but in a meantime a very focused environment. Great workshop!”

SPECIAL EVENT: National Meeting of Women in Financial Mathematics. APRIL 27 - 28, 2017

Organizing Committee:
Tanya Beder (SBCC Group, IPAM Trustee)
Xin Guo (University of California, Berkeley (UC Berkeley))
Rosemary Macedo (QS Investors)
Monique Miller (Wilshire Funds Management, IPAM Trustee)
Thaleia Zariphopoulou (University of Texas at Austin, Departments of Mathematics and IROM)

The second national conference of Women in Financial Mathematics (WFM) will provide a dynamic platform to promote and foster networking and collaboration between academics, practitioners, supervisors, and others in the field of financial mathematics. Along with several networking events, this two-day conference will feature several panel discussions covering various topics currently relevant to the finance industry and research talks presenting recent advances in financial mathematics. You can read the panelist and speaker bios here. The conference will be of interest to practitioners, academics, regulators and service providers in financial mathematics. The conference included a poster session on the second day.

Industry Day Panel Topics (April 27, 2017)

- The Here-to-Stay Roles of Big Data and Machine Learning
- The Outlook for Quantitative Investing
- Predictions for Portfolios and the Role of Robo Advisors
- Predictions for FinTech & Asset Management
- New Directions in Financial Mathematics –Risk/Algorithmic Trading/ETFs and Beyond

Academic Day Research Talks (April 28, 2017)

- General Research Directions in Financial Mathematics
- Systemic Risk and Central Clearing Counterparty Design
- Recent Advances in Factional Stochastic Volatility Models
- The Impact of Fintech & Data Science on Financial Institutions: The Need for New Skill sets
- Equilibrium with Transaction Costs
- Portfolio optimization in a short time horizon
- Illiquidity, Credit risk and Merton's model
- Optimal Reward & Mean Field Game of Racing

This conference provides an especially unique networking opportunity for students planning to enter the job market in the coming months. However, for those who cannot attend the event in person, all panels and research talks will be available via Livestream. Access the Livestream of the WFM conference at: livestream.com/IPAM. Remote viewers are highly encouraged to post questions or comments in the Livestream chat window, which will be monitored by a moderator.

Support for The National Meeting of Women in Financial Mathematics includes a donation from SBCC Group, AMD, Wilshire Funds Management, and the UCLA Anderson Master of Financial Engineering (MFE) program.

Anonymous comments from survey:

- It was a high quality conference. A powerhouse full of information and experience. I would recommend it others.

- It was great to meet with other women in the Financial Industry and talk about relevant topics that we are seeing and sharing in. It was also great to have conversations with

some students and give them insights into the changing environment of the financial world.

- The speakers and resources at this conference gave a very clear and innovative insight to what is to come in our economy. The information was broken drown in a manner that all could understand. It was a very exciting conference as it was diversity in perspective. It also confirmed a lot of what was felt and executed within my organization - Technology resources collaborating with financial resources to compete and understand client's demand of lower fees.

WORKSHOP II: Full Waveform Inversion and Velocity Analysis. MAY 1 - 5, 2017

Organizing Committee:
Tariq Alkhalifah (King Abdullah Univ. of Science and Technology (KAUST))
Florence Delprat-Jannaud (IFP)
Sue Minkoff (University of Texas at Dallas)
Mauricio Sacchi (University of Alberta)
William W. Symes (Rice University)
Jean Virieux (Université de Grenoble I (Joseph Fourier))
David Yingst (ION Geophysical)

Geophysical methods provide structural maps of the Earth's subsurface and are used throughout exploration and production to guide the development of petroleum prospects. Of the various geophysical methods, seismology generally provides the most highly resolved spatial information. The processing and interpretation of seismic survey data has undergone a number of revolutions since industrial seismology began in the 1920′s: the most recent is the transition to Full Waveform Inversion, or FWI (model-driven data fitting), using numerical optimization methods and computational wave propagation to drive 3D mechanical models towards fitting observed data. The improvement in clarity and resolution gained from inversion can be stunning, often enough that every major oil and gas company and seismic contractor firm has deployed research groups to develop inversion algorithms, software, and workflows. This technology is still experimental, however, and beset by numerous challenges. This workshop will address several of the most important ones, for example:

- **Inversion Physics:** The physics of seismic waves are complex, encompassing at least anisotropic and anelastic behavior, yet most FWI is based on constant-density acoustics. How much earth structure is missed as a result? What is the importance of going beyond acoustics in FWI, towards realistic wave propagation (attenuation, anisotropy…), and how does one best parametrize and invert multi-mode, anisotropic, and anelastic models? How does one deal with parameter cross-talk in multi-parameter (joint) inversion, often very ill-conditioned problems? What can be done about the orders-of-magnitude cost differential between constant density acoustics and anisotropic viscoelasticity, on top of the "curse of dimensionality?" What numerical techniques deal well with gross scale disparities and nonlinearity in very high dimensions?

- **Resolution and Uncertainty:** Seismic imaging conventionally resolves structure at a fraction of a wavelength. Reservoir intervals are often smaller than that, and earth structure exists and influences seismic response at far sub-wavelength scales. Inversion yields uncertain results for these and many other reasons, such as parameter cross-talk, and this uncertainty can manifest as unreliable inference of earth structure. How can we understand the resolution of FWI, both in the conventional continuum sense (structural resolution limits as function of wavelength) and the way in which it interacts with model description (sampling, reduction, smoothing…) and encodes sub-wavelength and sub-cell earth structure? What is gained/lost from sparsity constraints of various types?
- **Velocity Estimation:** Inversion is a fantastically difficult optimization problem: descent algorithms tend to stall because of serendipitous destructive cancellation between predicted and observed data ("cycle skipping"). Many approaches to overcome the cycle skipping problem have been suggested: an incomplete list might include RWI/MBTT, various types of dataset comparison and misfit design (such as Laplace domain), source extensions (AWI, WRI…), medium extensions (DSO of various flavors…), and optimal transport. Are we anywhere near identifying best practices?
- **Integrating Non-Seismic Data:** Many sources of information about active prospects are nearly always available: structural geology, petrophysics, well logs, flow history, even other geophysical inversions such as passive and active source EM and gravimetry. How should we approach the multi-physics integration of various non-seismic constraints with FWI, combining direct and remote information and inevitably involving different resolution scales?
- **Microseismicity and Complex Sources:** With market forces dictating increased efficiency in unconventional field operations, microseismic FWI should receive serious attention. What can be gained by inversion of microseismic data for unconventional play imaging, and more generally by inversion of complex spatially extended sources?

Anonymous comments from participants:

- One of the best workshops I have attended in terms of maximizing the percentage of talks and discussion that were very interesting to me.

- Cross-disciplinary presentations were particularly useful.

- Really helpful workshop to learn about FWI and meet the main people of the field.

- Kudos to the organizer Bill Symes who managed to get all the best people in the field. This does not happen often.

- I hope that IPAM can hold more workshops like this in upcoming years.

- The workshop was outstanding. It has been the greatest fun I've had in ages, and the most educational experience I've had in at least that long. Continue to get Bill Symes to run the session on waveform inversion - he did a great job.

WORKSHOP III: Data Assimilation, Uncertainty Reduction, and Optimization for Subsurface Flow. MAY 22 - 26, 2017

Organizing Committee:
Lou Durlofsky, Chair (Stanford University)
Eldad Haber, Co-chair (University of British Columbia)
Jan-Dirk Jansen, Co-chair (Delft University of Technology, Geoscience & Engineering)
Albert Reynolds (University of Tulsa)
Xiao-Hui Wu (ExxonMobil)

There are major computational challenges and substantial uncertainties associated with model inversion and performance optimization in oil field applications. As production and (in some cases) 4D seismic and electromagnetic data are collected, there are inevitably discrepancies between the predicted and actual reservoir responses. This drives the need for data assimilation, usually referred to as history matching in petroleum engineering. History matching involves the solution of a computationally demanding, highly ill-conditioned, inverse problem. Key complications that arise are the uncertain nature of the geology (and thus the need to "properly" sample the posterior distribution), combined with the need to retain geological realism in history-matched reservoir descriptions. Additional complexity enters as a result of the unknown rock-physics quantities needed to integrate multiphysics data sets. Computational optimization is also of great importance for oil and gas production, given the complexity of the reservoir flow response and the very high costs associated with large-scale field development. An emerging area is the joint optimization of field development and operation, in which decision variables could include the sequence and type (producer or injector, vertical or horizontal) of wells to be drilled, well locations, and time-varying controls. This problem involves real, integer and categorical variables and is thus a MINLP problem. Additional issues that arise are the need to perform these optimizations under uncertainty (i.e., robustly), and the need to treat multiple, possibly conflicting, objective functions.

This workshop is expected to include discussion of computational procedures addressing the following topics, among others:

- Algorithms for inverse modeling/history matching, including use of production and geophysical data
- Uncertainty quantification/reduction in flow predictions and seismic and electromagnetic inversion
- Optimal design of reservoir surveillance programs
- Optimization of oil and gas field development and operation under uncertainty
- Optimization of unconventional (e.g., shale gas) resource plays and CO2 storage projects
- Multi-objective optimization for oil field problems
- Related/enabling topics such as reduced-order and proxy/surrogate modeling, proxy-based optimization/inversion, multilevel optimization, etc.

- Approaches in other application areas such as hydrology/hydrogeology, basin modeling, weather prediction, etc.

Anonymous comments from participants:

- Excellent overall workshop. The talks were consistently interesting, and the workshop format allowed for the right amount of questions & answers after talks and discussion during breaks.
- In my opinion this workshop was very useful. I look forward to others to come in the future. Good job!
- I really enjoyed the workshop and I really liked the format. In my view, it was a success.

WORKSHOP: Computational Issues in Oil Field Applications Culminating Workshop. June 4 – 9, 2017

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

The final workshop in the long program, Computational Issues in Oil Field Applications, 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.

REUNION CONFERENCE: Traffic Flow Management Reunion Conference I. June 4 – 9, 2017

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

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

REUNION CONFERENCE: Mathematics of Turbulence Reunion Conference II. June 4 – 9, 2017

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

This was the second reunion conference for participants of the fall 2014 long program "Mathematics of Turbulence." 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

IPAM continued partnerships with two- and four-year schools in the Los Angeles area in order to increase the representation of minorities and women in its programs. IPAM invited students at East Los Angeles College, Santa Monica College, and Cal State Northridge to attend our public lectures. IPAM continues to support the UCLA chapter of SACNAS: The outreach coordinator attends quarterly meetings and encourages them to participate in IPAM programs. The chapter used IPAM facilities for a K-12 educational event, their year-end banquet, and occasional other meetings and study sessions.

A representative of IPAM attended the Nebraska Conference for Undergraduate Women in Math (NCUWM) in January to promote RIPS and talk to undergraduate women about opportunities in math. Four RIPS students from the 2016 program also attended and presented their research; IPAM paid for their travel.

IPAM awarded Berland Foundation awards to twelve participants (mostly women) 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.

Other diversity-related activities during this reporting period:

- IPAM advertised its RIPS (undergraduate) program through minority institutions and organizations.
- With the other NSF math institutes, IPAM supported the AWM Mentor Network Program.
- IPAM shared a booth at SACNAS with four other math institutes.
- IPAM sponsored two programs aimed at underrepresented groups: Modern Math Workshop and National Meeting of Women in Financial Mathematics. They are described above.

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. The list excludes IPAM's scientific staff (directors) and members of IPAM's Science Advisory Board, who are listed in section O, Committee Membership.

Name	Institution
Mohammed Abouzaid	Columbia University
Tariq Alkhalifah	King Abdullah Univ. of Science and Technology (KAUST)
Rick Archibald	Oak Ridge National Laboratory
Adam Arkin	University of California, Berkeley (UC Berkeley)

Alán Aspuru-Guzik	Harvard University
Francois Baccelli	University of Texas at Austin
Hélène Barcelo	Mathematical Sciences Research Institute
Tanya Beder	SBCC Group
Jacob Bedrossian	University of Maryland
Hans-Joachim Bungartz	Technical University Munich (TUM)
Kieron Burke	University of California, Irvine (UCI)
Eric Cances	École Nationale des Ponts-et-Chaussées
Attila Cangi	Max Planck Institute of Microstructure Physics
Pierre Cardaliaguet	Université de Paris IX (Paris-Dauphine)
René Carmona	Princeton University
Cecilia Clementi	Rice University
Gabor Csanyi	University of Cambridge
Rafael de la Llave	Georgia Institute of Technology
Florence Delprat-Jannaud	IFP
Suhas Diggavi	University of California, Los Angeles (UCLA)
Charles Doering	University of Michigan
Lou Durlofsky	Stanford University
Yalchin Efendiev	Texas A&M University - College Station
Eleazar Eskin	University of California, Los Angeles (UCLA)
Gregory Eyink	Johns Hopkins University
Andrew Feinberg	Johns Hopkins University
Christina Fragouli	University of California, Los Angeles (UCLA)
Wilfrid Gangbo	University of California, Los Angeles (UCLA)
Don Geman	Johns Hopkins University
Sujit Ghosh	Statistical and Applied Mathematical Sciences Institute (SAMSI)
Shyam Gollakota	University of Washington
Leslie Greengard	New York University
Hardy Gross	Max Planck Institute of Microstructure Physics
Xin Guo	University of California, Berkeley (UC Berkeley)
Eldad Haber	University of British Columbia
Zhu Han	University of Houston
Tom Hou	California Institute of Technology
Jan-Dirk Jansen	Delft University of Technology
Frank Jenko	Max Planck Institute for Plasma Physics and UCLA
Vadim Kaloshin	University of Maryland
Young-Kee Kim	University of Chicago
Yves Le Jan	Université d'Orsay
KnutAndreas Lie	SINTEF
Rosemary Macedo	QS Investors

Mauro Maggioni	Duke University
Stéphane Mallat	École Normale Supérieure
Ciprian Manolescu	University of California, Los Angeles (UCLA)
Noa Marom	Carnegie-Mellon University
Glenn Martyna	IBM Watson Research Center
Rafe Mazzeo	Stanford University
Marina Meila	University of Washington
Monique Miller	Wilshire Funds Management
Sue Minkoff	University of Texas at Dallas
Klaus-Robert Müller	Technische Universität Berlin
Andrew Neitzke	University of Texas at Austin
Albert Reynolds	University of Tulsa
Alejandro Ribeiro	University of Pennsylvania
Fredrik Saaf	Shell
Mauricio Sacchi	University of Alberta
Sadasivan Shankar	Harvard University
Susan Sinnott	Pennsylvania State University
Katepalli Sreenivasan	New York University
Catharina Stroppel	Rheinische Friedrich-Wilhelms-Universität Bonn
William W. Symes	Rice University
László Székelyhidi	Universität Leipzig
Hamdi Tchelepi	Stanford University
Alexandre Tkatchenko	University of Luxembourg
Jean Virieux	Université de Grenoble I (Joseph Fourier)
Mary Wheeler	University of Texas at Austin
Amie Wilkinson	University of Chicago
Ulrica Wilson	Institute for Computational and Experimental Research in Mathematics (ICERM)
Xiao-Hui Wu	ExxonMobil
David Yingst	ION Geophysical
Thaleia Zariphopoulou	University of Texas at Austin

L. PUBLICATIONS LIST

This report includes publications that resulted from winter 2015, spring 2016, and summer 2016 programs, as well as the publications of our Director, Associate Directors, and Director of Special Project from the past year. We asked the participants of Mathematics of Turbulence

(fall 2015), Culture Analytics (spring 2016), and summer research programs (RIPS 2016) to respond to: "Please list up to three publications of the past year (including preprints and technical papers) that were a result of or influenced by your participation at the IPAM program" in an electronic survey. We also ask long program participants for recent publications at the reunion conferences. These publications were entered into the project reports "products" form in Research.gov.

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:

- An Office of Naval Research grant supported IPAM's 2016 summer school "Putting the Theory Back in Density Functional Theory"
- The 2016 Computational Genomics Summer Institute was entirely supported by a grant from the NIH. (IPAM was a cosponsor and did not administer the grant.)
- KI-Net, an NSF research network focused on the development, analysis and computation of novel kinetic descriptions, provided direct participant support for the workshop "Big Data Meets Computation"
- An IRES grant through NSF-OISE supports RIPS-Hong Kong
- Research in Industrial Projects for Students (RIPS) collects sponsorship fees from its corporate sponsors, which covers some of the program expenses
- Los Alamos National Lab supported the 2016 Modern Math Workshop
- SBCC Group, Wilshire Funds Management, and the UCLA Anderson Masters of Financial Engineering program supported the National Meeting of Women in Financial Mathematics with small donations
- A generous gift from AMD supported several programs this year, including RIPS and Women in Financial Math

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, 35 of them held positions in government or military organizations, and 132 worked in industry. 8 of our workshops speakers came from government or military—mostly researchers in the national labs. A total of 59

speakers came from industry; eight of them served as organizers, too. Women in Financial Mathematics had 15 industry speakers, three of which were also organizers. The workshops that were part of the Computational Issues in Oil Field Applications long program also saw a high level of industry participation, employed by companies such as Shell, Chevron, and Exxon.

N. EXTERNAL SUPPORT

In addition to the funding listed in Table N below, IPAM receives substantial in-kind financial support from UCLA. The Director's entire salary and administrative stipend are paid directly by UCLA. The Director of Special Projects is released from two courses at the cost of replacing him by a junior person. IPAM is not charged for the use of its building or for custodial care. The value of these items is considerable. Additionally, senior long-term participants from other universities are usually funded on a teaching replacement-buyout basis, by which they are released from teaching for the cost of hiring a junior person as a replacement. The table shows other funding received from July 1, 2016 through May 31, 2017.

Table N: Other Funding Support

Federal Funding	**Amount**
NSF-IRES: RIPS-Hong Kong	$74,900
Office of Naval Research (Density Functional Theory)	69,863
Sub-total	$144,763
Support from Foundations	
Schwinger Foundation	$375,000
Simons Foundation	192,985
Berland Foundation	11,000
Los Angeles Police Foundation	$4,000
Sub-total	$582,985
University Funding Support	
Dean Physical Sciences	$135,302
Vice Chancellor for Research	135,096
Sub-total	$270,398
Industrial Affiliates and Other Support	
Aerospace Corporation	$50,000
Arete	25,000
CSX Transportation	25,000
Google	25,000
Gum Gum, Inc.	25,000
HRL, Inc.	25,000
Microsoft	10,000
Twitter	25,000
Sub-total	$210,000

Others	
Frontier's Society and Other Contributions	$24,021
Registration Fees	22,529
Los Alamos National Laboratory	6,000
Green Family Foundation Net Investment Income	2,449
Sub-total	$54,999
TOTAL	**$1,263,145**

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, 2016-2017 Membership

Name	Institution	Title
David Balaban	Amgen	Technical Lead
Tanya Beder	SBCC Group Inc.	Chairman & CEO
Tony Chan	HKUST	President
Bill Coughran	Sequoia Capital	Partner
Karina Edmonds	Google	University Relations Lead
Mark Green	UCLA	Professor (Emeritus)
Alfred Hales	CCR West	Director (Retired)
Sallie Keller	Virginia Tech University	Professor and Director
Steven Koonin	New York University	Professor, Director
Alan Lee	AMD Research	Corporate Vice President, Research
Monique Miller	Wilshire Funds Management	Managing Director
Nancy Potok	U.S. Government	Chief Statistician
Ronald Stern	UC Irvine	Dean (Emeritus)
Tatiana Toro	University of Washington	Professor
Leland Wilkinson	H20.ai	Chief Scientist

Jeannette Wing	Microsoft Research	Corporate Vice President

Science Advisory Board, 2016-2017 Membership

Name	Institution	Discipline/Expertise
Alexei Borodin	MIT	Mathematics
Michael Brenner	Harvard	Applied Math and Physics
Brown, Emery	MIT	Neuroscience
Robert Calderbank	Duke University	Director, Information Initiative
Emmanuel Candes	Stanford University	Statistics
Cecilia Clemente	Rice University	Chemistry
Iain Couzin	University of Konstanz	Biology
Cynthia Dwork	Harvard University	Computer Science
Jordan Ellenberg	Univ of Wisconsin	Mathematics
Peter Wilcox Jones	Yale University	Mathematics
Michael Kearns	University of Pennsylvania	Computer Science
Yann LeCun	New York University/Facebook	Computer Science
David Levermore	University of Maryland	Applied Math
Assaf Naor	Princeton	Mathematics
Pablo Parrilo	MIT	Control and Dynamical Systems
Terence Tao	UCLA	Mathematics
Amie Wilkinson	Univ. of Chicago	Mathematics