Institute for Pure and Applied Mathematics, UCLA
Award/Institution #0439872-013151000
Annual Progress Report
November 10, 2008

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EXECUTIVE SUMMARY

IPAM had a productive year. Highlights of IPAM's accomplishments and activities for 2007-2008 include:

- This year's two long programs for 2007-08 were highly successful and well-attended:
  - Search Engines
  - Optimal Transport
- IPAM's 2008 winter workshops continued the tradition of focusing on emerging topics where Mathematics plays an important role:
  - Scientific Computing Applications in Surgical Simulation of Soft Tissues
  - Image Analysis Challenges in Molecular Microscopy
  - Expanders in Pure and Applied Mathematics
  - Graph Cuts and Related Discrete or Continuous Optimization Problems
- IPAM hosted a successful affiliate workshop SAGE (Software for Algebra and Geometry Experimentation) Days 7, and sponsored a program for local community college students "Making the Connection: Mathematics in the Real World"
- IPAM sponsored four reunion conferences for its 2005-2006 long programs
- The first and second of a series of workshops sponsored by the National Geospatial Intelligence Agency, "Advancing the Automation of Image Analysis" were held, and the final workshop will be held in December 2008. Plans for additional interactions with NGA are being planned.
- IPAM continued offering public lectures, featuring distinguished mathematicians and scientists attending IPAM workshops. Court Cutting spoke on virtual surgery and Ewald Weibel spoke on "From the Lung to the Cells' Powerhouses: Symmorphosis in the Design of the Pathway for Oxygen."
- RIPS had 8 projects in summer 2008 and was highly successful. Instead of offering RIPS Beijing, which was impossible due to the Olympics, Microsoft Research Asia sponsored a project in the UCLA version of RIPS. We received 268 applications for 32 positions.
- IPAM's Summer School for 2008 "Mathematics of Brain Imaging" was a great success by all accounts.
- A collaboration with MITACS began, with MITACS sponsoring some Canadian speakers and participants at IPAM's "Mathematics of Brain Imaging," and IPAM sponsoring some American speakers at a MITACS workshop on "Fusion, Mining and Security for Networks." Each program fits into a longer effort at the other institution, e.g. the MITACS workshop dovetails with IPAM's "Internet Multi-Resolution Analysis" long program

- IPAM co-sponsored a reception of the NSF math institutes at SACNAS in Salt Lake City (September 08), and a diversity reception at the Joint Math Meetings in San Diego (Jan. 08).
- Discussions were initiated with the African Mathematics Millenium Science Initiative about a summer school collaboration between AMMSI and IPAM
- IPAM made a successful bid to hold the "Infinite Possibilities Conference" for minority women mathematicians in spring 2010. The proposal includes participation from Vice Provost Rosina Becera's office and from the Departments of Mathematics, Statistics, Biomathematics and Biostatistics.
- Joining IPAM's Science Advisory Board are Yann LeCun, David Levermore and Assaf Naor.
- Peter Jones, Chair of IPAM's Science Advisory Board, was elected to the National Academy of Sciences, and SAB member Terence Tao was elected as a foreign associate.
- Additional 2008 inductees into the NAS who have spoken at IPAM are Steven Boxer, Emily Carter, Kenneth Dill, Thomas Liggett and Peter Zoller.
- 2008 Alfred P. Sloan Fellows with connections to IPAM include Inwon Kim (Geometrically Based Motions, Optimal Transport); Xiole (Shirley) Liu (Sequence Analysis Toward System Biology, Search and Knowledge Building for Biological Datasets); Anna Lysyanskaya (Securing Cyberspace: Applications and Foundations of Cryptography and Computer Security); Mauro Maggioni (Multiscale Geometry and Analysis in High Dimensions, Internet Multi-Resolution Analysis); Ben Weinkove (Geometric Flows: Theory and Computation); and Eric Xing (Social Data Mining and Knowledge Building). Selim Esedoglu (RIPS 2003 and 2004) won an NSF CAREER Award from the Division of Mathematical Sciences.
- 2008 McArthur Prize winner with connections to IPAM include Andrea Ghez (Adaptive Optics, Astronomical Imaging) and Alexei Kitaev (Quantum Computing, Topological Quantum Computing).
- The article "Cryptography: How to Keep Your Secrets Safe," written by IPAM participant Anna Lysyanskaya (Securing Cyberspace), appeared in the August 2008 issue of Scientific American.
- RIPS 2006 student Marcelo Alvisio won a prestigious Gates Cambridge Trust international scholarship for 2008-2009.
- IPAM rolled out a new website in Spring 2008.
- Christian Ratsch, Associate Director, agreed to serve a third year (2008-2009), which will aid in the transition to a new Director.
- Mark Green stepped down as Director July 1, 2008, and was replaced by Russ Caflisch.
- Jichun Li (UNLV, Mathematics) was hired as a second Associate Director starting August 2008.

A. PARTICIPANT LIST

A list of all participants in IPAM programs is provided in electronic form (Excel). The list includes participant lists for programs starting between August 1, 2007 and July 31, 2008. We

chose to include the participants of RIPS 2008, which started in June 2008 but ended after July 31, 2008, as well as the associated RIPS 2008 Projects Day, held on August 15, 2008.

B. FINANCIAL SUPPORT LIST

A list of participant support information is provided in electronic form (Excel). The list includes all funded participants of programs that occurred between August 1, 2007 and July 31, 2008. We chose to include all financial transactions related to RIPS 2008, which started in June 2008 but ended after July 31, 2008.

C. INCOME AND EXPENDITURE REPORT

	A	*B*	*C* *A-B=C*	*D*	*E* *B+D=E*	*F* *A-E=F*
Budget Category	**Appropriation Yrs 1, 2 & 3**	**Actual Expenses as of July 2008**	**Current Balance as of July 2008**	**Projected Expenses as of July 2008**	**Total Expenses as of July 2008**	**Projected Balance as of July 2008**
A. Operations Fund	$5,038,041	$3,739,907	$1,298,133	$173,045	$3,912,952	$1,125,089
B. Participant Cost	$5,195,725	$5,016,903	$178,823	$112,295	$5,129,198	$66,527
3-Year Total Budget	**$10,233,766**	**$8,756,810**	**$1,476,956**	**$285,340**	**$9,042,150**	**$1,191,616**

In the renewed grant, IPAM has received 3 years of funding with a total of $10,233,766. The actual expenditure as of July 31, 2008 is $8,756,810 giving a balance of $1,191,616. We have projected expenditures of $285,340 which will increase total expenditures to $9,042,150 by July 31, 2008. Since we have been using the carry-forward from year 2 of approximately $1,401,825 (combined balance from years 1 & 2) towards our 2007-2008 programs, the budget for the third year of the current grant is partially spent with an anticipated balance as of July 31, 2008 as carry-forward to year 4 in the amount of $1,191,616.

Projected Expenditures up to July 31, 2008

A. The Operational fund (salaries, benefits, equipment, supplies, and travel including overhead) for 3-year budget has appropriation of $5,038,041 with total expenditures of $3,739,907 plus anticipated expenses up to July 31, 2008 of $173,045. This will give us an anticipated carry-forward of $1,125,089 ($730,577 direct cost and $394,512 indirect cost).
B. Participant Cost Category for 3-year budget has appropriation of $5,195,725 with total expenditures of $5,016,903 as of July 31, 2008 plus anticipated expenses of $112,295 by July 31, 2008 with anticipated carry-forward to year 4 of $66,527. The projected carry

forward will partially cover the outstanding expenses for Mathematics in Brain Imaging Summer Workshop and RIPS08.

The combined expenditures of operational fund and participant cost category will result in carry-forward funds of approximately $1,191,616 to be used as follows:

A. To augment operational fund category for salaries, benefits, equipment, supplies, and travel expenses. The overall carry-forward will cover the cost of living and merit increase at the university set rate of 4% for the next 2 years. IPAM has hired a second Associate Director and the salary and benefits will be partially covered from the carry-forward. Part of the carry-forward will also be used for much needed computer system upgrade; supplies and materials; and travel for directors/senior staff. This will sustain and support the growing needs of IPAM's programmatic structure.
B. To augment the participant cost for 2008-2009 programs. There will be additional costs for the increasing number of participants based on the growth trend of participants' applications brought about by continued success of the previous programs. The anticipated carry-forward from the previous years will cover the overall cost of additional programs for the housing and travel costs which have increased by 30-35%. With the growth of the programs and increasing costs, the carry-forward of $66,527 will help sustain the increasing program costs over the next 2 years.

D. POSTDOCTORAL PLACEMENT LIST

IPAM does not appoint postdoctoral fellows so we have no data to report in this section.

E. INSTITUTE DIRECTORS' MEETING REPORT

Meeting of the NSF Math Institute Directors
May 2-3, 2008
Minutes

In attendance:

Doug Arnold	IMA	arnold@ima.umn.edu
Jim Berger	SAMSI	berger@samsi.info
Jean Bourgain	IAS	bourgain@ias.edu
Robert Bryant	MSRI	bryant@msri.org
Russel Caflisch	IPAM	caflisch@math.ucla.edu
Brian Conrey	AIM	conrey@aimath.org
Avner Friedman	MBI	afriedman@mbi.osu.edu
Marty Golubitsky	MBI	mg@mbi.osu.edu
Mark Green	IPAM	mlg@ipam.ucla.edu
David Levermore	Facilitator	lvrmr@math.umd.edu
Tony Nance	MBI	tony@mbi.osu.edu
Fadil Santosa	IMA	santosa@ima.umn.edu

Tony Chan	NSF	tfchan@nsf.gov
Dean Evasius	NSF	devasius@nsf.gov
Joanna Kania-Bartoszynska	NSF	jkaniaba@nsf.gov
Hans Kaper	NSF	hkaper@nsf.gov
Deborah Lockhart	NSF	dlockhar@nsf.gov
Peter March	NSF	pmarch@nsf.gov
Chris Stark	NSF	cstark@nsf.gov

May 2, 2008 (Institute Directors only)

1. Discussions

i. We briefly reviewed the Institutes' role in publicizing CDI to the mathematical sciences community. Once the competition is complete we plan to evaluate the impact of these activities. We will discuss with NSF the usefulness of continuing such activities.

ii. We reviewed the page we received from DMS on a proposed report "Mathematical Sciences 2025". There was general support for the idea, and interest in learning more and discussing it with Peter and other NSF representatives. We feel that the Institutes can help this effort through community forums to gather input and promote discussion.

iii. We discussed the rising cost of air transportation and our reimbursement policies for it.

iv. Herb Clemens reported on the US National Committee for Mathematics and the IMU Developing Countries Strategy Group activities, and led a discussion on institute support for mathematicians in the developing world. Herb offered to help the Institute Directors identify mathematicians and mathematical activities in developing countries.

2. Action Items from May 2nd

i. Technical Committee

- Technical committee should draft a page with links to subscription pages for all the Institutes newsletters, etc. [Mark Green]
- Each year starting with the annual meeting, the chair of the technical committee will be the representative from the institution hosting the next meeting. The chair will report to the MIDs at the next meeting. [Jim Berger]

ii. AWM mentoring network

- The Institutes will continue their financial support of the AWM Mentor Network at roughly $550/year each.

iii. Diversity events/committee

- At each annual meeting, the representative to the Math Institutes Diversity Committee from the institution hosting the meeting will report on the activities of the Diversity Committee over the preceding year. [Jim Berger]
- Changes to the Diversity Committee web page:
  a) The link on the sidebar should be identified with text.
  b) There should be a list of the members (people not institutes) of the Committee. c) The list of member institutes should be identified as such.
  d) There should be links to a diversity page at each member institute, either linked from the list of member institutes or elsewhere on the page. A fortiori every member institute must have such a page.
  e) The link to the 2005 Blackwell-Tapia press release should be replaced by a Blackwell-Tapia page, listing all previous winners, preferably with photos and citations, and links to all past Blackwell-Tapia conferences.
  f) See about adding IAS to the Diversity Committee web page. [Jim Berger]
- Members could help each other with NSF reporting appendices, as needed

iv. Math Institute Website

- Update links to MBI at mathinstitutes.org. [Doug Arnold]
- Add highlight (formerly "nugget") submission schedule to highlight instructions. Send mathinstitutes.org login instruction to all institutes. [Doug Arnold]
- Post MID minutes somewhere in a protected part of mathinstitutes.org [Doug Arnold]

vii. Data Collection for NSF Reporting

- NSF/DMS will send each institute a letter amending their grants to formalize the reporting procedure agreed to at the May 2006 MID meeting.. Brief report due May 1 (to be submitted via FastLane as annual report), full report due in the fall after fiscal year closing." [NSF]

2. Brainstorming

- Investigate possibilities for a joint searchable video archive for the institutes. [Brian Conrey]

May 3, 2008 (NSF included)

** = Action Item from May 3rd

1. Report to NSF

Institute Directors reported on their May 2 meeting and presented the minutes to NSF.

2. Presentation by NSF

NSF Budget Breakdown and Overview
Tony Chan presented a budget breakdown starting at the Directorate level then moving into MPS. The American Competitiveness Initiative (ACI) is driving the budget. MPS is an ACI directorate, and DMS is an ACI division, but Tony had to make a case for the latter status.

Mathematical Sciences 2025
Based on a two-page document prepared by Peter March, there was a discussion on where mathematics should be positioned by 2025. Tony Chan mentioned that NRC may be asked to produce a report on this topic.

"What More Can We Get From The MID Group?"
The MID group sees and thinks about emerging developments in the Mathematical Sciences as well as connections with other fields. Tony Chan mentioned that he would like to take advantage of the directors' knowledge by having them take on a trend-spotting role, and to also include personal opinions.

**MPS/DMS will initiate the request for this voluntary and confidential report.

2007 Committee of Visitors (COV) report revisited
Peter March mentioned that on both 2004 and 2007 the COV wanted better DMS clarity on the two issues of:

- Coverage – Are there areas of math not served?
- Overlap – Are the institutes stepping on each others' toes? Is there coordination?

Addressing this question must also include an answer to the question "How does DMS know?"

**Peter suggested a workshop of stakeholders addressing the above and other questions DMS may have, including "What data do we have (collectively)?

Location and Date of MID 2009: April 17-18, 2009 was approved, hosted by SAMSI.

F. PARTICIPANT SUMMARY

In fiscal year 2007-2008, 2,079 participants enrolled in two long programs, 24 workshops, four reunion conferences, and two summer programs. IPAM actively seeks women and members of underrepresented ethnic groups to participate in its programs as speakers and participants. While most participants choose to report their gender and ethnicity, some choose not to do so. See table F-1.

Table F-1: Total Participants and Underrepresented Groups by Program Type							
				Underrepresented Ethnic Groups			
Program Type	Total Participants	Female	No. Reporting Gender	American Indian	Black	Hispanic	No. Reporting Ethnicity
Long Programs	113	22	112	1	4	6	106
Workshops	1561	287	1508	12	40	103	1400
Summer Programs	319	126	314	6	10	21	290
Reunion Conferences	86	13	83	0	1	2	78
Total	2079	448	2017	19	55	132	1874
Percent of No. Reporting		22.2%		1.0%	2.9%	7.0%	

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

Table F-2: U.S. Citizen and Permanent Residents by Program Type		
Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency
Long Programs	56	113
Workshops	917	1537
Summer Programs	184	317
Reunion Conferences	42	84
Total	1199	2051
Percent of No. Reporting	58.5%	

The majority (90%) of 2007-2008 participants of IPAM programs held academic positions (faculty, postdoc, graduate student, or undergraduate student). The remaining 204 participants held positions in government, military, or industry. The following sections provide summary data for the requested sub-groups: postdocs, graduate students, and undergraduate students.

G. POSTDOCTORAL PROGRAM SUMMARY

IPAM does not offer a postdoctoral program in the usual sense of multi-year positions. However, researchers at the postdoctoral level participate in all IPAM workshops, long programs, and reunion conferences, as well as Graduate Summer School and as faculty mentors in our undergraduate summer program, RIPS.

Table G-1: PostDocs: Total Participants and Underrepresented Groups by Program Type							
				Underrepresented Ethnic Groups			
Program Type	Total Postdoc Participants	Female	No. Reporting Gender	American Indian	Black	Hispanic	No. Reporting Ethnicity
Long Programs	24	5	24	0	0	3	21
Workshops	215	28	208	0	0	9	183
Summer Programs	42	20	40	1	1	4	38
Reunion Conferences	23	5	22	0	0	0	20
Total	304	58	294	1	1	16	262
Percent of No. Reporting		19.7%		0.4%	0.4%	6.1%	

Table G-2: PostDocs: U.S. Citizen and Permanent Residents by Program Type		
Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency
Long Programs	8	24
Workshops	97	213
Summer Programs	22	40
Reunion Conferences	6	23
Total	133	300
Percent of No. Reporting	44.3%	

Here is a comment we received this year from past postdoctoral core participants in IPAM Long Programs:

Yannet Interian (Berkeley) SE2007 “Before IPAM I was not involved in data mining and search engine type of research. Currently I am an analyst at Google. It would have been much more difficult to find this job without going to the semester on ‘Mathematics of Knowledge and Search Engines’.”

H. GRADUATE STUDENT PROGRAM SUMMARY

Graduate Students may participate in any IPAM program, including long programs, and a few serve as faculty mentors in our undergraduate summer program. 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 Student Participants: Underrepresented Groups by Program Type							
				Underrepresented Ethnic Groups			
Program Type	Total Grad Student Participants	Female	No. Reporting Gender	American Indian	Black	Hispanic	No. Reporting Ethnicity
Long Programs	27	8	27	1	2	0	27
Workshops	392	98	383	7	10	29	356
Summer Programs	141	68	139	4	3	10	128
Reunion Conferences	12	2	12	0	1	0	11
Total	572	176	561	12	16	39	522
Percent of No. Reporting		31.4%		2.3%	3.1%	7.5%	

Table H-2: Graduate Students: U.S. Citizen and Permanent Residents by Program Type		
Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency
Long Programs	8	27
Workshops	128	390
Summer Programs	66	141
Reunion Conferences	6	12
Total	208	570
Percent of No. Reporting	36.5%	

IPAM's two-week Summer School "Mathematics in Brain Imaging," held in July 2008, attracted over 200 applications for support, and had 209 attendees excluding speakers. Forty-two graduate students received funding and 139 graduate students attended the program.

Below you will find some comments from graduate student participants of IPAM programs and some of their self-reported collaborations:

Kai-min Chang (Carnegie-Mellon, Language Technologies Institute) GSS2007: "Collaboration with Dr. Charles Kemp. I plan to have him on my thesis committee."

"I participated in the graduate summer school Probabilistic Models of Cognition: The Mathematics of Mind. The summer school has a profound impact in my research direction as I plan to propose my thesis work in this area."

Vipul Goyal (UCLA, CS) SC2006: "IPAM has significantly affected my career and research direction. When IPAM started, I was beginning my second year as a PhD student and was just starting to do research. The talks at IPAM were really helpful for me to get an idea of the various interesting problems people were working on. I came to know about the big results and the big open problems. When I finished IPAM, I already had a stack of problems (which I thought were interesting) to work on. Overall I think the knowledge and ideas I got during one quarter at IPAM could easily be equated to at least one year of regular PhD studies."

Christoph Haselwandter (MIT, Physics) NANO2003, MA2005: “My involvement with IPAM very much helped me in broadening my research outlook. One of the major strands of my research concerns the systematic coarse-graining of atomistic surface processes, connecting atomistic and continuum descriptions of morphological evolution. Traditionally, however, atomistic and coarse-grained (continuum) properties of surfaces are investigated by separate communities of researchers. The informal and friendly environment provided by IPAM has allowed me to learn about the latest developments in both of these communities. Moreover, thanks to the very interdisciplinary nature of IPAM, I started, during my time at IPAM, to become interested in physics-type approaches to biological problems. Most of my current research is concerned with statistical physics in biology. Thus, my involvement with IPAM had a profound and lasting effect on my career and research direction.”

Yingying Huang (Thermo Electron) PROT2004: “The opportunity to meet Tseng and Yuan, and worked together as a team towards a common goal during IPAM's proteomics program in 2004 was definitely one of the highlights of my PhD study. The environment that IPAM provided was excellent to foster collaborations like this. The time I spent to participate the IPAM program was the most enjoyable and productive period during my graduate study.”

Frank Jäkel (Max-Planck-Institut für Biologische Kybernetik) GSS2007: “I met my future post-doc advisor. I will do a post-doc in the area of the IPAM GSS.”

Dan Kushnir (Weizmann Institute of Science) MGA2004: “I will be joining next year Yale Math dept. for a postdoc position. I will work there at Prof. R. Coifman group. This possibility emerged during my stay at IPAM and my acquaintance with the members of the group and their work.”

Helen Lei (UCLA) RS2007, OT2008: “I was in residence at IPAM during the Random Shapes program and there I met Ilia Binder and together with him and Lincoln Chayes we completed the proof of convergence to SLE_6 for a percolation model which Lincoln and I worked on previously. Our collaboration with Ilia has been very fruitful indeed: We have recently started another project on conformal invariance and we hope there will be many more to come!” “Most importantly, Random Shapes happened at an early but very critical time in my career and it was truly instrumental in sealing my decision to become an academic.”

Paul Macklin (UCI) CM2006: “Many of the contacts I met have been valuable in sharing knowledge, and some led to post-doc offers. IPAM helped me decide to focus my research on computational and predictive oncology. My discussions with other IPAM participants strengthened my conviction that tissue modeling needs to be improved for cancer study. Also, my interactions with several participants helped me to decide to do a post-doc at a medical school on joint biological, medical, mathematical, and computational research -- which I had not previously considered.”

Silvina Matysiak (Rice, Chemistry and Biochemistry) MA2005: “My residency at IPAM steered my career a lot. My interest in developing multiscale techniques for biophysics started there. Right now I am doing my post-doc and I am involved in a multiscale project that involves people

from different areas like material science, mathematics, chemistry. My stay at IPAM helped me in learning the languages and problems from other disciplines."

I. UNDERGRADUATE STUDENT PROGRAM SUMMARY

Undergraduate students participate in our summer program, Research in Industrial Projects for Students (RIPS), and the one-day workshop "Making the Connection: Math in the Real World." RIPS Projects Day is listed as a separate event, as we invited undergraduate students who were not part of the RIPS program, in order to expose them to industrial research and encourage them to apply to RIPS in the future.

Table I-1: Undergraduate Participants: Underrepresented Groups by Program Type

Program Type	Total Grad Student Participants	Female	No. Reporting Gender	Underrepresented Ethnic Groups			No. Reporting Ethnicity
				American Indian	Black	Hispanic	
Workshops	93	36	93	2	7	27	90
Summer Programs	32	15	32	0	4	2	30
Total	125	51	125	2	11	29	120
Percent of No. Reporting		40.8%		1.7%	9.2%	24.2%	

Table I-2: Undergraduate Students: U.S. Citizen and Permanent Residents

Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency
Workshops	74	91
Summer Programs	21	32
Total	95	123
Percent of No. Reporting	77.2%	

This year, there were 267 applicants for RIPS, from which 32 were chosen. We had another successful year recruiting women and minority students to RIPS. In addition, the "Math in the Real World" workshop attracted students from across the ethnically diverse Los Angeles area, primarily from community colleges. Some of the same students came to RIPS Projects Day.

A detailed description of each program as well as comments from participants is available in section J of this report.

J. PROGRAM DESCRIPTION

The programs are listed in chronological order by start date. The list includes all IPAM programs from August 2007 through July 2008 (also including RIPS2008 Projects Day, which was held on August 15, 2008 and was associated with the summer program RIPS).

Please note that two of IPAM's workshops in 2007-2008 featured **public lectures**. IPAM asked a workshop speaker with a national reputation to speak on a topic of broad interest to an audience that included non-scientists. The lectures were held in a 200-seat auditorium and were publicized widely. The 2007-2008 public lectures are included in the description of the relevant workshops.

Long Program: Mathematics of Knowledge and Search Engines
September 10 - December 14, 2007

Organizing Committee: Ronald Coifman (Yale University), Yuval Kluger (New York University), Yann LeCun (New York University), Vladimir Rokhlin (Yale University), Karin Verspoor (Los Alamos National Laboratory)

The rise of the search engine as a major tool for searches on the internet has spawned a large and growing industry that has changed modern commerce, education, and the study of scientific, financial, and social data bases. The underpinnings of these search engines are mathematical algorithms which are well adapted to large and rapid computations, mainly from linear algebra. While the impact of this industry has been enormous, there is a parallel development in the applications of these methods to other related problems concerning the extraction of knowledge from large databases. This IPAM long program was devoted to new mathematics and methodologies of knowledge engines: the mathematical procedures used to extract knowledge from large databases. While this includes topics related to search engines it is mainly devoted to the more general problem of finding features in a database or using defined features to search within a database. This program was relevant to a large number of scientific fields, including pure and applied mathematics, statistics, bioinformatics, and engineering, with connections to finance, the social sciences, and the humanities. Some of the topics investigated include the following:

1. One set of problems consists of searching a data set that is presented as either a graph (perhaps with weighted edges) or a set of points in Euclidean space, perhaps of very high dimension. Many of the presently used algorithms for search engines use some variant of spectral graph theory, where one uses eigenfunctions of a Laplace operator (or some related object) to start searching. An exciting development is the related idea of Diffusion Geometry, where one has a given set in Euclidean space. While some of these ideas appear in a variety of contexts of data analysis, such as spectral graph theory, manifold learning, nonlinear principal components and kernel methods, one can augment these approaches by showing that the diffusion inference distances are key intrinsic geometric quantities linking spectral theory of the Markov process (Laplace operator or Kernels) to the corresponding "geometry of information". It has recently been shown that one explanation for the robustness of such algorithms is that on domains in Euclidean space of dimension d with volume bounded by one (or manifolds with the correct assumption on curvature bounds), there are at any point in the domain d eigenfunctions for Laplacian (Dirichlet or Neumann) that not only provide local coordinates on B(x, e distance(x, boundary)) but map that ball to (approximately) a ball of radius one. In other words the

eigenfunctions play a role similar to the classical Riemann Mapping Function of complex analysis. Another area is to use various PDE's to define an initial diffusion, where the PDE could vary depending on location. Another area of interest here is the preprocessing stage, which requires recent advances (e.g. the work of Assaf Naor) on embeddings of metric spaces into Euclidean space.

2. The problems of numerical linear algebra that arise include computations of eigenfunctions and eigenvalues (or some analogue when one is not dealing with a Laplace operator), and squaring of matrices. An overriding theme is how to build sparse approximating matrices while respecting the appropriate features. This means that all problems are much more severe than simply approximating in the operator norm. One methodology, presently under intensive development, is to adapt multiscale techniques related to the work of Beylkin, Coifman, Rokhlin. It turns out that for many of these numerical issues a goal is to find the appropriate scales defined by a matrix, often in a coordinate system given by a nonlinear change of coordinates.
3. A third important area is to develop methodologies for steerable searches ("Dynamic Navigation"). In a certain sense this can be seen as the unifying goal of the entire area. This is of outsized importance in the world of commerce, where one has already seen a profusion of specialized search engines, but the next step is to allow searches which are more flexible in the sense that the goal can be changed on the fly.
4. An evolving area of search is developing effective similarity measures for different types of data, particularly data that is unstructured or which has a non-traditional type of structure. Some examples are images, music, video, patient databases.

Tutorials for Mathematics of Knowledge and Search Engines
September 11 - 20, 2007

Organizing Committee: Ronald Coifman (Yale University), Yuval Kluger (New York University), Yann LeCun (New York University), Vladimir Rokhlin (Yale University), Karin Verspoor (Los Alamos National Laboratory)

We offered tutorials in the first two weeks of the program, to provide an introduction to the relevant problems as well as to the relevant concepts from mathematics, computer science and applications. The goal was to familiarize participants with the issues and techniques involved in search and knowledge building and to create a common language among researchers coming from different fields.

Workshop I: Dynamic Searches and Knowledge Building
October 1 - 5, 2007

Organizing Committee: Karin Verspoor, Chair (Los Alamos National Laboratory), Jennifer Chu-Carroll (IBM Watson Research Center), Ronald Coifman (Yale University), Carey Priebe (Johns Hopkins University, Center for Imaging Science/Applied Mathematics and Statistics)

The workshop explored the interactions between search and knowledge, and more specifically looked at how knowledge might be captured by searching through a data space, or how existing or acquired knowledge – about a user, a domain, or the world – can be used to improve the search for information. Topics included:

- Natural Language Question Answering
- User-tailored search
- Textual entailment
- Knowledge Discovery and Data Mining
- Analysis and organization of search results
- Measures of document or semantic similarity
- Multi-media data mining and semantic annotation, including images, video and audio
- Applications integrating search and knowledge (e.g. biomedicine, customer relationship management)

Several of the talks (Ferrucci, Harabagiu, Webber) were on the topic of Question Answering, i.e. using natural language processing (NLP) techniques in the context of search to hone in on specific answers to questions rather than simply retrieving documents. Some of the talks (e.g. Eliassi-Rad, Meiss, Verspoor) explored how to exploit semantic structures such as ontologies or social networks to assist in data analysis and prediction. There were talks exploring mathematical or NLP techniques for hierarchy induction from data (Coifman, Jones, Maggioni, Maldovan), methods for and issues in constructing knowledge resources (Hovy, Pasca), and algorithms for learning models capturing knowledge (Blei, Dolan, El-Yaniv). Other talks discussed search more explicitly (Davis, Lin, Shatkay), with some focusing on user needs and user models in search (Kelly, Thomas) and others looking at computational issues in data structures for search (Manasse).

On Thursday afternoon there was a panel discussion which was kicked off with the open-ended question of how to get the various communities represented in the room (applied mathematicians, computer scientists, computational linguists) to better collaborate. Panelists included David Blei, Tina Eliassi-Rad, Peter Jones, Mauro Maggioni, and Bonnie Webber though there was significant interaction from the broader group.

Workshops II: Numerical Tools and Fast Algorithms for Massive Data Mining, Search Engines and Applications
October 22 - 26, 2007

Organizing Committee: Yann LeCun (New York University), Ming Gu(University of California, Berkeley) , Piotr Indyk (Massachusetts Institute of Technology), Vladimir Rokhlin (Yale University), Sam Roweis (University of Toronto), and Andrew Zisserman (University of Oxford)

The present era of science can be said to have begun with the appearance of computers and large data sets. For more than a half century the tools of numerical and statistical analysis have required repeated honing in the attempt to keep up with the explosion of data and information generated in our technological world. The next step in evolution has been the rise of massive networks (e.g. the internet and world wide web) in which the content is largely unstructured.

Increasingly, large data sets are no longer restricted to classical scientific domains, but arise in virtually all fields, including finance, economics, arts and entertainment, social networks, law, and the humanities.

What is now beginning to emerge is a new generation of algorithms that can automatically extract knowledge from massive streams of unstructured data, including images, video, audio, and text. A common feature of these algorithms is that they are scalable and robust.
This workshop brought together experts from several fields of applied mathematics and computer science, including researchers in large-scale numerical methods, optimization, computer vision, natural language processing, and machine learning. The participants described and discussed advances in the following topics:

- Dimensionality reduction, manifold learning and approximation
- New approaches to density estimation and unsupervised learning for very large, high-dimensional datasets
- New approaches to high-dimensional, non-convex optimization
- Automatic feature extraction for image and video content analysis
- Learning feature hierarchies
- Deterministic and randomized algorithms for nearest neighbor search
- Deterministic and randomized algorithms for matrix approximation
- High precision randomized algorithms of linear algebra
- On-line algorithms for statistical estimation
- Fast kernel methods
- Interior point methods
- Analysis of dense matrices
- Fast algorithms for SVD solvers
- Algorithms for l0 and l1 approximation
- Band-limited functions on data sets
- Stochastic gradient methods

IPAM Workshop: **Cyber-Enabled Discovery and Innovation: Knowledge Extraction**
October 29, 2007

Organizing Committee: Mark Green, Stanley Osher

The NSF introduced major new initiative in September 2007 called “Cyber-enabled Discovery and Innovation.” This began as a $50 million dollar program the first year, and will grow over the next 5 years into a $250 million program.

The IPAM workshop informed the scientific community about the CDI program, with the aim of eliciting strong proposals involving mathematical scientists. This workshop focused on the “knowledge extraction” aspect of the CDI program.

Outcomes of the CDI Workshop:

The list of CDI awards from 2008 (22 awards from the math division and 72 awards in total) included a significant number of PIs (4) and co-PIs (1) who attended IPAM's CDI Workshop, including Oscar Bruno, Stan Osher (co-PI with YY Lin), Mauro Maggioni, Konstantin Mischaikow from DMS and Cecilia Clementi from Chemistry.

Many other CDI PIs have participated in other IPAM programs: Peter Plechac (core participant), Ananth Grama (organizer), Bud Mishra (speaker), Tom Mitchell (speaker), Markos Katsoulakis (organizer), Lou Kondic (speaker), Dion Vlachos (speaker), Mary Wheeler (speaker), Bin Yu (speaker), Avi Wigderson (organizer), Shankar Subramaniam (speaker), Mohammed Zaki (speaker) and Corey O'Hern (sent a student or postdoc to Random Shapes).

***Affiliate Workshop*: Advancing the Automation of Image Analysis Workshop I**
October 30 - November 1, 2007

Organizing Committee: Robert Rand (NGA), Paul Salamanowicz (NGA)

This is the first of a series of meetings hosted by IPAM with the scientific participation of the National Geospatial Intelligence Agency (NGA). The goal of the workshops is to facilitate technology issues of interest to NGA by bringing together a targeted group of researchers under contract from NGA together with renowned experts in the areas of image analysis and data visualization, with a view toward aiding NGA in developing its national research agenda in these areas and in making researchers who are capable of making major contributions to NGA's program aware of the scientific and mathematical issues on which NGA wants to see further advances.

In the first workshop, NGA presented an overview of the analysis tasks and data types of interest, such as image registration, target recognition, and feature recognition, as well as the higher-level tasks which currently constitute bottlenecks. Key technologies and processes were identified and made available to participants in advance of the meeting. The meeting was structured around short presentations of existing techniques, with significant time devoted to discussion and brainstorming. After explaining the problems that are important to its mission, the NGA will make available to participants some sample data to work on to give a proof-of-concept of their algorithms and techniques.

Comments from participants in "Automation of Image Analysis Workshop I" are grouped with those from "Automation of Image Analysis Workshop II."

***Workshop III:* Social Data Mining and Knowledge Building**
November 5 - 9, 2007

Organizing Committee: Peter Jones, Chair (Yale University, Mathematics), Johan Bollen (Los Alamos National Laboratory), Ronald Coifman (Yale University), Andrew McCallum

(University of Massachusetts Amherst, Computer Science), Karin Verspoor (Los Alamos National Laboratory, CCS-3)

Social Data Mining is a fast-growing and exciting area of inquiry, in which connections among and interactions between individuals are analyzed to understand innovation, collective decision making, and problem solving, and how the structure of organizations and social networks impacts these processes. Analysis of such inherently relational datasets is currently being applied in e-commerce to drive recommendation systems, in bibliometrics to describe patterns of publication and determine the influence of specific individuals, in security environments to understand the structure of terrorist or gang networks, and numerous other areas. This workshop brought together researchers in mathematics, computer science, and the social sciences to explore the following topics:

- collective decision making
- social network analysis
- social mapping and bibliometrics
- the role of information visualization in understanding social networks
- the application of graph-theoretical analysis to social networks
- data representation strategies, e.g. the Semantic Web

Workshop IV: **Search and Knowledge Building for Biological Datasets**
November 26 - 30, 2007

Organizing Committee: Yuval Kluger, Chair (New York University), Xiaole Liu (Dana-Farber Cancer Institute, Biostatistics), Itsik Pe'er (Columbia University, Computer Science), Gustavo Stolovitzky (IBM Thomas J. Watson Research Center, IBM Computational Biology Center), Olga Troyanskaya (Princeton University).

The development of new bio-technologies that probe previously unexplored aspects of biological systems has changed the world of biological research radically within the last 10 years. The nature of the data of this rapidly changing biology has created a fertile ground for quantitative scientists. Issues of appropriate strategies for search, what to search for, and how to turn massive quantities of biological data into useful knowledge have moved to the forefront. Contributions from diverse areas such as combinatorics, graph and network theory, differential equations, machine learning, data mining, statistics and statistical physics have been used to create more powerful information search and knowledge management.

This interesting blend of fields has created a tower of Babel out of which a communication currency has yet to emerge. This workshop brought together quantitatively oriented researchers addressing these issues in their quest to answer important biological questions, and provided a forum for researchers with quite different perspectives and interests to listen to each other in an atmosphere that encourages the cross-fertilization of ideas and mutual interest in the ways other quantitative researchers are thinking about other biological problems.

Culminating Workshop at Lake Arrowhead for Mathematics of Knowledge and Search Engines
December 9 - 14, 2007

Organizing Committee: Ronald Coifman (Yale University), Yuval Kluger (New York University), Yann LeCun (New York University), Vladimir Rokhlin (Yale University), Karin Verspoor (Los Alamos National Laboratory)

This final workshop at Lake Arrowhead 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.

Provided below are some comments from participants in the Search Engines long program and related workshops, and some of their self-reported collaborations:

Leon Bottou (NEC Research Institute): "The quality of the workshop I attended (SEWS2) was extremely high. It is always a positive experience to benefit from such a concentration of good presentations and top notch expertise."

Kevin Boyack (SciTech Strategies, Inc.): "I started a collaboration with Johan Bollen of LANL as a result of our meeting at IPAM."

Michael Kurtz (Harvard-Smithsonian Center for Astrophysics): "As an astronomer and leader of a digital library, I rarely get to interact with leaders in the statistical disciplines relevant for the DL. I did do this at IPAM."

Rauf Malick (Karachi, CS) SE2007: "I had chance to communicate several researchers during my stay at IPAM. My collaborative work initiated with Professor Matteo Pilligrini, Department of Molecular, Cell, and Development Biology, UCLA. We agreed to work at Gene Regulatory Networks and their Mathematical models."

"Participation in IPAM is simply the best for me as a graduate student. I learned a lot during my stay at IPAM, especially the last workshop regarding Biological Data Sets opened several dimensions of research work. In short, it's a great experience and I like to thanks all of the administrative agencies, who supported this interdisciplinary program. Administrative support and academic support were excellent and an excellent opportunity for a budding scientist."

Naoki Saito (UC Davis) MG2004, SE2007, LE2009: "Linh Lieu, my current postdoc, came to UC Davis thanks to my interaction with her advisor Luminita Vese through IPAM activities."

"Participating in the IPAM programs was decisive for shaping my current research projects. In particular, my project on Laplacian eigenfunctions was largely influenced by the workshop on Multiscale structures in the analysis of high-dimensional data back in October 2004 that I organized as a chair along with my participation in the Mathematics of Knowledge and Search Engines workshop of fall 2007."

Ruslan Salakhutdinov (Toronto, CS) GSS2007, SE2007: “IPAM had positively affected my research career. I got to meet many top researchers and exchange some of my ideas with them, which was very important to me. For example, once I finish my PhD, I planned to do a postdoc or get a research scientist position. During one of my invited talks, I got to meet people from MIT and Microsoft, and I basically received unofficial offers -- thanks to IPAM.”

Timothy Tangherlini (UCLA, Scandinavian Section) SE2007: “My involvement with IPAM has allowed me to significantly deepen my understanding of what may be possible in computation in regards to humanities research. In particular, the seminar has allowed me to embark on a series of experiments that I believe may lead to the development of a computational folkloristics that weds advances in natural language processing, machine learning, and social networks, along with GIS, into an integrated approach to large, heterogeneous humanities collections (largely not in English). It would be hard to express my excitement with these new vistas for my research. Since I am already a professor at a research university, I doubt much future change in my actual career, although I do expect the work deriving from my participation in IPAM will have a quite positive influence on my ability to work in a truly interdisciplinary fashion in the future.”

Nicolae Tecu (Yale) SE2007: “While I am a fairly pure mathematician, the programs at IPAM have given me an idea of how my knowledge could be useful for more practical problems.”

Jim Thomas (Battelle Pacific Northwest Laboratories) SE2007: “IPAM was a major step in developing a new program now funded by NSF in visual analytics. IPAM was a great forum to start the discussion about the applied mathematical foundations that are not the centerpiece for FODAVA, the NSF program on the Foundations of Data and Visual Analytics. This will affect hundreds of faculty and students with new opportunities. I would like to thanks IPAM on behalf of the National Visualization and Analytics Center.”

Oksana Yakhnenko (Iowa State, CS) SE2007: “SEWS II workshop was an amazing resource. I am interested in modeling and analyzing multi-modal data (data of different sources, such as text and images) and a lot of talks at SEWS II were on learning and analyzing image data, so I learned of state-of-the art image representation techniques, which I currently use in my research.”

Reunion Conference: Grand Challenge Problems in Computational Astrophysics December 9 - 14, 2007

Organizing Committee: Christian Klingenberg (Bayerische-Julius-Maximilians-Universität Würzburg), Mark Morris (UCLA), Harold Yorke (Jet Propulsion Lab)

This was the second reunion conference for participants of the spring 2005 long program “Grand Challenge Problems in Computational Astrophysics.” It was a timely get-together to continue some of the collaborations that were started during the long program and at the first reunion.

An example of such an interdisciplinary interaction is given by a group made up of a solar physicist (Michael Knölker, director HAO, Boulder), a computational physicist (Matthias

Rempel, HAO), a computational mathematician (Knut Waagan, HAO) and an applied mathematician (Christian Klingenberg, Wurzburg Univ., Germany). The common goal was to move towards a self consistent modeling of coronal eruptions. Recent observations call for newer and better models than what exists today.

Here physical insight at what are the relevant physical phenomena have to join forces with numerical methodologies which are either available or which are possible to develop within a reasonable time frame. A major issue is on how to deal with widely disparate scales intrinsic in the problem. In lengthy discussions at Lake Arrowhead the relevant issues came into focus for the participants of this group giving rise to further cooperation.

***Reunion Conference*: Cells and Materials: At the Interface between Mathematics, Biology and Engineering**
December 9 - 14, 2007

Organizer: Tom Chou (UCLA)

This conference was a reunion meeting of the long program "Cells and Materials: At the Interface between Mathematics, Biology and Engineering." This long program (March 13 - June 16, 2006) intended to bring together scientists studying aspects of cellular organization and mechanics. The four workshops covered Membrane protein science and engineering, microfluidic flows, angiogenesis/morphogenesis, and systems biology. Although the reunion was most heavily attended by researchers in the membrane protein science area, all program areas were represented. The quality of the research presented was high. Eleven out of the 14 presentations were of new research performed since the time of the main program, and were not yet published. In particular, Deserno discussed new results for the boundary conditions for the contact region of biomembranes with colloids, while Ovryn discussed new optical experiments on cell-substrate adhesion. Collaborations were also initiated and furthered during the reunion. Atzberger and Ovryn initiated discussions of modeling the affects of cell membrane dynamics and cell adhesion, K. Y. Lee also initiated collaboration with J. Liang (long program participant) on screening for antimicriobial peptides, while Ayati, Chou, D'Orsogna, Klapper, and Lee collaborated on writing a grant proposal.

***IPAM Workshop:* Scientific Computing Applications in Surgical Simulation of Soft Tissues**
January 7 - 11, 2008

Organizing Committee: Court Cutting (New York University, Plastic Surgery), Dwight Meglan (SimQuest LLC), Silvia Salinas-Blemker (University of Virginia, Mechanical and Aerospace Engineering), Joseph Teran (University of California, Los Angeles (UCLA), Mathematics)

Surgical simulation of soft tissues is an increasingly viable tool for predicting surgical outcomes and in training medics and residents. Simulated procedures include laproscopic surgery, craniofacial reconstruction, z-plasty, breast reduction, gastrointestinal surgery and reconfiguration of musculoskeletal geometry. In these and many other scenarios, a subject

specific simulation environment in which procedures can be practiced is of immeasurable value for training as well as for actual research and development of surgical techniques. Several technological and algorithmic problems currently limit the applicability of surgical simulation; the solutions to these problems require collaboration between mathematicians, computer scientists, engineers and clinicians. For example, until recently most simulation techniques for soft tissues were too computationally burdensome to be applicable in a real or interactive time environment. Offline computations have always been of use in helping to determine the results of a procedure, however many algorithms were developed that sacrificed accuracy for speed in an attempt to satisfy interactive frame rates. In the process, many of these algorithms were doomed to produce scientifically unreliable results making them of little use in accurately predicting surgical outcomes. As computer performance improves, computational power is less and less frequently precluding the use of more widely accepted scientific computing algorithms for soft tissues at interactive rates. Also, larger regions of the body can be simulated (e.g. in examining musculoskeletal procedures related to motion). In this workshop, we investigated the most promising directions for algorithm design, use of architectures, surgical simulation interface design and procedures that lend themselves to simulation by encouraging interdisciplinary cooperation between medicine, engineering, applied math and computer science.

Cardio-thoracic surgeon Eugene Grossi of the NYU medical center gave a talk on mitral valve repair procedures that was particularly compelling and stimulated great discussion of future integration of imaging and simulation to help in the development of patient specific procedures via simulation (tuned to a specific individual) with state of the art processing of ultrasound and MRI data. Cranio-facial reconstructive surgeon Court Cutting (also of NYU) gave the public lecture on the potential impact of similar technologies for subject specific cranio-facial reconstruction. The symposium was also conceived of as means for the engineers, mathematicians and computer scientists to present and discuss the state of the art in simulation and talks by Ming Lin (UNC, computer science), Demetri Terzopolous (UCLA, computer science), Eftychis Sifakis (UCLA, applied math/computer science) and Mathias Harder (ETH-Zurich) amongst others provided a wide range of content that was both technical and accessible to the physicians.

On the day before the final presentations of workshops, a panel discussion was held on the topic of establishing a more seamless collaboration between the engineers, mathematicians, and physicians. The most salient difficulty in this regard was agreed to be a lack of communication across disciplines and institutions. A disturbing trend is the development of algorithms, software and general infrastructure at great expense for problems thought by the engineers, mathematicians and computer scientists to be of relevance to the physicians. In too many cases, prioritization of effort has been suboptimal as far as development of simulation infrastructure that is of highest impact for the physicians. This workshop provided a very effective means for the communication needed to remedy this trend.

Public Lecture: **Virtual Surgery: Computational Methods and Simulations for Facial Reconstructions**
January 9, 2008

Public lecture presented by Court Cutting. This lecture was part of the IPAM workshop "Scientific Computing Applications in Surgical Simulation of Soft Tissues" (above) and was cosponsored by the Center for Advanced Surgical and Interventional Technology (CASIT). Approximately 80 people attended.

Presented below are some comments from participants of Surgical Simulation:

Mark Ottensmeyer (Massachusetts General Hospital) VS2008: "[The workshop] led to an invitation from a textbook publisher to prepare a manuscript."

Christopher Rozell (Rice, Electrical and Computer Engineering) COG2005, ES2005, SN2007, VN2007: "At IPAM I had initial discussions with both Michael Wakin and Justin Romberg about possible projects to collaborate on. Both of these are in the beginning stages, with preliminary ideas generated and grants being submitted over the next few weeks. These collaborations are pushing into exciting new directions, taking ideas from sparse representations discussed at IPAM into new areas of time-series analysis/chaotic system prediction and analog devices for efficient compressive sensing reconstruction."

"Being at the beginning stage of my career, it is valuable to interact and make contacts with the leaders in my field of research. The workshop I attended at IPAM facilitated these interactions very well. In particular, I found the discussion time built into the workshop very useful. Thank you for supporting junior researchers!"

IPAM Workshop: **Image Analysis Challenges in Molecular Microscopy**
January 28 - February 1, 2008

Organizing Committee: Guillermo Sapiro, Chair (University of Minnesota, Twin Cities), Alberto Bartesaghi (National Institute of Health NCI), Jacqueline Milne (National Institutes of Health), Sriram Subramaniam (National Institutes of Health)

Understanding the hierarchical organization of molecules, multi-protein assemblies, organelles and networks within the interior of a eukaryotic cell is a challenge of fundamental interest in cell biology. A wide variety of microscopic and spectroscopic methods already exist for imaging intact cells and their components: modern fluorescence microscopic methods provide powerful tools for imaging at spatial resolutions in the micron range, while emerging methods in electron microscopy can be used to image the arrangement of protein assemblies at resolutions of 1 nm or better. To take advantage of these rapid advances in imaging technology, it is critical to develop and apply advanced computational strategies for image processing that can cope both with the volume and complexity of the data.

The goal of this meeting was to put together a very interdisciplinary group of speakers and audience in the areas related to image analysis in molecular microscopy. The meeting was

unique and first of its kind in this respect, with a superb combination of leading mathematicians developing theories of relevance for molecular microscopy, leading engineers that are developing the most advanced molecular microscopy tools, and leading biologists that are using those tools. While many of the participants are using each other tools and/or theories, they never met in the past, and this meeting provided a unique environment for such incredible interaction.

This workshop brought together leaders, including biologists, physicists, mathematicians and specialists in microscopy and image analysis, whose work exists at this interdisciplinary interface of image processing. The workshop sought to stimulate new partnerships to address computational problems at this exciting frontier of cell biology.

Comments from participants in Molecular Microscopy workshop:

John Kaufhold (SAIC): "We are actively involved in discussions with the organizers lab (Sriram Subramaniam) and the vendor of his microscope to bring our work at the micron scale to their analyses at the nano scale."

"Because emails are constantly changing, IPAM could start a group on a social networking site which would allow it to periodically ask participants this question again. I was updated with the state of the art on single particle imaging and tilt series reconstructions at the nano scale. Although still too academic for me to make a case that our company should be involved in that work, it was good to see how far it has come."

Xianghong Zhou (USC, Biostatistics) FG2000, SEQ2006, IMM2008: "I got to know my post-doc advisor, Wing Wong, from IPAM. I joined his lab after the IPAM. Also through IPAM, I got to know my close collaborator, Haiyan Huang along with my current mentor, Mike Waterman." "My current career focused on functional genomics and microarray analysis. Before I came to IPAM, I had no idea of those topics. IPAM has played crucial role in defining my research direction. IPAM has helped me to get my post-doc job and also my faculty job, because I met my advisor and current faculty mentor there."

Affiliate Workshop: **Software for Algebra and Geometry Experimentation: Combinatorics February 5 - 9, 2008**

Organizer: Craig Citro

"Sage" is free and open-source software that supports research and teaching throughout mathematics. Both the Sage development model and the technology itself are distinguished by a strong emphasis on openness, community, cooperation, and collaboration: Sage is about building the car, not reinventing the wheel. Sage is several hundred thousand lines of new code that uses standard open source libraries and programs (such as GAP, Maxima, Singular, PARI, and Python) and more specialized libraries to create a unified and powerful open source mathematical software system.

Sage has recently had two major improvements with regards to combinatorics. First, Robert Miller and Emily Kirkman have used NetworkX to provide a huge amount of graph theory

functionality in Sage, much more than is provided by NetworkX itself. In addition, Robert made the first open-source graph isomorphism checker, based on the same ideas as Nauty (which is currently available both independently and in MAGMA). Second, Mike Hansen has created a huge framework for working with combinatorics in Sage, with well over 30,000 lines of new code, including an extensive interface to Symmetrica.

The workshop included two days of lectures followed by three days of intense working sessions consisting mostly of groups working to implement new functionality in Sage, or discussing design decisions for new features.

Here's a brief summary of some of the larger accomplishments at Sage Days 7:

• Sage-combinat:
During Sage Days 7, a core group of researchers from the Mupad-Combinat group worked closely with Sage developers to consider the viability of switching from Mupad to Sage as the platform for their research. The Mupad-Combinat group (URL) is a group of researchers who maintain a large library of open-source code built on Mupad for a large range of research in algebraic combinatorics. This library has led to the publication of over 25 papers in the field. This group implemented crystal bases of quantum groups in Sage during the workshop as a test of the feasibility of porting their codebase to Sage. This project was successful. The Mupad-Combinat group has since continued porting their codebase to Sage, and has recently made the decision to completely switch to Sage for their research.

• Hermite Normal Form:
William Stein and Clement Pernet spent most of Sage Days 7 creating an optimized p-adic/modular algorithm for computing Hermite normal forms of matrices over the integers. For random square nonsingular matrices with small entries it is similar to Magma in speed, and vastly faster than the implementations in Gap, NTL, and PARI. For matrices with large entries (e.g., 16 bits or more), it is faster than anything else in the world. For nonsquare matrices it is also reasonably good, though more optimization is needed since Magma is much better in some cases. We also implemented related code for computing determinants over Q and Z, which is again the fastest in the world especially when the
matrix entries are large.

• Graph infrastructure:
New basic structures were written in compiled code to replace NetworkX for graphs in Sage. This gives a speedup for basic operations on graphs of up to a factor of 100.

• Graphs on surfaces:
Boyer and Myrvold's reference implementation of linear-time planarity testing for graphs was incorporated into Sage, which is widely considered to be the most robust implementation of linear-time planarity testing. Schnyder's algorithm for linear-time embeddings of planar graphs on surfaces was implemented from scratch in Sage.

• Debian and Sage:

Michael Abshoff and Tim Abbott began the process of making Sage available as a standard package for Debian GNU/Linux. This has progressed, and starting with the next major release of Debian (known as “Debian Lenny”), one should be able to simply type apt-get install sagemath and it will automatically download and install Sage.

IPAM Workshop: **Expanders in Pure and Applied Mathematics**
February 11 - 15, 2008

Organizing Committee: Alexander Gamburd (University of California, Santa Cruz), Alexander Lubotzky (The Hebrew University of Jerusalem), Audrey Terras (University of California, San Diego), Avi Wigderson (Institute for Advanced Study)

Expander graphs are finite graphs of small degree and with high convectivity properties. They serve as basic building blocks in various communication networks and have a huge amount of applications in computer science. The subject of expanders attracted many pure mathematicians as their explicit construction has used deep mathematical theories such as Kazhdan property (*T*) from rep- resentation theory of semisimple Lie groups or Ramanujan conjecture from the theory of automorphic forms. 2008 marks two important anniversaries in the development of the theory of expander graphs: the field was born 35 years ago, in 1973, when, following Pinsker’s observation that random regular graphs are expanders, Margulis gave the first explicit construction using Kazhdan’s Property T; fifteen years later, in 1988, Margulis, Lubotzky, Phillips and Sarnak constructed Ramanujan graphs (optimal expanders form spectral point of view) using deep results from the theory of automorphic forms. After a period of steady development, the theory of expander graphs has undergone explosive growth over the past several years: on the one hand, a number of long-standing problems have been resolved; on the other hand, several completely new and unexpected lines of development have emerged. Currently expanders are at the center of a great deal of research involving mutually beneficial interactions between computer science, number theory, combinatorics, group theory, and geometry. In 2004 a first conference on this subject was organized at IPAM, which brought together mathematicians and computer scientists. It was followed by a year long research program at the Institute for Advanced Study in Princeton during the year 2005/6.

The current conference was a continuation of this activity. Its special feature was the exposition of various projects which show that in recent years, expanders started to also play an important role in pure mathematics. The talks of Lackenberg and Reid illustrated the central parts played nowadays by expanders in the study of hyperbolic 3-manifolds, Bourgain talked about applications to number theory and Lubotzky on ¯nite simple groups. There were a good number of talks on applications and challenges from computer science by Wigderson, Linial and others. An interesting talk by Kristin Lauter, the head of the cryptography team of Microsoft, illustrates how expanders are starting to play an important role in products of Microsoft and in particular in the design of hash functions. A special afternoon session was dedicated to the memory of Beth Samuels, a brilliant young American mathematician who gave a great talk at the 2004 conference on Ramanujan complexes. Samuels passed away last year after fighting cancer for two years. Several talks on Ramanujan complexes were given showing that Samuels' topic is °ourishing.

The participants came from many diverse backgrounds but a sense of community has been developing as this conference is a continuation of previous ones.

Presented below are a few comments from participants in Expanders workshop and some of their self-reported collaborations:

Nathan Linial (Hebrew University, CS) AG2004, CM2006, SE2007, EG2008, MG2009: "I am currently collaborating with Joel Friedman (UBC, Vancouver) in research. This collaboration was initiated during our visit to IPAM."

"There are very few comparable places throughout the world in terms of the quality of the meetings that IPAM puts together. Due to IPAM's high prestige, they succeed in bringing in the world's leaders in the respective research areas. The generous help they provide by covering travel and lodging expenses allows even people from far-away places and promising research students to attend."

Alexander Lubotzky (The Hebrew University of Jerusalem) AGG2004, EG2008: "The meeting help to crystalize the very interesting community that have been emerged in recent years from the previous IPAM meeting in 2004. The year long program at the IAS in 2005/6 and the recent IPAM meeting in 2008. This groups consists of people who usually don't go to the same confrences: Computer scientists, number theorists, groups theorists, topologies, geometers and more- with a common interest in expanders."

"Well, for me these two conferences were some of the highlights of my career: I worked really hard to help create this community and this subarea and I am grateful to the IPAM for making it possible."

Christophe Petit (Université Catholique de Louvain, ELEC CRYPTO) SC2006, EG2008: "The workshop on Cryptography and Number Theory: Open Problems was outstanding. I have been working on the cryptographic hash function of Kristin Lauter and the workshop on Expander in Pure and Applied Mathematics really came at the good moment for me."

IPAM Workshop: **Graph Cuts and Related Discrete or Continuous Optimization Problems February 25 - 29, 2008**

Organizing Committee: Yuri Boykov (University of Western Ontario), Daniel Cremers (University of Bonn), Jerome Darbon (University of California, Los Angeles), Hiroshi Ishikawa (Nagoya City University), Vladimir Kolmogorov (University College London), Stanley Osher (University of California, Los Angeles)

Many computer vision and image processing problems can be formulated as a discrete optimization problem. Among several available optimization schemes, combinatorial min-cut algorithms on graphs emerged as an increasingly useful tool for performing these optimizations. This success is mainly twofold. First, in some cases graph cuts produce globally optimal solutions. More generally, there are iterative graph-cut based techniques that produce provably good local optimizer that are also high-quality solutions in practice. Second, graph-cuts allow for a geometric interpretation. Provided some assumptions, a cut on a graph can be seen as a

hypersurface in N-D space embedding the corresponding graph. This point of view has been very fruitful in computer vision for computing hypersurfaces. Besides, graph-cut approaches have been shown to be very fast in practice. Finally some links between graph-cuts, message passing and belief propagation have been recently shown.

The workshop primarily focused on combinatorial and continuous optimization methods for energy functionals that are very common in computer vision and medical image analysis. The following topics, among others, were addressed:

1. **Minimizing surface functionals via maxflow**. The first talk on the topic was given by Boykov, who showed one possible way to approximate continuous functionals via discrete functionals. An alternative approximation was presented by Sullivan. A very interesting theoretical perspective on continuous maxflow was given by Strang, a pioneer in the field.
2. **Implementation of maxflow algorithms**. There were talks about both discrete maxflow (Goldberg) and continuous maxflow (Talbot, Cremers, Darbon).
3. **Solving variation (TV) problems via maxflow-based approaches** (Hochbaum, Zalesky, Yin, Darbon).
4. **Solving energy minimization problems with multiple labels.** Some talks were about linear (Komodakis,Schlesinger,Wainwright,Ravikumar) and non-linear (Keuchel,Torr) relaxations of the problem, while other talks used move-making algorithms (Veksler,Blake) and belief propagation (Felzenszwalb).

There were also talks about solving quadratic non-submodular functions via maxflow (Boros), graph partitioning via maxflow (Kolmogorov), phase unwrapping via maxflow (Bioucas-Dias), multi-scale techniques (Brandt, Basri). Grady gave a very interesting talk showing how continuous and discrete problems can be formulated in a single framework using tools of algebraic geometry.

Comments from participants of Graph Cuts workshop:

Jerome Darbon (UCLA): “During the IPAM workshop on Graph-cuts, two collaboration were strongly strengthened. I worked with Florence Tupin (Telecom ParisTech, Paris) on Graph-cuts for Radar images and with Jose Bioucas (IST, Lisboa, Portugal) on optimization. Simply said, it changed my way of thinking in a very strongly positive way.”

Long Program: **Optimal Transport**
March 10 - June 13, 2008

Organizing Committee: Andrea Bertozzi (University of California, Los Angeles), Yann Brenier (Université de Nice Sophia Antipolis), Jose Carrillo, Chair (Autonomous University of Barcelona), Wilfrid Gangbo (Georgia Institute of Technology). Peter Markowich (University of Cambridge, Department of Applied Mathematics and Theoretical Physics), Jean-Michel Morel (École Normale Supérieure de Cachan, CMLA)

The general problem of irrigation and transportation in physics and biology is to transport in the most economical way a source mass distribution onto a fixed well distribution. Both source and wells distributions are usually modeled as positive measures in a Cartesian space or in a metric space. This problem can be looked at as a generalization of the optimal assignment or the optimal flow problem in operational research, in which case the subjacent space is a fixed graph. In the new more general setting, the irrigation network is itself an unknown of the problem. The examples are manifold: lungs, blood vessels, irrigation or draining networks, natural or artificial. On the side of urban optimization, the question ranges from the optimization of the supply networks (power, water, wires) to the public transportation and traffic optimization problem. The simplest and more noble and antique version of the problem is the Monge-Kantorovich problem, where the cost assigned to transportation is just an increasing function of distance. Fluid mechanics arguments have to be added as soon as the transportation network is optimized with a flow-dependent cost as is natural in most of the above mentioned situation: the thicker the vessel, the road, the channel, the wire etc., the cheaper the transportation.

This program brought together physicists, biologists, mathematicians working on the optimization of transportation networks. Many people stayed for significant parts or all of the 14 weeks of the program. A number of new collaborations were formed, and previously existing collaborations had a chance to deepen. The following list includes some of the collaborations that were started at or benefitted from this program: Carrillo, Laurent, and Bertozzi, Gualdani, Gonzalez, Kim, and Chayes (Gualdani will in fact spend some time at UCLA with Chayes in the spring of 2009), Salafia and Oberman, and Salafia and Grenkov (placenta modeling), Figalli, Yolcu, and Gangbo, Gangbo and Osher, Gangbo, Lei, and Chayes, D'Orsogna, V. Panferov, and J. A. Carrillo, Figalli, DiFrancesco, Slepcev, Laurent, and Carrillo, Carlen, Carrillo, and Carvalho, Kim and Grunwald, and DiFrancesco and Rosado. Many of these collaborations have already led to publications, or to publications that are in preparation.

***Tutorials*: Optimal Transport**
March 11 - 14, 2008

Organizing Committee: Jose Carrillo, Chair (Autonomous University of Barcelona), Andrea Bertozzi (University of California, Los Angeles), Yann Brenier (Université de Nice Sophia Antipolis), Wilfrid Gangbo (Georgia Institute of Technology). Peter Markowich (University of Cambridge, Department of Applied Mathematics and Theoretical Physics), Jean-Michel Morel (École Normale Supérieure de Cachan, CMLA)

This tutorials week was devoted to an introduction to the optimal transport theory in a broad sense. The basic question consists of how to transport certain amount of material from its original place to a target destination in some optimal (to be defined) way. This question had its roots in optimization problems with applications and ramifications in probability theory, calculus of variations, differential geometry and partial differential equations leading to applications as diverse as: assignment problems in economy, swarming and coarsening of physical systems, river basin formation, transport in biological systems and so on.

The main idea in the conception of these tutorials was to have a balance between real introductory talks and possible unexplored applications of this field. On one hand, some of the

talks were devoted to classical approaches in optimal transport theory that students and newcomers to the field could use as introductory material to the thematic program: talks of Qinglan Xia, Adam Oberman, Martial Agueh and José A. Carrillo were in this direction. Broadening the scientific perspective of this field of mathematics and its possible use in other areas of science was the aim of the other set of chosen speakers: talks of William Zame, Andrea Bertozzi, Maria Rita D'Orsogna and Bjorn Birnir.

***Workshop I*: Aspects of Optimal Transport in Geometry and Calculus of Variations**
March 31 - April 4, 2008

Organizing Committee: Wilfrid Gangbo, Chair (Georgia Institute of Technology), Luigi Ambrosio (Scuola Normale Superiore), Yann Brenier (Université de Nice Sophia Antipolis), Jose Carrillo (Autonomous University of Barcelona), Craig Evans (University of California, Berkeley)

This workshop was devoted to the interplay between the theory of optimal transport, geometrical inequalities and nonlinear partial differential equations. Specific topics included optimization and evolution problems arising in geometry, urban planning, mathematical biology, kinetic theory, and fluid flows. The purpose of the meeting was to bring together experts in several areas of mathematics, namely mass transportation and geometry, with experts in the calculus of variations, partial differential equations and fluid dynamics. The meeting consisted of twenty four talks.

Mass transportation theory was originally developed as a way of solving optimization problems in the areas of operations research and probability. It has more recently found a much wider range of applications, such as network design, economics, medical imaging and reflector design. A wide variety of other application areas were discussed at the workshop, such as modeling transport at small scales, regularity of Monge-Ampere equations, Poisson structure, biological aggregation. In particular, it has been shown that it can be applied to kinetic theory and can be useful for studying conservative systems. Mass transportation theory can also be given a geometrical interpretation, which has led to important extensions in its applicability.

The first main theme was to increase interaction between scientists developing the theory of optimal transportation, which is a very generic mathematical method, and the application to fluids mechanics and partial differential equations. The content of the workshop was a mixture of theoretical and applied talks, illustrating the breadth of the applications of mass transportation theory. At the application level, there was a talk on issues related to modeling transport at small scales. Some talks were on the application to biological aggregation, where distributions of mixtures coarsen with time because interfaces are energetically costly. A description of such a system was done, and its relation to other models using different metrics was mentioned. At the theoretical level, there were talks on the Wasserstein space over the Wiener space, the Monge Ampere equations with homogenous right hand side. There was a talk describing the singularities of the exponential map on the group of volume-preserving diffeomorphisms.

The workshop hosted over eighty participants, including fourteen women and five african

americans. The participants include many students, postdocs or junior faculty members from various background such as analysis, physics, biomathematics and scientific computations. There was a large variety of nationalities, including Benin, Canada, France, Italy, Portugal and the United Kingdom.

Workshop II: **Numerics and Dynamics for Optimal Transport**
April 14 - 18, 2008

Organizing Committee: Yann Brenier (Université de Nice Sophia Antipolis), Karl Glasner (University of Arizona), Allen Tannenbaum (Georgia Institute of Technology, School of Electrical and Computer Engineering), Richard Tsai (University of Texas at Austin)

This workshop brought together a diverse group of mathematicians and other scientists to discuss dynamical and numerical aspects of optimal transport. Optimal transport provides a natural geometry for characterizing and studying many evolutionary partial differential equations. In particular, their dynamics is seen to possess either a gradient flow or Hamiltonian structure when viewed on a manifold endowed with an optimal transport metric. These connections have found diverse applications, ranging from fluid mechanics to materials microstructure evolution and Ricci flow.

Algorithms for numerical transport optimization have applications in a variety of areas such as image processing, medicine, computational cosmology, geosciences, or urban transport. Numerical transport optimization methods have not yet reached their full capacity where they can meet the most demanding practical applications. For example, in cosmology, effective handling of galaxy catalogues with millions of entries for reconstruction of early velocities according to the Zeldovich model is a big challenge. Up to now, there are two principal numerical approaches to optimal transport: In one approach, one chooses a suitable numerical discretization, and optimal transport becomes a large scale combinatorial optimization problem. Alternatively, transport plans can be generated by solutions to suitable partial differential equations. Both cases and their comparison with recent second order cone programming (SOCP) methods that are particularly popular in image processing were discussed.

IPAM Workshop**: "Making the Connection: Math in the Real World"**
April 25, 2008

Organizing Committee: Mark Green (UCLA), Luminita Vese (UCLA), Joseph Teran (UCLA)

This one-day event introduced current UCLA undergraduates and community college students in math, engineering, computer science and physics to two topics in applied math. UCLA Professors of Mathematics Joseph Teran and Luminita Vese presented their research and engaged the students in activities to demonstrate the power of mathematics to solve real-world problems. Dr. Vese focused on problems in image processing (especially in medical imaging) and some solutions using applied mathematics models. Dr. Teran presented the application of mathematics in simulating physical events, such as water, fire, smoke and explosions. The

program concluded with a tour of UCLA's Laboratory of Neuro Imaging (LONI) and a demonstration of 3D graphics software on UCLA's sophisticated "visualization portal."

Workshop III: **Transport Systems in Geography, Geosciences, and Networks**
May 5 - 9, 2008

Organizing Committee: Andrea Bertozzi (University of California, Los Angeles), Bjorn Birnir (University of California, Santa Barbara), Dan Rothman (Massachusetts Institute of Technology), William Zame (University of California, Los Angeles, Economics)

In recent years a large number of scaling laws in geomorphology have been found to be equivalent to only two scaling laws. Recent results on river meanders indicate that there may be only one universal scaling law, implying all the others. Moreover, recent theoretical results on turbulent flow in rivers indicate that turbulent flow is the source of the universal scaling of river basins and river networks.

These results provide a key to the understanding of the fundamental structure of the surface of the earth, to which layers of complexity such as tectonic uplift, earthquake rifts and the action of glaciers can then be added. It provides a way of quantifying transport of water, sediments and chemicals over the surface and exchanges of dissolved chemicals between the water and the atmosphere. In particular this seems to provide a method to quantify the transfer of carbon dioxide from rivers to the atmosphere.

This workshop examined why and how this transport due to turbulent flow takes place and is optimal. Other transport such as transport of magma in volcanoes, and how similar ideas can be used to identify and quantify transport in social networks and economics, was also covered.

Workshop IV: **Optimal Transport in the Human Body: Lungs and Blood**
May 19 - 23, 2008

Organizing Committee: Suncica Canic (University of Houston), Denis Grebenkov (École Polytechnique, Laboratoire de Physique de la Matiere Condensee), Bertrand Maury (Université d'Orsay), Anne Marie Robertson (University of Pittsburgh)

The human body is a fascinating transport system, in which organs must exchange nutrients, water, oxygen, and waste to maintain life. To allow rapid access of a large amount of oxygen to the whole body, the respiratory and cardiovascular systems exhibit extremely complex geometrical structures. In the course of evolution, these organs have been optimized for efficient transfer under various and sometimes unknown constraints. For instance, the respiratory systems in mammals and birds are very different, although they are both highly efficient. At the same time, the efficiency may be substantially reduced by deteriorations, aging, or diseases. A better understanding of the optimal transport in these systems is a key for curing diseases, drug delivery, and design of artificial implants.

This workshop brought together internationally renowned experts as well as postdocs and students with research interests in the respiratory and cardiovascular systems, as well as in optimal transport. Participants included mathematicians, physicists, physiologists, medical doctors, engineers, and computational fluid-dynamicists. Participants gained a perspective of cross-disciplinary aspects of the same fundamental topic from the experts in the field and had opportunities to establish new research collaborations.

An informal lunch for women participants was organized to provide an opportunity for the women to meet with each other in a relaxed setting. During the planning stages, the proposal for the lunch was enthusiastically received by all 8 senior women researchers. At least 16 women participated in the luncheon. An evaluation form for the luncheon was returned from 7 participants (5 from junior, 2 from senior people). Everyone liked it, and thought it was beneficial.

> ***Public Lecture*: From the Lung to the Cells' Powerhouses: Symmorphosis in the Design of the Pathway for Oxygen.**
> **May 21, 2008**
>
> Public lecture presented by Ewald Weibel. This lecture is part of the IPAM workshop Optimal Transport in the Human Body: Lungs and Blood (above) and was cosponsored by the David Geffen School of Medicine. The lecture received an audience of about 80.

***Mini-Workshop*: Entropies and Optimal Transport in Quantum Mechanics**
June 5 - 6, 2008

Organizer: Peter Markowich (University of Cambridge, Institute of Mathematics)

In many important applications (such as ultra integrated solid state devices, or other applications in nanoscience) so called open quantum systems occur, which model the interaction of the particles not only with each other (electrostatically) but also with their environment. Typical questions that occur are existence of steady states, convergence to equilibria, and speed of convergence, which in some cases can be dealt with by exploiting the mathematical properties of the quantum entropy. This mini-workshop addressed the application of optimal mass transportation techniques to linear and nonlinear Schrödinger equations.

***Culminating Workshop* at Lake Arrowhead for Optimal Transport**
June 8 - 13, 2008

Organizing Committee: Andrea Bertozzi (University of California, Los Angeles), Yann Brenier (Université de Nice Sophia Antipolis), Wilfrid Gangbo (Georgia Institute of Technology). Peter Markowich (University of Cambridge, Department of Applied Mathematics and Theoretical Physics), Jean-Michel Morel (École Normale Supérieure de Cachan, CMLA)

This final workshop at Lake Arrowhead 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.

For example, the collaboration between Carrillo, Laurent, and Bertozzi was started during the long program, and the time at Lake Arrowhead was in fact used to finalize the first publication that originated from this new collaboration. Other new collaborations were already listed in the general description of the program on Optimal Transport. We also note that the overlap with the second reunion of the program on Bridging Time and Length Scales in Materials Sciences and Biophysics gave a chance to Vvedensky and Salafia to deepen their collaboration, that started a year earlier at Lake Arrowhead, and that has already led to a joint student, and a joint grant proposal.

Another highlight of the culminating workshop was a session with inspiring overview and summary talks by Carrillo and Brenier on Wednesday afternoon, that led into an energetic discussion on Wednesday evening.

Presented below are a few comments from participants in Optimal Transport long program and related workshops, and some of their self-reported collaborations:

Marcos Aboubacar (Institut de Mathematiques et de Sciences Physiques, Benin: "IPAM has paid much attention for financial difficulties encountered to provide travel tickets for participants coming from abroad and I expect that a possible future co-organization of such scientific activities with IPAM in Africa will enable us to accept more participants"

François Bolley (Université de Paris IX (Paris-Dauphine)): "I stayed at IPAM in April 08 as part of the optimal transport program. Besides attending the conferences and discussing diverse problems with the participants, I have had the opportunity to work more deeply with Dr Irene Gamba from The University of Texas at Austin ad Dr José Antonio Carrillo, from the University Autonoma de Barcelona (Spain), who was one of the organizer of the program. We have started a project on the Boltzmann equation, which is a kinetic PDE, in particular by means of techniques base on optimal transport. We are currently working on it."

Wilfried Gangbo (Georgia Tech): "This is a collaboration I started with A. Figalli. It T. Yolcu, involved a PhD student of mine whose stay was supported by IPAM. Figalli and I knew that each other will be at IPAM but we never planned to have the fortune to collaboration this time. Then simple discussions led to a paper which is already over 25 pages long."

"I have been often discussing with L. Chase of UCLA. We are from very different backgrounds and so, without our meeting at IPAM, it was unlikely that we work together. Our next plan is to have Lincoln visit me at GTech in the near future. We don't know yet if we will succeed in completing an interesting work but we are still hoping that our discussions will lead somewhere."

Denis Grebenkov (École Polytechnique) RS2007, OT2008, LE2009 (organizer): "Thanks to the IPAM long-term program Random Shapes, I have established 4 new scientific projects and numerous collaborations such as with Dr. Maria McGee about diffusive transport in porous

interstitial structure of the human skin; we submitted a proposal for a funding grant for this project; with Dr. Carolyn Salafia about new methods for studying transport and functioning of placenta; with Prof. P. Jones about the localization of the Laplace operator eigenfunctions and properties of Brownian motion; and with Dr. D. Belyaev about the properties of stochastic Loewner evolution with non-Brownian driving forces."

"I think that IPAM programs have very deep impact in general and in my particular case, allowing scientists from diverse fields and with different background to meet and discuss in quiet and comfortable conditions. The program Random Shapes substantially enriched my knowledge about SLE and related problems and gave an opportunity to develop new directions in my research towards biology and physiology. I'm definitely positive about these programs and I'm participating now in organization of the long term program Optimal Transport for Spring 2008."

Ewald Weibel (Universität Bern) OT2008: "As emeritus for 15 years my career has come to an end, but I have been much stimulated in reformulating some of my research plans by the debates at IPAM. Very rewarding."

Michael Yampolsky (Toronto) RS2007, OT2008: "After coming in contact with medical practitioners at IPAM, I have started work on applications to medical science. This has been very fruitful: together with C. Salafia we have found an exciting new direction of research of human placental pathology, and the way it affects adult health risks."

William Zame (UCLA, Econ) FM2001, OT2008: "IPAM has re-stimulated by thinking about the mathematical foundations and economic applications of my work on matching and optimal transport."

Reunion Conference: Bridging Time and Length Scales in Materials Science and Bio-Physics
June 8-13, 2008

Organizing Committee: Christian Ratsch, Russel Caflisch, Cecilia Clementi

This was the second reunion conference for participants of the Fall 2005 long program "Bridging Time and Length Scales in Materials Science and Biophysics." It was a timely get-together to continue some of the collaborations that were started during the long program and at the first reunion. Some of the collaborations that had a chance to deepen were the following: Smereka and Schulz are collaborating on fast KMC schemes, and a model to incorporate strain in a KMC model, to model growth of quantum dots. Similarly, Ratsch and Smereka are working on level set models that incorporate strain, with the same goal of modeling the formation and growth of quantum dots. Ratsch and Schulz are collaborating on fast KMC methods. Tkatchenko and von Lilienfeld have been collaborating on van der Waals corrections in DFT methods. Vvedensky and Caflisch are working on renormalization group theory approaches in plasma physics.

The reunion started with 2 inspiring overview talks. Russ Caflisch and Sid Yip gave overviews over the current status and the open problems in multiscale modeling from the point of view of an applied mathematician (Caflisch) and a materials scientist (Yip).

As suggested in the first reunion, we had several rather focused sessions during this reunion. For example, on Wednesday morning, Voter, Perez, Fichthorn, and Henkelman contributed to a session on acceleration methods to study rare events. This session was started with a beautiful overview talk by Art Voter. This session also served as an advertisement to an upcoming IPAM workshop on Rare Events (February 2009). On Wedneday afternoon, Plechac and Lusking delivered 2 lectures that illustrated how progress has been made to give multiscale modeling a more rigorous mathematical footing. We also had a session that focused on biophysics on Tuesday morning (Clementi, Ledbetter, Tran, Ireta).

Discussions during the reunion sparked some ideas and suggestions for possible upcoming IPAM programs. Most noticeable were discussions with Fichthorn and Voter, to finalize plans for the upcoming workshop on Rare Events, and discussions with von Lielienfeld and Yip, that led in fact to a proposal for a long program, that will be considered at this fall's Scientific Advisory Board meeting for the academic year 2010/11.

Reunion Conference: **Securing Cyberspace: Applications and Foundations of Cryptography and Computer Security**
June 8-13, 2008

Organizer: Rafail Ostrovsky

This was the first reunion conference for participants of the Fall 2006 long program "Securing Cyberspace." It was a timely get-together to continue some of the collaborations that were started 18 months earlier. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations.

Affiliate Workshop: **MITACS International Workshop on Fusion, Mining, and Security for Networks**
June 16-20, 2008

Organizing Committee: Michael Rabbat (McGill University) Mark Coates (McGill University), Jeanette Janssen (Dalhousie University), Nur Zincir-Heywood (Dalhousie University)

This workshop was held at McGill University in Montreal, Canada. IPAM supported this workshop by financially supporting seven U.S. citizens to participate. MITACS also supported some Canadian participants of Mathematics in Brain Imaging (below). IPAM and MITACS have signed an agreement to continue this arrangement for five years.

National security and intelligence organizations are faced with the problem of gathering and processing vast amounts of data from sources including the internet and telephone network,

social networking sites, and networks of embedded sensors. There is a pressing need for novel mathematical models, methods, and algorithms that efficiently fuse diverse data sources and extract salient information such as anomalies or community structure. Furthermore, these techniques should account for the networked nature of the data being processed.

This event brought together researchers from academia and industry to discuss challenges and research directions in the fields of fusion, data mining, defense, and security in networks. The first two days were tutorial-style short courses, and the subsequent three days consisted of shorter research-oriented presentations.

Comments from participants in MITACS workshop and self-reported collaborations:

David Liben-Nowell (Carleton College)RS2007, MITACS2008: "Aaron Clauset (Sante Fe Institute) and I are in the very initial steps of a potential collaboration. We met at the IPAM workshop."

"As someone who works at a liberal arts school -- with a high teaching load, no graduate program, and a very small department with no colleagues who work in my area of research interest -- I find it particularly difficult to keep up with recent results in the field. Having the chance to participate in this IPAM workshop, with such a top-tier group of researchers, was extremely valuable."

IPAM Summer Program: **Research in Industrial Projects for Students (RIPS) 2008**
June 22 - August 22, 2008

Organizing Committee: N/A

The Research in Industrial Projects (RIPS) Program provides an opportunity for high-achieving undergraduate students to work in teams on a real-world research project proposed by a sponsor from industry or a national lab. RIPS recruits its students from all over the world. Each RIPS team is comprised of four students, a faculty mentor, and an industrial sponsor. The research problem is developed by the industrial sponsor in consultation with IPAM; it is always a real problem of serious interest to the sponsor and that offers a stimulating challenge to students. The students, with direction from their faculty mentor and industrial sponsor, spend nine weeks learning about the problem, mastering the latest analytical approaches and techniques to solve it, and developing report-writing and public-speaking skills to be able to make professional presentations about the progress and results of their work to a scientific audience. Industry mentors provide regular contact between the team and the sponsor, monitoring and helping to guide student work. Ultimately, RIPS provides valuable real-world technical and managerial experience for students as well as valuable R&D for sponsors.

RIPS 2008 sponsors and projects included:

RIPS 2008 Sponsors and Projects	
Organization	**Project Title**
Aerospace Corp	Optimizing Network Topologies
Amgen	Modelling and Measuring Unstable Behavior in Hematopoiesis
Arete	Automatic Target Recognition
JPL	Using Level Sets to Represent Invariant Manifolds for Trajectory Design
MSRA	Study on network formation games
Pixar	Detail Preservation for Simulated Characters
Spielberg Center for Applied Proteomics (Cedars-Sinai)	Development of a probabilistic framework for estimating protein quantities in LCMS Experiments
Symantec	Indexing techniques for databases of graphs

Here are a few examples of student feedback about RIPS from their program evaluations:

I was quite impressed with RIPS. I've learned a TON in nine weeks about graph theory and managing an international research team, and I've had a blast doing it. *Michael Hughes, Franklin W. Olin College of Engineering*

It's a great program. It is well-organized and structured, but there is also a good amount of freedom to work on your own schedule, and to chart out an interesting course in your research. *Rachel Hodos, University of Houston*

RIPS not only give one the opportunity to put mathematics at work in the industrial world, it also allows one to develop "people skills," since you have to communicate and collaborate with bright students from all over the world!! *Ismael Djima, College of Staten Island, CUNY*

I think the educational value was very high because as students, we got to work on projects that professionals have been tackling and studying for years. We get to become experts in a short period of time. *Nkenge Wheatland, University of Maryland Baltimore County*

RIPS is exceptional in the opportunities it provides to its participants. The interactions with the industry sponsors and knowing that your work will be used to tackle actual problems makes it unique. I would definitely recommend RIPS to other undergrads. *Arunima Ray, SUNY Geneseo*

I think RIPS has a great educational value. I learned a lot about the theory related to my problem, how to work in a research team, and how to do research. There are invaluable skills for people wanting to go into science/math/theory research. *Sarah McBride, Brigham Young University*

RIPS is an extremely unique opportunity because it allows students to work on projects that will actually be used in product development. It was extremely satisfying to make progress in advancing the "state-of-the-art." *Eric Klein, Yale University*

RIPS is a great way to get hands on experience of how mathematics is used in a wide range of industries: from virus detection, to space studies, to biology projects. It was an exciting, valuable summer. *Melanie Kanter, Stanford University*

> ***Subworkshop:*** **Research in Industrial Projects for Students (RIPS) Projects Day**
> **August 15, 2008**
>
> Organizing Committee: N/A
>
> The eight RIPS 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. Prospective RIPS students, math and science majors, family members of the students, and others in UCLA's math and science community attended.

***IPAM Summer Program*: Mathematics in Brain Imaging Summer School**
July 14 - 25, 2008

Organizing Committee: Michael Miller (Johns Hopkins University, Center for Imaging Science), Thomas Nichols(University of Oxford, GlaxoSmithKline Clinical Imaging Centre), Russel Poldrack (University of California, Los Angeles, Psychology), Jonathan Taylor (Stanford University, Statistics), Paul Thomspon (University of California, Los Angeles, Laboratory of NeuroImaging), Keith Worsley (McGill University, Department of Mathematics and Statistics)

This two-week "summer school" focused on mathematical techniques applied to brain images to measure, map and model brain structure and function. Topics ranged from modeling anatomical structures in MRI scans, and mapping connectivity in diffusion tensor images, to statistical analysis of functional brain images from fMRI and other imaging modalities. Current applications in radiology and neuroscience were highlighted, as were new directions in the mathematics of structural and functional image analysis. In the second week on Functional Brain Mapping, a series of lectures on diffusion tensor imaging discussed the tools for registration, segmentation, fiber tracking and connectivity modeling in tensor and "beyond-tensor" (high-angular resolution) diffusion images, using metrics on Riemannian manifolds. Software implementing a wide range of algorithms was demonstrated; tutorial notes were provided. Talks were of interest to newcomers as well as experts in the field. Morning lectures focused on the principles behind the methods; afternoon lectures presented applications in depth.

Presented below are some comments from participants in the Brain Imaging Summer School and some of their self-reported collaborations:

Tom Beckers (Katholieke Universiteit Leuven, Psychology): "I'm currently collaborating with Alan Yuille (co-organisor of the summer school), Hongjing Lu (one of the lecturers at the

summer school), and Randall Rojas (a student of Yuille), trying to develop a Bayesian model that can account for human and animal learning data that I presented at the summer school."

"The summer school at IPAM has been a unique way to get myself better acquainted with Bayesian and other mathematical models of cognition, and has allowed me to establish a number of new contacts with key researchers in the field and to strengthen existing relationships. It has also influenced my work more directly, by setting the stage for the collaboration cited above."

Anna Caroli (Mario Negri Institute, Laboratory of Epidemiology, Neuroimaging and Telemedicine): "IPAM was incredibly useful and enabled to create lots of new contacts with people working on the same research field (both speakers and partecipants). I really appreciated the speakers helpfulness (both summer school and CCB Demo Day), and after IPAM I recontacted some of them in order to try and use the tools they presented. I found the CCB Demo Day particularly useful, I asked for access to the LONI pipeline and I am currently starting to use it. For the purpose of creating new contacts I found useful also the list of all partecipants email addresses provided."
"IPAM helped me a lot in opening my reasearch horizons. During the summer school we had a great overview about the hot issues in neuroimaging research. I got many new ideas and cues for future work, and I knew about new tools to try and use on my neuroimaging data."

Prerona Mukherjee (Edinburgh, psychiatry): "Most importantly, it has made me feel tremendously excited about the wide variety of methods that I encountered and also the application space they have already been employed on. Further, the contacts made will be hopefully extremely helpful while I try to explore these methods mentioned above. Finally, coming early in my phd the IPAM experience has really helped me by suggesting new potential directions in which I could take my work, apart from the range of methods, which would inform 'how' I would do so."

Julia Owen (UCSF, Radiology) GSS2007, MBI2008: "My involvement with IPAM helped introduce me to the field of probabilistic modeling in neuroscience. It gave me a good foundation in Bayesian statistics and understanding the general application of Bayesian modeling in the cognitive scientists. It also introduced me to a number of graduate students and postdocs working in my field at UCSF and UCB. It helped create a sense of community amongst those of us applying these methods to our research, despite how different our individual research might seem."

Russell Poldrack (UCLA, Psychology) MBI2008: "Collaboration with Tom Nichols of GSK."
"My experiences at the conference led to a stronger focus in my laboratory on fundamental issues of fMRI data analysis, and led indirectly to the book that I am now writing with Tom Nichols on this topic."

Affiliate Workshop: Advancing the Automation of Image Analysis Workshop II
July 29-31, 2008

Organizing Committee: Robert Rand (NGA), Paul Salamanowicz (NGA)

This is the second in a series of meetings hosted by IPAM with the scientific participation of the National Geospatial Intelligence Agency (NGA). The first workshop was held in fall 2007.

The second workshop invited the participants from the first workshop back to present and discuss the results of their inter-workshop research, to allow NGA the opportunity to evaluate the potential of a wide variety of competing approaches and assess the feasibility of the approaches proposed during Workshop 1 in the light of the participants experience using real data.

The outcome of the entire series will be the development of a long range R&D program for **Science to Further the Automation of Image Analysis and Visualization.**

A third workshop is planned for December 2008.

Comments from participants in Automation of Image Analysis Workshops I and II:

Paul Salamonowicz (NGA): "A significant collaboration with Yale University relating to improved non-linear techniques for image feature classification resulted directly from participation in IPAM sponsored programs. Other important collaborations have evolved with the Univ of Minnesota as well as UCLA involving several aspects of image processing, including segmentation, smoothing and classification. Prior relationships existed with these universities, however, these collaborations were significantly enhanced through IPAM related events. We also introduced R&D staff of other government agencies to IPAM. Collaborations with these agencies and our own is a major goal of the DoD. The work we initiated as a result of our interactions with IPAM has been instrumental in developing these collaborations with other government labs and R&D centers."

"Interactions through IPAM have introduced us to several cutting-edge computational technologies. We, in turn, have sponsored government broad agency announcements (BAA) for R&D on image processing and analysis topics directly related to our IPAM collaborations. The BAAs have resulted in significant funding being applied to research contracts and grants with a number universities and government labs. These efforts are now a major thrust of our research portfolio. Furthermore, this research has allowed us to attract highly qualified new employees who perform further research internally and who will continue to interact with the applicable research community. Based on this work we have transitioned capabilities to the devlopment and operational components of our agency. In summary our interaction with IPAM has had a significant beneficial impact on our research programs."

K. PROGRAM CONSULTANT LIST

IPAM consulted a variety of scholars and practitioners in the development of ideas for programs and the organization of each program. The list below is in chronological order by program. Upcoming programs for which planning has begun are also included.

SE2007

Karin Verspoor, Los Alamos National Laboratory, CCS-3

Ronald Coifman, Yale University

Vladimir Rokhlin, Yale University

Yann LeCun, New York University

Yuval Kluger, New York University

SETUT

Karin Verspoor, Los Alamos National Laboratory, CCS-3

Ronald Coifman, Yale University

Vladimir Rokhlin, Yale University

Yann LeCun, New York University

Yuval Kluger, New York University

SEWS1

Carey Priebe, Johns Hopkins University, Center for Imaging Science/Applied Mathematics and Statistics

Jennifer Chu-Carroll, IBM Watson Research Center

Karin Verspoor, Los Alamos National Laboratory, CCS-3

Ronald Coifman, Yale University

SEWS2

Andrew Zisserman, University of Oxford

Ming Gu, University of California, Berkeley (UC Berkeley)

Piotr Indyk, Massachusetts Institute of Technology

Sam Roweis, University of Toronto

Vladimir Rokhlin, Yale University

Yann LeCun, New York University

CDI2007

Mark Green, University of California, Los Angeles (UCLA), Mathematics

Stanley Osher, University of California, Los Angeles (UCLA), Institute for Pure and Applied Mathematics

SEWS3

Andrew McCallum, University of Massachusetts Amherst, Computer Science

Johan Bollen, Los Alamos National Laboratory

Karin Verspoor, Los Alamos National Laboratory, CCS-3

Peter Jones, Yale University, Mathematics

Ronald Coifman, Yale University

SEWS4

Gustavo Stolovitzky, IBM Thomas J. Watson Research Center, IBM Computational Biology Center

Itsik Pe'er, Columbia University, Computer Science

Olga Troyanskaya, Princeton University

Xiaole Liu, Dana-Farber Cancer Institute, Biostatistics

Yuval Kluger, New York University

PCARC2007

Christian Klingenberg , Bayerische-Julius-Maximilians-Universität Würzburg, Universitaet Wuerzburg

Harold Yorke, Jet Propulsion Laboratory, Astrophysics

Mark Morris, University of California, Los Angeles (UCLA), Physics & Astronomy

CMRC2007

Tom Chou, University of California, Los Angeles (UCLA), Mathematics

VS2008

Court Cutting, New York University, Plastic Surgery

Dwight Meglan, SimQuest LLC

Joseph Teran, University of California, Los Angeles (UCLA), Mathematics

Silvia Salinas-Blemker , University of Virginia, Mechanical and Aerospace Engineering

IMM2008

Alberto Bartesaghi, National Institute of Health NCI, National Cancer Institute

Guillermo Sapiro, University of Minnesota, Twin Cities

Jacqueline Milne, National Institutes of Health (NIH), Center for Cancer Research

Sriram Subramaniam, National Institutes of Health (NIH), Graduate Partnerships Program

SAGE2008

Craig Citro, University of California, Los Angeles (UCLA), Mathematics

Mike Hansen, Harvey Mudd College, Mathematics

Robert Miller, University of Washington, Mathematics

William Stein, University of Washington, Mathematics

EG2008

Alexander Gamburd, University of California, Santa Cruz (UC Santa Cruz)

Alexander Lubotzky, The Hebrew University of Jerusalem

Audrey Terras, University of California, San Diego (UCSD)

Avi Wigderson, Institute for Advanced Study

GC2008

Daniel Cremers , University of Bonn

Hiroshi Ishikawa, Nagoya City University

Jerome Darbon, University of California, Los Angeles (UCLA)

Stanley Osher, University of California, Los Angeles (UCLA), Mathematics

Vladimir Kolmogorov , University College London

Yuri Boykov, University of Western Ontario

OT2008

Andrea Bertozzi, University of California, Los Angeles (UCLA), Mathematics

Jean-Michel Morel, École Normale Supérieure de Cachan, CMLA

Jose Carrillo, Autonomous University of Barcelona, ICREA

Peter Markowich, University of Cambridge, Institute of Mathematics

Wilfrid Gangbo, Georgia Institute of Technology

Yann Brenier, Université de Nice Sophia Antipolis

OTTUT

Andrea Bertozzi, University of California, Los Angeles (UCLA), Mathematics

Jean-Michel Morel, École Normale Supérieure de Cachan, CMLA

Jose Carrillo, Autonomous University of Barcelona, ICREA

Peter Markowich, University of Cambridge, Institute of Mathematics

Wilfrid Gangbo, Georgia Institute of Technology

Yann Brenier, Université de Nice Sophia Antipolis

OTWS1

Craig Evans, University of California, Berkeley (UC Berkeley), Mathematics

José Carrillo, Autonomous University of Barcelona, ICREA

Luigi Ambrosio, Scuola Normale Superiore

Wilfrid Gangbo, Georgia Institute of Technology

Yann Brenier, Université de Nice Sophia Antipolis

OTWS2

Allen Tannenbaum, Georgia Institute of Technology, School of Electrical and Computer Engineering

Karl Glasner, University of Arizona

Richard Tsai, University of Texas at Austin, Mathematics

Yann Brenier, Université de Nice Sophia Antipolis

REAL2008

Joseph Teran, University of California, Los Angeles (UCLA), Mathematics

Luminita Vese, University of California, Los Angeles (UCLA), Mathematics

OTWS3

Andrea Bertozzi, University of California, Los Angeles (UCLA), Mathematics

Bjorn Birnir, University of California, Santa Barbara (UC Santa Barbara)

Dan Rothman, Massachusetts Institute of Technology

William Zame, University of California, Los Angeles (UCLA), Economics

OTWS4

Anne Marie Robertson, University of Pittsburgh, Engineering

Bertrand Maury, Université d'Orsay

Denis Grebenkov, École Polytechnique, Laboratoire de Physique de la Matiere Condensee

Suncica Canic, University of Houston, Mathematics

OTWS5

Peter Markowich, University of Cambridge, Institute of Mathematics

MARC2008

Cecilia Clementi, Rice University, Physics

Christian Ratsch, University of California, Los Angeles (UCLA), Institute for Pure and Applied Mathematics

Russel Caflisch, University of California, Los Angeles (UCLA), Mathematics and Materials Science

SCRC2008

Rafail Ostrovsky, University of California, Los Angeles (UCLA), Computer Science, Mathematics

RIPS2008

Maria D'Orsogna, California State University, Northridge (CSUN), Mathematics

Susana Serna, University of California, Los Angeles (UCLA), Mathematics

Xiaoqun Zhang, University of California, Los Angeles (UCLA), Mathematics

Jonathan Essen, University of California, Santa Barbara (UC Santa Barbara), Mathematics

Shawn Cokus, University of California, Los Angeles (UCLA), Molecular Biology

Matteo Pellegrini, University of California, Los Angeles (UCLA), Molecular Biology

Gunes Ercal-Ozkaya, University of California, Los Angeles (UCLA), Computer Science

Tamar Shinar, Stanford University, Scientific Computing

Sudhir Singh, University of California, Los Angeles (UCLA), Electrical Engineering

Tom Chou, University of California, Los Angeles (UCLA), Mathematics

Mark Coodey, Aerospace Corp

Mark Durst, Amgen

Egbert Tse, Arete

Martin Lo, Jet Propulsion Laboratory (JPL)

Wei Chen, Microsoft Research Asia

John Anderson, Pixar Animation Studios

Parag Mallick, The Spielberg Center for Applied Proteomics (Cedars-Sinai)

Darren Shou, Symantec

Don Lanzinger, Aerospace Corp

Gilles Gnacadja, Amgen

Eric Cheng, Arete

Geoffrey Irving, Pixar Animation Studios

Roland Luethy, The Spielberg Center for Applied Proteomics (Cedars-Sinai)

Tzi-cker Cheueh, Symantec

Michael Raugh, Interconnect Technologies

MBI2008

Jonathan Taylor, Stanford University, Statistics

Keith Worsley, University of Chicago, Department of Mathematics and Statistics

Michael Miller, Johns Hopkins University, Center for Imaging Science

Paul Thompson, University of California, Los Angeles (UCLA), Laboratory of NeuroImaging

Russell Poldrack, University of California, Los Angeles (UCLA), Psychology

Thomas Nichols, University of Oxford, GlaxoSmithKline Clinical Imaging Centre

NGA2008

Paul Salamonowicz , National Geospatial-Intelligence Agency

Robert Rand, National Geospatial-Intelligence Agency

MRA2008

Anna Gilbert, University of Michigan, Mathematics

Craig Partridge , BBN Technologies

John Doyle, California Institute of Technology, Control and Dynamical Systems

Matthew Roughan , University of Adelaide

Mauro Maggioni, Duke University, Mathematics and Computer Science

Paul Barford , University of Wisconsin-Madison, Computer Science

Walter Willinger, AT&T Technologies, Engineering Research Center, Mathematics

MRATUT

Anna Gilbert, University of Michigan, Mathematics

John Doyle, California Institute of Technology, Control and Dynamical Systems

Matthew Roughan , University of Adelaide

Mauro Maggioni, Duke University, Mathematics and Computer Science

Paul Barford , University of Wisconsin-Madison, Computer Science

Walter Willinger, AT&T Technologies, Engineering Research Center, Mathematics

MRAWS1

Anna Gilbert, University of Michigan, Mathematics

Mauro Maggioni, Duke University, Mathematics and Computer Science

Morley Mao, University of Michigan

Paul Barford , University of Wisconsin-Madison, Computer Science

Rob Nowak , University of Wisconsin-Madison

MRAWS2

Bill Aiello, University of British Columbia

Farnam Jahanian, University of Michigan, Electrical Engineering and Computer Science

Matthew Roughan , University of Adelaide

Mike Reiter , University of North Carolina

Niels Provos, University of Michigan

Paul Barford, University of Wisconsin-Madison

Tal Malkin , Columbia University, Computer Science Department

MRAWS3

Craig Partridge, BBN Technologies

David Alderson, Naval Postgraduate School, Operations Research Department

John Doyle, California Institute of Technology, Control and Dynamical Systems

Ramesh Govindan, University of Southern California (USC), Computer Science

Walter Willinger, AT&T Technologies, Engineering Research Center, Mathematics

MRAWS4

Anna Gilbert, University of Michigan, Mathematics

Denis Zorin, New York University

Matthew Roughan , University of Adelaide

Peter Jones, Yale University, Mathematics

Robert Calderbank, Princeton University

Steven Low, California Institute of Technology

RSRC2008

Peter Jones, Yale University, Mathematics

CMRC2008

Tom Chou, University of California, Los Angeles (UCLA), Mathematics

MG2009

Assaf Naor, New York University

Bruce Kleiner, Yale University

Manor Mendel, The Open University of Israel

Subhash Khot, New York University

Yuval Rabani, Technion - Israel Institute of Technology

QS2009

Guifre Vidal, University of Queensland

Simon Trebst, Microsoft Research, Station Q

Ulrich Schollwöck, RWTH Aachen

LE2009

Denis Grebenkov, École Polytechnique, Laboratoire de Physique de la Matiere Condensee

Naoki Saito, University of California, Davis (UC Davis), Mathematics

Peter Jones, Yale University, Mathematics

RE2009

Arthur Voter, Los Alamos National Laboratory, Theoretical Division

Christof Schuette, Freie Universität Berlin

Eric Vanden-Eijnden, New York University

Giovanni Ciccotti, Università di Roma "La Sapienza"

Ioannis Kevrekidis, Princeton University

Kristen Fichthorn, Pennsylvania State University

KT2009

Christian Ringhofer, Arizona State University, Department of Mathematics and Statistics

Dave Levermore , University of Maryland, Department of Mathematics

Eric Carlen , Rutgers University, Department of Mathematics

Frank Graziani, Lawrence Livermore National Laboratory

Irene Gamba, University of Texas at Austin

Karl Kempf, Intel Corporation

Marshall Slemrod, University of Wisconsin-Madison, Mathematics

Peter Markowich, University of Cambridge, Institute of Mathematics

Pierre Degond, Université de Toulouse III (Paul Sabatier)

Shi Jin , University of Wisconsin-Madison, Department of Mathematics

Stanley Osher, University of California, Los Angeles (UCLA), Mathematics

KTTUT

Christian Ringhofer, Arizona State University, Department of Mathematics and Statistics

Dave Levermore , University of Maryland, Department of Mathematics

Eric Carlen, Georgia Institute of Technology

Frank Graziani, Lawrence Livermore National Laboratory

Irene Gamba, University of Texas at Austin

Karl Kempf, Intel Corporation

Marshall Slemrod, University of Wisconsin-Madison, Mathematics

Peter Markowich, University of Cambridge, Institute of Mathematics

Pierre Degond, Université de Toulouse III (Paul Sabatier)

Shi Jin, University of Wisconsin-Madison, Department of Mathematics

Stanley Osher, University of California, Los Angeles (UCLA), Institute for Pure and Applied Mathematics

KTWS1

Anna-Karin Tornberg, Royal Institute of Technology (KTH), NADA

Bjorn Engquist, University of Texas at Austin

Caroline Lasser, Freie Universität Berlin

Frank Graziani, Lawrence Livermore National Laboratory

Pierre Degond, Université de Toulouse III (Paul Sabatier)

Shi Jin, University of Wisconsin-Madison, Department of Mathematics

KTWS2

Dave Levermore , University of Maryland, Department of Mathematics

Irene Gamba, University of Texas at Austin

Laure Saint Raymond, Université de Paris VI (Pierre et Marie Curie)

Marshall Slemrod, University of Wisconsin-Madison, Mathematics

Reinhard Illner, University of Victoria

KTWS3

Benedetto Piccoli, Consiglio Nazionale delle Ricerche (CNR)

Christian Ringhofer, Arizona State University, Department of Mathematics and Statistics

Karl Kempf, Intel Corporation

M. C. Carvalho, Georgia Institute of Technology, Mathematics

Stephan Mischler, Université de Paris IX (Paris-Dauphine)

KTWS4

Anne Nouri, Université d'Aix-Marseille I (Université de Provence)

Cederic Villani , École Normale Supérieure de Lyon

Eric Carlen, Rutgers University, Department of Mathematics

Irene Gamba, University of Texas at Austin

Mario Pulviventi , Università di Roma “La Sapienza”

Peter Markowich, University of Cambridge, Institute of Mathematics

Robert Pego , Carnegie-Mellon University

RIPS-Beijing

Hsiao-Wuen Hon, Microsoft Research Asia

Lolan Song, Microsoft Research Asia

CMA2009

Angelika Steger, ETH Zürich

Benjamin Sudakov, University of California, Los Angeles (UCLA)

Gil Kalai, Hebrew University, Institute of Mathematics

Janos Pach, New York University, EPFL- Lausanne

Noga Alon, Tel Aviv University

Terence Tao, University of California, Los Angeles (UCLA), Mathematics

Vera Sos, Hungarian Academy of Sciences (MTA)

CMATUT

Angelika Steger, ETH Zürich

Benjamin Sudakov, University of California, Los Angeles (UCLA)

Gil Kalai, Hebrew University

Janos Pach, New York University, EPFL- Lausanne

Noga Alon, Tel Aviv University

Terence Tao, University of California, Los Angeles (UCLA), Mathematics

Vera Sos, Hungarian Academy of Sciences (MTA)

CMAWS1

Alan Frieze, Carnegie-Mellon University, Mathematical Sciences

Angelika Steger, ETH Zürich

Benjamin Sudakov, University of California, Los Angeles (UCLA)

Nathan (Nati) Linial, Hebrew University, Computer Science

Prasad Tetali, Georgia Institute of Technology

CMAWS2

Alexander Barvinok, University of Michigan

Emo Welzl, ETH Zürich, Theoretical Computer Science

Gil Kalai, Hebrew University, Institute of Mathematics

Janos Pach, New York University, EPFL- Lausanne

Jozsef Solymosi, University of British Columbia, Mathematics

CMAWS3

Benjamin Sudakov, University of California, Los Angeles (UCLA), Mathematics

Dhruv Mubayi, University of Chicago

Jacques Verstraete, University of California, San Diego (UCSD)

Penny Haxell, University of Waterloo, Mathematics

Vera Sos, Hungarian Academy of Sciences (MTA)

CMAWS4

Alex Samorodnitsky, Hebrew University

Ben Green, University of Cambridge

Gil Kalai, Hebrew University, Institute of Mathematics

Irit Dinur, Weizmann Institute of Science

Terence Tao, University of California, Los Angeles (UCLA), Mathematics

Van Vu, Rutgers University, Mathematics

CL2010

Bjorn Stevens, University of California, Los Angeles (UCLA), Atmospheric & Ocean Sciences

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Deborah Estrin, University of California, Los Angeles (UCLA), Computer Science

Matthew Fisher, University of California, Santa Barbara (UC Santa Barbara), Physics, KITP

Irene Gamba, Univ of Texas, Austin, Mathematics

Ronald Graham, University of California, San Diego (UCSD), Computer Science and Engineering

Peter Wilcox Jones, Yale University, Mathematics

Doug Lauffenburger, CSBi, Massachusetts Institute of Technology, Biological Engineering

Stanley Osher, University of California, Los Angeles (UCLA), Mathematics

Christian Ratsch, University of California, Los Angeles (UCLA), Physics

Ken Ribet, University of California, Berkeley (UC Berkeley), Mathematics

Terence Tao, University of California, Los Angeles (UCLA), Mathematics

Simon Tavaré, University of Southern California (USC), Mathematics

Gang Tian, Massachusetts Institute of Technology, Mathematics

Grace Wahba, University of Wisconsin - Madison, Statistics

Andrew Yao, Princeton, Computer Science

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Mac Hyman, Los Alamos National Lab

Linda Keen, Lehman College, CUNY, Mathematics

Cleve Moler, MathWorks, Inc.

Arlie Petters, Duke University, Mathematics

Harry Shum, Microsoft Research Asia

GENERAL

Jason Cong, University of California, Los Angeles (UCLA)

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Warren Mori, University of California, Los Angeles (UCLA), IDRE

Charles Doering, University of Michigan, Mathematics

Irene Fonseca, Carnegie-Mellon University, Mathematics

Christoph Thiele, University of California, Los Angeles (UCLA), Mathematics

Mikhail Belkin, Ohio State University, Computer Science

Arvind Gupta, MITACS

James Lake, University of California, Los Angeles (UCLA), Human Genetics

Laina Long, University of California, Los Angeles (UCLA)

Heather Calahan, University of California, Los Angeles (UCLA), Mathematics

Kristin Lauter, Microsoft

Adam Smith, Pennsylvania State University

Andrea Bertozzi, University of California, Los Angeles (UCLA)

Nassif Ghoussoub, University of British Columbia

Heather Tarleton, University of California, Los Angeles (UCLA), Curtis Center for Mathematics Education

Harold Yorke, Jet Propulsion Laboratory (JPL)

Michael Knoelker, National Center for Atmospheric Research (NCAR)

L. PUBLICATIONS LIST

A list of publications, presentations and patents of our participants (self-reported) is provided as an appendix.

M. INDUSTRIAL AND GOVERNMENTAL INVOLVEMENT

IPAM received a $123K, 3-year grant from NSF's International Research Experiences for Students (IRES) program to run RIPS-Beijing for three years in partnership with Microsoft Research Asia (MSRA). We were unable to run the program in 2008 due to the Olympics; instead, to continue the relationship, MSRA sponsored a project in IPAM's RIPS-LA program.

We have significant involvement of industry and government labs in our summer program, Research in Industrial Projects for Students (RIPS). See the program description for this program on page 38-39 for a complete list of sponsors. The Aerospace Corporation sponsored a project in RIPS-LA for the first time. A representative of Google was invited to and attended Projects Day; we expect them to sponsor a project next year.

Finally, IPAM received a contract and organized a series of workshops with the National Geospatial Intelligence Agency, two of which were held in 2007-2008, and a third is planned for the coming academic year.

Several members of industry and government labs serve on IPAM's boards, and many attend IPAM programs. Here are some comments from some of them, as well as a few examples of collaborations that have emerged as a result of their participation:

Leon Bottou (NEC Research Institute): "The quality of the workshop I attended (SEWS2) was extremely high. It is always a positive experience to benefit from such a concentration of good presentations and top notch expertise."

Kevin Boyack (SciTech Strategies, Inc.): "I started a collaboration with Johan Bollen of LANL as a result of our meeting at IPAM."

Anthony Davis (Los Alamos National Laboratory) TR2004, CMT2006: "Coming from atmospheric radiation transport theory, I have now started to interact with several of my colleagues from the neutron transport community, for our mutual benefit."

"I now identify myself more as a transport theoretician that happens to work in atmspheric applications, rather than an atmospheric scientist that uses radiative transfer theory. This opens many new possibilities. Recently, I have been approached to be on the technical committee of a nuclear engineering conference."

Nick Gentile (Lawrence Livermore National Laboratory): “My collaborations on developing parallel Monte Carlo algorithms grew out of contacts that occurred at the IPAM sponsored Granlibakken conference on Radiation Transport, as did collaborations on radiation transport test problems.”

“The Granlibakken conference has enhanced two important collaborations, and resulted in the publication of four papers. it also provides an opportunity for many stimulating discussions, and provides an important opportunity to see an overview of computational radiation transport developments in many fields.”

Martin Peters (Springer-Verlag): “The IPAM workshop on cryptography topics led to a multi-author book on the future of cryptography with the title, Post-quantum Cryptography, edited by Johannes Buchmann et al, which is scheduled to appear later this year.”

“IPAM visits have been excellent to learn about cross-disciplinary topics where mathematics plays a role. This is important for developing Springer's program in these fields. Of all similar institutes, I find IPAM to be the one which best cover newly emerging, cross-disciplinary topics.”

Knut Waagan (National Center of Atmospheric Reseach), PCA2005: “My first postdoc position came about as a direct consequence of the IPAM program on computational astrophysics.”

N. EXTERNAL SUPPORT

In addition to the funding listed in Table N-1 below, IPAM receives substantial in-kind financial support from UCLA and other elsewhere. The Director’s entire salary is paid directly by UCLA, the Director of Special Projects is released from two courses at the cost of replacing him by a junior person, and IPAM is not charged for the use of its building or for custodial care. The value of these three items is approximately $800K. Additionally, senior long-term participants from other universities are usually funded on a replacement-buyout basis, by which they are released from teaching for the cost of hiring a junior person as a replacement.

Table N: Other Funding Support, 2007 to 2008

Federal Grants	**Year**	**Amount**
NSF- IRES RIPS Beijing China	2009	41,000.00
NSF- IRES RIPS BeijingChina	2010	41,000.00
Sub-total		82,000.00
University Funding Support		
Dean Physical Sciences Support	2007-2008	60,000.00
Dean Physical Sciences Matching 1/2 IT Wages	2007-2008	43,354.00
Vice Chancellor 's Support	2007-2008	60,000.00
Sub-total		163,354.00
Industrial Affiliates Support		
Aerospace	2007-2008	10,000.00
Amgen	2007-2008	10,000.00
Cedars-Sinai	2007-2008	10,000.00
JPL	2007-2008	6,650.00
Pixar -Disney	2007-2008	10,000.00
Microsoft	2007-2008	10,000.00
Symantec	2007-2008	10,000.00
Sub-total		66,650.00
Others		
Registration Fees-Programs	2008	48,546.00
*UCLA NIH NITP - Miller & Poldrack	2008	12,721.00
Green Family Lectureship Foundation	2008	150,000.00
UCLA NIH - Toga	2008	14,040.00
Johns Hopkins	2007-2008	6,780.00
J.B. Berland Foundation	2008	13,000.00
Sub-total		245,087.00
TOTAL		**$557,091.00**

O. COMMITTEE MEMBERSHIP

IPAM's committees include the Board of Trustees, Science Advisory Board, and Human Resources Committee. A Director Search Committee was formed in December 2006 and served until June when the position was filled. The members of each as of August 1, 2008 are listed here.

Science Advisory Board

Russel Caflisch (Director, IPAM)

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Matthew Fisher (Institute for Theoretical Physics, UCSB)
Irene Gamba (Mathematics, Univ of Texas)
Mark Green (UCLA, Mathematics)
Peter W. Jones-Chair (Mathematics, Yale)
David Levermore (Mathematics, University of Maryland)
Yann LeCun (Computer Science, New York University)
Assaf Naor (Mathematics and Computer Science, New York University)
Stanley Osher (UCLA, IPAM)
Christian Ratsch (UCLA, IPAM)
Kenneth Ribet (Mathematics, Berkeley)
Terence Tao (Mathematics, UCLA)

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Russel Caflisch (Director, IPAM)
Mark Green (UCLA, Mathematics)
Stu Feldman (IBM)
Mac Hyman-Chair (Los Alamos National Lab)
Linda Keen (Lehman College, CUNY, Mathematics)
Cleve Moler (MathWorks, Inc.)
Stanley Osher (UCLA, Mathematics and IPAM)
Arlie Petters (Duke University, Mathematics)
Christian Ratsch (UCLA, IPAM)
Leonard Rome (UCLA, Biological Chemistry)
Linda Rothschild (UCSD, Mathematics)
Harry Shum (Microsoft Research Asia)

Director Search Committee

Deborah Estrin (UCLA, Computer Science)
Mark Green, Advisor (IPAM)
James (Mac) Hyman, co-chair (Los Alamos National Laboratory)
Peter W. Jones (Yale, Mathematics)
Linda Keen (Lehman College CUNY, Mathematics)
Stanley Osher (IPAM)
Christoph Thiele, co-chair (UCLA, Department of Mathematics Chair)

P. CONTINUING IMPACT OF PAST IPAM PROGRAMS

IPAM chose to add this section which was not requested by NSF. Here are a few comments from participants of programs prior to the past academic year that testify to the continuing impact their participation had made on their careers and research. A few examples of new collaborations are also reported.

William Allard (Duke): “I first met Mauro Maggion at IPAM two years ago. I managed to persuade our department to hire him and am discussing various mathematical matters with him with an eye toward future collaboration. Also, I have gotten to know many other mathematicians, pure and applied, as a result of my visits to IPAM.”

William Allard (Duke): “My time at IPAM has greatly expanded my perspectives on pure and applied mathematics, which I think were pretty broad to begin with. The workshops have allowed me to attain a working knowledge of several areas of mathematics that are extremely interesting (e.g. compressed sensing) which I could not have attained, practically speaking, any other way. I have the highest opinion of the individuals who direct IPAM, in particular Peter Jones. In my opinion they are doing a fantastic job of bringing together the best of pure analysis with many compelling real world applications.”

Brian Avants (Pennsylvania, Bioengineering) MBI2004: “We instituted a UPenn-UCLA CCB collaboration entitled "Shape optimizing diffeomorphisms for computational anatomy."
“My involvement with IPAM encouraged a continued commitment to medical image quantification and rigorous technical development. At the same time, my experience with IPAM highlighted the value of developing techniques with specific clinical applications in mind.”

Joel Bader (Johns Hopkins) CM: “IPAM has been very helpful in giving a stronger mathematical and theoretical basis to problems that my group works on. In several cases the theoretical understanding has led to important practical performance gains for algorithms designed to analyze biological networks.”

Peter Battaglia (Minnesota, Twin Cities, Psychology) GSS2007: “It was a fantastic experience, I would recommend it to everyone. I have a much more solid understanding of probabilistic modeling and a variety of machine learning techniques.”

Natth Bejraburnin (Stanford) RIPS2007: “During my stay at IPAM, I was greatly exposed to a research topic in Computer Science, which is data mining. This topic has been of my interest since. In the academic year to follow, I have been always looking for opportunities to do research more on data mining projects.”

John Benedetto (Maryland), NGA2007: “Thanks to our visit to IPAM we have started collaborations with D. Gillis of NRL, B. Olshausen of UC Berkley, and A. Banerjee of Johns Hopkins University.”

David Buchanan (Brown, Cognitive and Linguistic Sciences) GSS2007: “I am beginning a modeling collaboration which began at IPAM, after a discussion about applying some of the ideas presented to causal reasoning.”
“My goal is to become versed in both experimental psychology and probabilistic models of cognition. This workshop provided essential training for me, much of which was not available at my home university. Thanks to this summer school, I was able to get the grounding that I needed in order to begin producing computational models.”

Eric Buchlin (Université Paris-Sud 11 Institut d'Astrophysique Spatiale), PCA2005 ; "Continuous collaboration with Marco Velli. I also got acquainted with numerical code presented by Axel Brandenburg."
"Helped development of my numerical code and broadened my perception of numerics in astrophysics."

Martin Burger (UCLA): "Collaboration with Bo Su (GBM Reunion 2002) on the analysis of nonlocal geometric motion laws in polymers. With Marc Droske (Inverse Problems 2003) on image processing, via Marc Droske with Martin Rumpf and others. I also worked with Bob Eisenberg and Heinz Engl (Inverse Problems 2003) on ion channels, Hend Benameur on inverse problems in elasticity (Inverse Problems 2003), Axel Voigt (Multiscale Analysis 2005) on surface diffusion and on BCF-Models, Ronny Ramlau on image processing (Inverse Problems 2003-2006), and Chiu-Yen Kao (GBM 2002) on optimization with level sets. Various collaborations not directly leading to papers but to later visits or other joint activities such as seminars and workshops included Guillaume Bal, Antonin Chambolle, Joyce McLaughlin, Frank Natterer (Inverse Problems 2003-2006), Omar Lakkis, Kenneth Karlsen, Richard Tsai, and Hongkai Zhao (GBM 2002, 2003)."

"My involvement with IPAM has been beneficial for my career and research in many ways. First of all, the programs I attended at IPAM have always be extremely stimulating for my research, and I learned a lot that influenced my research direction, e.g. about geometric motion in 2002 and multiscale analysis techniques in 2005, both later becoming more important in my research. Moreover, my involvement with IPAM has always been a very positive point for hiring committees, and finally I received a call to one of the most interesting chairs for inverse problems at the age of 29 after participating in various IPAM programmes on that subject! And there were various very indirect effects. E.g. I met Kenneth Karlsen at GBM Reunion 2002, where I talked on inverse problems. He later recommended me as a speaker in Norway, so I became a key speaker of a very interesting winter school in 2005. There are several other stories of this kind. I currently also benefit from IPAM indirectly, via students that get the chance to participate at IPAM programmes (e.g. RIPS or special semesters). Let me also say that various pdfs / ppt files of talks that are put on the IPAM webages are of great interest for myself and my students, e.g. currently the optimal transport tutorials. Hence, the positively affect my research."

Owen Carmichael (UC Davis, Neurology and Computer Science) MBI2004 "The IPAM workshops helped me to very quickly get an understanding of the state of the art mathematical methods in brain imaging. It is a unique setting for coming to grips with the fundamental mathematical issues currently under study."

Dale Durran (Washington, Atmospheric Sciences)MAMAOS2003: "It prompted me to take a close look at WENO schemes, which turned out to have nice properties for Atmospheric Science, except that they were too computationally inefficient. The essence of the WENO strategy was distilled into the more efficient scheme presented in the JCP article that is now in press."

Henk Elffers (Netherlands Institute for the Study of Crime and Law Enforcement) CHS2007: "IPAM helped me strenghtened ties with various researchers in spatial criminology, including the mathematical study of methods in this field, from US, UK, Australiea and the Netherlands."

Marcus Felson (Rutgers University-Newark) CHS2007 "The main results of speaking at IPAM were invitations to present similar work to an applied math group at Rutgers -New Brunswick (DIMACS)an another next week to an applied math conference in Pisa, Italy. I also presented to a group of crime analysts in Pasadena, some of whom heard me at IPAM."

William Foster (Houston), CM2006: "Collaboration with members of the Institute of Engineering in Medicine at Penn, some of whom attended IPAM. I have also developed a productive collaboration and obtained funding from the National Academies Keck Futures Grant program. Also ongoing collaboration with Tom Chou, a participant in the IPAM program, whereby he provides theoretical support for my experimental research program. I have visited the lab of and had numerous helpful discussions with Robert Rafael, another participant at IPAM."

"My participation in the IPAM program helped me to re-integrate into the scientific community following a hiatus to attend medical school and complete clinical training, to obtain grant funding, and to re-acquaint myself with colleagues after a hiatus to attend medical school and complete my clinical training."

K. Gopalakrishnan (East Carolina) SC2006: "My involvement with IPAM has definitely reinvigorated my committment to research in Cryptography and Information Security. I teach at a small university and we don't even have weekly colloquiums in my department. Further there is no one around my university with interests in cryptography. Hence, I was very much isolated. Coming to IPAM and attending the SC 2006 program has definitely helped me to keep abreast of the current trends and happenings in the field. It helped me to motivate myself to do good work in the field. I personally feel that my IPAM visit was a definite turning point in my career. I published a paper that was completed during my stay at IPAM and am working on two other different project inspired by the IPAM visit. They are on secret sharing schemes, bit committment schemes and private information retrieval. I intend to acknowledge IPAM if and when these projects get completed and become full length papers."

Daniel Holcomb (Massachusetts, Amherst, Electrical and Computer Engineering) SC2006: "IPAM has helped guide me towards a career in security. This guidance was especially helpful, as I am an MS student, and the workshop occurred at the same time that I was applying to PhD programs. It helped me to decide to pursue a PhD, and to pursue one at UC Berkeley. It was great that IPAM allowed such a junior researcher to attend."

Jonathan Katz (Maryland) SC2006, CM2006: "I initiated collaborations with Vipul Goyal, a graduate student at UCLA who was visiting IPAM during this time. This led to a paper that is currently under submission. I also had the chance to meet and work with numerous other researchers including Yuval Ishai and Eyal Kushilevitz."

"My time at IPAM was an incredible chance to focus solely on research for a semester, and to be able to do so in a nurturing environment surrounded by outstanding researchers from around the world. It was an amazingly productive time for me, leading directly or indirectly to many publications. I also feel that I learned a lot from the weekly seminars as well as the four workshops that were held throughout the semester."

Konrad Koerding (Northwestern University Medical School) GSS2007: “I recruited the lecturers for a recent winter school from the speakers at IPAM.”

Petko Kusev (City University, Psychology) GSS2007: “Collaboration with Professor Craig Fox from UCLA in the are of judgment and decision-making, in particular, memory-biased preferences.”

“New research grant: The British Academy award. Research fellow and Co-investigator. Memory-biased preferences: The influence of accessibility on risky decision-making.”

Lei Li (USC, Computational Biology) FG2000, PROT2004, SEQ2006 “Since my involvement at IPAM, I established several fruitful collaborations in computational biology and functional genomics. Some collaborative projects are as follows: yeast aging project with Dr. V. Longo; Diploid sequencing project, with Dr. Waterman; optical mapping, Dr. Schwartz and Dr. Waterman; and biological boolean network, with Dr. Lu.”

“After the participation with IPAM, I switched my department from traditional statistics department to joint appointment with biology and mathematics. My work are not published in computational biology, genomics and statistics.”

Sharon Lubkin (North Carolina State) CM2006: “I got to know James Glazier, and I am now using his method in my own research. This method in turn has formed the basis of undergraduate research projects for 6 students and one publication in review.”

Dionisios Margetis (Maryland) MA2005: “My involvement with IPAM has helped my career tremendously in several ways. When I visited IPAM in Fall 2005 I was only an instructor in applied mathematics. My participation in the 3-month IPAM workshop in Bridging Time and Length Scales, September-December 2005, as an invited speaker and attendant, preceded my search and interviews for tenure-track faculty positions (January-March 2006). My active participation, interactions and networking with other participants at IPAM contributed to: (i) an improvement of my understanding of epitaxial phenomena; and (ii) additional interviews that I got for faculty positions. Finally, I had various offers of faculty positions in the spring 2006. Today I am an assistant professor of mathematics at the University of Maryland, College Park. Most recently, I developed a collaboration with Prof. M. Scheffler, which started at the reunion conference at IPAM, Lake Arrowhead, in June 2007. This collaboration has led us -- jointly with the surface scientist Dr. H. P. Bonzel -- to surprisingly interesting results. These results emphasize the importance of quantum effects on macroscopic surface energies. Preliminary findings have pointed to new problems in my research at the interface of physics and math. Specifically, I now try to re-direct my research towards linking atomistic theories such as Density Functional Theory (DFT) with macroscopic equations (PDEs) for crystal surfaces.”

Ifeanyi Ogueli (Galenica Senese. Nigeria) PROT2004: “Due to my stay at IPAM, I established a collaboration with Professor Joseph Loo of the UCLA Proteomics core facility. We worked briefly on the De novo sequencing of a protein we believe inhibits the activity of snake venom, and later initiated another one with Prof Paul Bajaj both of UCLA. I was also opportuned to meet Professor Paul Bajaj of the Orthopedic Surgery Department in the same workshop, and again at the Proteomics reunion workshop at Lake Arrowhead. It was during the meeting at Lake

Arrowhead that I learnt more about Professor Bajaj's research and we worked out the possibility of assaying the protease specificity of the protease inhibitor from the aqueous protein extract of the plant I am working with, with the hope of crystalize the protein."

Vidvuds Ozolins (UCLA) NANO2002: "My involvement with IPAM has greatly influenced my career. It has enabled me to find collaborations in the area of crystal structure prediction and global optimization, which are both very important for the computational discovery of new materials in my research group."

Fernando Perez (Colorado) MGA2004: "While at IPAM I became aware for the first time of the work done by Coifman, Maggioni et al on diffusion geometries. I am currently developing an application of these ideas to problems in brain imaging, and was invited to present a full proposal to the NSF CDI initiative (after successful review of the short proposal). I can most definitely say that my IPAM visit has thus continued to pay dividends long after its conclusion, and I hope to return to IPAM again in the future for similar programs."

Nikodem Poplawski (Indiana, Department of Physics and Biocomplexity Institute) CM2006: "Collaboration with Alexander R. A. Anderson on simulating tumor growth and studying the effects of surface tension on tumor morphologies."

"My participation in workshops organized by IPAM in spring 2006 resulted in research on mathematical modeling of biofilms and tumors, and relating their pattern formation to physical phenomena, thus bridging the fields of physics and mathematical biology."

Sergey Prants (Pacific Oceanological Institute of the Russian Academy of Sciences) SGP2003: "My collaboration with Prof. G. Zaslavsky and his group at the New York University and Courant Institute of Mathematical Sciences has grown out of my stay at IPAM in 2003 and 2005. Now, in 2008, we are preparing a book on ray and wave chaos in underwater acoustics."

Peter Smereka (Michigan) Nano2002, MA2005, CM2006: "I have been fortunate to have attended a number of IPAM workshops and been a long term visitor on two occasions. I feel that the IPAM has had a significant influence on my research over the years. My work on epitaxial growth has been shaped by various IPAM workshops and dicussions that have occurred while visiting. Finally IPAM provides a nice atmosphere in which to work."

Adam Smith (MIT, CS) SC2006: "The stay at IPAM was a wonderful opportunity both to get up to date on the latest developments in my field and also dedicate a block of time to focused research. The paper "Smooth Sensitivity and Sampling in Private Data Analysis", written with Kobbi Nissim and Sofya Raskhodnikova while were at IPAM, has been the starting point for much of the research I have done in subsequent years. My stay at IPAM provided vital impetus for my research program at a critical time: I started a faculty position immediately after the semester at IPAM, and my visit meant I had a list of interesting questions just waiting for investigation."

Andrew Stuart (Warwick) DA2005, RE2009: “The workshop on the mathematics of data assimilation has been an impetus for me to initiate a research program aimed at developing the mathematical foundations of this important field.”

Terence Tao (UCLA) many programs: “A new project with Yehuda Shalom on making Gromov's theorem on groups of polynomial growth quantitative.”

Dimitri Vvedensky (Imperial, Physics)GBM2001, Nano2002, MA2005: “New collaboration with Dr. Carrie Salafia on modelling the vascular structure of the human placenta as well as working on a new project with Russ Caflisch on applying the renormalization group to problems in plasma physics.”
“Both new projects described above are new directions. The project with Dr. Salafia, in particular, represents a major change of direction.”

David Wales (Cambridge, Chemistry) MA2005: “Collaboration with Mike Prentiss from Peter Wolynes' group in San Diego. I also worked with Elena Koslover, who attended my IPAM lectures, then came to Cambridge for a year as an MPhil student.“
“IPAM has led to work on protein structure prediction using global optimisation.”

Jeffrey Walker (Arkansas, Little Rock, Criminal Justice) CHS2007: “I continue to work with Paul and Pat Brantingham and others I got to know at IPAM.”
“My time at IPAM continues to play a significant part in my career. When I came there, I was looking for ways to integrate the substantial work in neighborhoods and crime with the methods and theory of complex systems science. I was able to advance my thinking there and to make important contacts with mathematicians and others who could further my though process. As an outgrowth of that work, I developed a new theory of crime (still in its infancy) called Ecodynamics Theory. I introduced the theory at my presidential address last March when I was president of the Academy of Criminal Justice Sciences (the national criminal justice academic organization).”

Comments from previous RIPS participants:

Thibaut Allemand (École Normale Supérieure de Cachan, France): “I have been involved in the RIPS program at IPAM. This gave me some insights to what actually are applied mathematics; as I liked it, I am currently an applied maths PhD student.”

Wai Sun Don (Lawrence Libermore National Laboratory) RIPS2003 (industry mentor): “IPAM has been intructmental in preparating and encouraging the student participants in pursuing their career in higher education and research in applied mathematics. IPAM has been very successful in obtaining its objectives in this regard. One of the past student participants, an American, under my mentor will soon obtain his PhD from the Div. of Applied Mathematics as a result of his participation in IPAM summer program.”

Jonathan Essen (Principia College, Math & Physics) RIPS2006, RIPS2008 (faculty mentor): “I was hired to work with Martin Lo, my RIPS project mentor, at Jet Propulsion Laboratory from October 2006 to August 2007. With his guidance, I applied and was accepted to the physics

department at UCSB beginning the Fall of 2007. This summer, I plan to work as a project mentor for the RIPS program."

"My summer at IPAM has had a great impact on my career. Because of that summer research, I have focused my interests in the direction of theoretical physics, gained confidence in my ability to do quality research with my peers, obtained a job at JPL with my project mentor, and was accepted to an excellent graduate program in physics at UCSB."

Jason Gertz (Cornell) RIPS2002, GSS2005: "I will be receiving my PhD in Computational Biology from Washingington University School of Medicine this year. IPAM has had a large impact on my career. After attending RIPS, it became clear that I wanted to pursue research in computational biology. I think that my experience at IPAM prepared me for graduate school. I am certain that my RIPS success led directly to me receiving an NSF graduate research fellowship. Attending the graduate summer school at IPAM also enhanced and broadened my graduate research."

Tag Hogg (Hawlett Packard Laboratories) NANO2003, RIPS2005 (industry mentor): "IPAM has helped expose me to people and results in different fields, particularly related to swarm behaviors in biological and mathematical systems, and fluid dynamics relevant for nanotechnology applications."

Gitendra Malla (Gettysburg College) RIPS2006: "I made a lot of friends during my stay at IPAM. I am still in touch with most of them. My mentor - Yanina Landa from UCLA has been especially helpful during my graduate school applications and job search. She has provided me with valuable recommendations and reference letters. The fact that she is so readily available for any help, in or outside academia is amazing. I am hoping that we could work on a similar project like last summer in the future too."

"My involvement with IPAM definitely helped me identify my graduate school topic of research. I was new to the field of Artificial Intelligence and Robotics when I came to join the program at IPAM. But here I came to see a lot of exciting opportunities and possibilites for research in this area, which helped a lot with my decision to apply for the jobs and PhD programs. I have applied and been accepted to programs ranging from Systems Engineering in Software Engineering to Information Systems that make use of Artificial Intelligence."