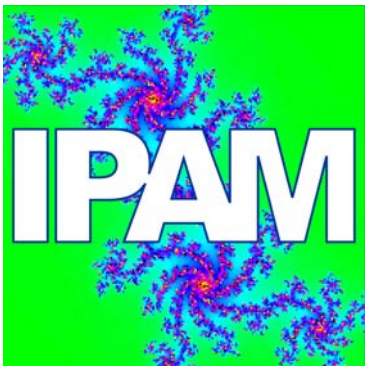

Institute for Pure and Applied Mathematics
at the University of California Los Angeles

Annual Progress Report
NSF Award/Institution #0439872-013151000
Submitted November 30, 2007

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EXECUTIVE SUMMARY

Highlights of IPAM's 2006-2007 fiscal year include the following:

- This year's two long programs were highly successful and well-attended:
  - Securing Cyberspace: Applications and Foundations of Cryptography and Computer Security
  - Random Shapes
- IPAM's Winter workshops continued the tradition of focusing on emerging topics where Mathematics is playing an important role:
  - Mathematical Challenges and Opportunities in Sensor Networking
  - Crime Hot Spots: Behavioral, Computational and Mathematical Models
  - Small Scales and Extreme Events: The Hurricane
  - Topological Quantum Computation
- There were two very successful Affiliates workshops:
  - Satisfiability Solvers and Program Verification (Microsoft)
  - Computational Methods in Transport (Lawrence Livermore)
- New long programs were approved:
  - F'08 Internet Multiresolution Analysis: Foundations, Applications and Practices
  - S'09 Quantum and Kinetic Transport Equations: Analysis, Computations and New Applications
- New 5-day workshops were approved for W'08:
  - 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 inaugurated a program of public lectures, featuring distinguished mathematicians and scientists who were present at IPAM programs. The first three speakers were Kerry Emmanuel on hurricanes, Michael Freedman on topological quantum computing, and Benoit Mandelbrot on roughness in mathematics and science. The number of attendees ranged from 200 to 375.
- RIPS maintained its steady-state number of 9 projects in 2007. Applications to RIPS 2007 increased from 225 to 293. RIPS Beijing launched on schedule this summer, with a 3-year NSF IRES grant of $143K. A program inspired by RIPS, the British Columbia Summer School in Industrial Mathematics, begins operations at Simon Fraser University under the auspices of MITACS.
- IPAM's Summer School for 2007, "Probabilistic Models of Cognition: The Mathematics of Mind," received 231 applications for support from graduate students and postdocs in Mathematics, Statistics, Cognitive Science, Neuroscience, and Psychology, and was attended by over 200 people. It received $100K in additional funding from NSF's

Division of Research on Learning in Formal and Informal Settings, and an additional $25K as an anonymous foundation grant.

- IPAM ran a short course in May on “Sparse Representations and High-Dimensional Geometry” to provide an introduction for junior participants with early-career speakers as preparation for the American Math Society’s von Neumann Lectures this summer.
- Richard Baraniuk's work using Compressive Sensing, which grew out of the Candes-Romberg-Tao work done during IPAM's "Multiscale Geometry and Analysis in High Dimensions" program in 2004 at which Rich was a participant, was cited by Technology Review as one of their "10 Emerging Technologies, 2007" which are the 10 advances they consider "most likely to alter industries, fields of research, and even the way we live." There are multiple potential industrial applications of compressive sensing, and the article focuses especially on the fact that it provides a completely new way for digital cameras to work.
- Felix Herrmann received over $1.65 million in funding from government and industry to continue his work on seismic imaging resulting from IPAM’s “Multiscale Geometry and Analysis in High Dimensions” program.
- The UCLA Mathematics Department won the AMS Exemplary Mathematics Program Award for 2007. IPAM is cited prominently in the award: “UCLA is home to the Institute for Pure and Applied Mathematics, which was conceived of by faculty from the department and founded as a result of a national competition. IPAM is known for its innovative interdisciplinary programming, for example the Research in Industrial Projects for Students (RIPS) Program. Interactions with IPAM have also led to several important initiatives, such as one of the National Institutes of Health’s initial round of "roadmap" institutes, the Center for Computational Biology.”
- A special issue of *Trends in Cognitive Science* in July 2006 was dedicated to IPAM’s “Probabilistic Models of Cognition” workshop
- A special semester on “Inverse Problems in Life Sciences” at the Radon Institute in Linz, Austria will follow up IPAM’s Inverse Problems Long Program
- The “Cambridge N-Body School,” sponsored by the Royal Astronomical Society, will follow up IPAM’s “N-body Problems in Astrophysics” workshop
- MITACS was awarded a $1.1 million Canadian grant from NSERC for international collaborations, with 4 international partners. IPAM was selected by MITACS as its US partner.
- IPAM was selected to represent UCLA at the Coalition for National Science Funding (CNSF) Exhibition and Reception on June 26 in Washington, D.C. The event showcases the crucial role NSF plays in supporting basic scientific research and education. IPAM presented their exhibit “Training Young Scientists for the Real World: From Hollywood to National Security” to members of Congress and their staff.
- The National Geospatial-Intelligence Agency (NGA) chose IPAM to host a series of three workshops on the topic “Advancing the Automation of Image Analysis” for their grantees and invited guests. The first of the workshops was held Oct. 30- Nov. 1, 2007.
- Mark Green will step down as Director in July 2008. Search process is under way, with a position authorized for the next Director by the university.

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, 2006 and July 31, 2007. We chose to include the participants of RIPS-LA and RIPS-Beijing 2007, which started in June 2007 but ended after July 31, 2007.

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, 2006 and July 31, 2006. We chose to include all financial transactions related to RIPS-LA and RIPS-Beijing 2007, which started in June 2007 but ended after July 31, 2007.

C. INCOME AND EXPENDITURE REPORT

Budget Category	Appropriation Yrs 1 & 2	Expenditures as of July 2007	Balance as of July 2007	Modified Total Direct Cost (MTDC) Carry Forward	Modified Total Indirect Cost (MTIDC) Carry Forward	TOTAL
A. Operational Fund	3,358,694.00	2,034,746.65	1,323,947.35	863,100.73	460,846.62	1,323,947.35
B. Participant Cost	3,441,306.00	3,363,428.84	77,877.16	77,877.16		77,877.16
2-Year Total Budget	6,800,000.00	5,398,175.49	1,401,824.51	940,977.89	460,846.62	1,401,824.51

In the renewed grant, IPAM has received 2 years of funding with a total of $6.8M. Since we have been using the carry-forward from year 1 of approximately $2,128,026 (combined balance from the previous five-year grant) towards our 2006-2007 programs, the budget for the second year of the current grant is partially spent with a balance as of July 31, 2007 as carry-forward to year 3.

Expenditures up to July 31, 2007

A. The Operational fund (salaries, benefits, equipment, supplies, and travel including overhead) for 2-year budget has appropriation of 3,358,694 with total expenditures of $2,034,747 has a balance of $1,323,947.

B. Participant Cost Category (short and long programs) for 2-year budget has appropriation of 3,441,306 with total expenditures of $3,363,429. This amount covered overall 2 years programs from August 2005 until July 2007; simultaneous programs from June 2007 to Aug 2007 for RIPS07 in Los Angeles and partial costs RIPS07 in Beijing (new program); and a 3-week long Graduate Summer School program in July 2007. This category has a carry forward balance of $77,877.

The combined expenditures of operational fund and participant cost category will result in carry-forward funds @ $1,401,825 (or $940,978 modified total direct cost) to be used as follows:

A. To augment operational fund category for salaries, benefits, equipment, supplies, and travel expenses. IPAM accumulated approximately 85% of salary savings for 4 FTE positions that were not filled for 6-10 months. The same salary savings will cover for the 3 newly hired staff and 1 person to be hired. The overall carry forward will cover for cost of living and merit increase at university set rate of 4% for the next 3 years. About 15% of the carry forward will be used for much needed computer system upgrade; supplies and materials; and travel for directors/senior staff. The carry forward amount of $1,323,947 has an actual balance of $863,101 (modified total direct cost) with corresponding indirect cost of approximately $460,847. This will sustain and support the growing needs of IPAM's programmatic structure.

B. To augment the participant cost for 2008 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 successful programs. The carry forward amount will be used towards continuation of programs such as RIPS-IRES (for 10 US students and 4 mentors), and Graduate Summer School workshop. It is anticipated that the carry forward from the previous years will cover the overall cost of additional programs for the housing and travel costs which have increased by 25-30% in the West Los Angeles area. With the growth of the programs and increasing costs, the carry-forward of $77,877 will help sustain the program costs.

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 Minutes of the NSF Math Institute Directors, held on May 11-12, 2007

In attendance:

Doug Arnold	IMA	arnold@ima.umn.edu
Jim Berger	SAMSI	berger@samsi.info
Jean Bourgain	IAS	bourgain@ias.edu
Brian Conrey	AIM	conrey@aimath.org
David Eisenbud	MSRI	de@msri.org
Avner Friedman	MBI	afriedman@mbi.osu.edu
Mark Green	IPAM	mlg@ipam.ucla.edu
David Levermore	Facilitator	lvrmr@math.umd.edu
Christian Ratsch	IPAM	cratsch@ipam.ucla.edu
May 12 only:		
Dean Evasius	NSF	devasius@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 11, 2007 (Institute Directors only)

** = Action item

David Levermore gave an introduction to BMSA and explained its mission, major themes, and makeup of its board.

Presentation of 2006 minutes. Approved.

1. Technical Committee

** IPAM will request from each institute the name and contact information of its appropriate IT staff member for the committee. Committee will coordinate efforts to improve and expand web site. Three issues to focus on initially:

- adding a method to subscribe to institutes' newsletters (radio buttons)
- Programs are sorted by date. Committee could design an alternative way to display results of a search, so that institutes' programs are equally accessible and visible. Give user choices for how results are presented, or search parameters (workshop vs. long program).
- Members could help each other with NSF reporting appendices, as needed

How does an issue come to the attention of the technical committee? Directors communicate by email to consider if an idea should be pursued, sent to committee.

Committee will communicate by email and conference call. **IPAM will arrange the first conference call. The IPAM representative will be the first committee chair.

2. Diversity Committee

AWM mentoring network
Network targets young women interested in math. **Each institute has agreed to give $500 this year towards the AWM mentor network. (exception: Jean Bourgain cannot commit funds on behalf of IAS but will take the request to the director). Request a report from them to show how our funds were used.

Footnote: IAS contributed $500 towards the AWM mentoring network on October 11, 2006.

AWM Network should inform mentors about resources available through the Institutes via the Math Institutes web page: www.mathinstitutes.org.

Blackwell-Tapia
Math Institutes Directors contacted them to convey the Institutes' offer to continue to rotate conference hosts among institutes, but has not yet received a response. SAMSI is hosting the November 2008 conference. MBI is hosting in 2010. The Institutes will continue to share mailing lists and information related to the conference. **David Eisenbud and Jim Berger will try to reach the Blackwell-Tapia Committee, to renew our offer and request a response.

Diversity Events/Committee
Institute directors inform each other of diversity events by email and communicate via the diversity committee. Help advertise and send literature for display.

** Add a page for "diversity in math" to the Math Institutes web site. Charge the diversity committee with writing the page. List organizations and upcoming conferences in the US, and offer a mechanism for organizations to enter their events.

3. Jim Pitman proposal (http://eprintweb.org)

Jim Pitman's emails were discussed. ** Doug Arnold will see that the copyright notice on our Institutes web site will be replaced with an appropriate statement of permissions.

4. Math Institutes' website

Doug Arnold showed how the Math Institutes web page is linked to the NSF page. All Institutes have been sending their nuggets according to the schedule. There will be seven added each year. This meeting serves as a reminder: **Each institute should send another nugget before next meeting. Only five of them fit across the top of the home page. **Will post the most recent one from each institute, rotate them in random order.

Rotation order:
MBI – Nov. 1
IPAM – Dec. 15
AIM – Feb. 1
SAMSI – Apr. 1
IMA – May 15
MSRI – July 15
IAS – Sept. 1

Size of tags (short titles under image) should be shorter: limited to __ characters

Reminder: ** Each institute should update its programs at least once a year.

** Recommend to NSF that we post a link to each institute's web page that currently have NSF support as indicated by NSF, as well as a link to the International Mathematical Sciences Institutes list. Ask NSF each year at the institute directors meeting which institutes to include.

**OK to share software to allow other institutes to create their own web sites.

5. Data Collection for NSF reporting

The data collection and reporting system agreed upon last year (see May 2006 meeting minutes) with NSF was reviewed and found to be working well.

**The Directors will request NSF to send official letter confirming the agreement of May 2006.

6. Brainstorming

1. The directors discussed how to initiate an analysis of the institutes' programs and will continue the discussion with NSF.

2. Invite Herb Clemens, chair of US National committee for mathematics, to discuss ideas with his committee, then tell us how they think institutes can help to support mathematician in the developing world. Schedule a conference call, to take place this summer. **Avner Friedman will contact Herb Clemens.

May 12 (NSF included)

1. Report to NSF

Institute Directors reported on their May 11 meeting and presented the minutes to NSF.

2. Presentation by NSF

Status of the renewal proposals

Deborah Lockhart informed the directors that NSF is in the process of completing recommendations on the institutes that were up for renewal. They will complete the process soon and hope to make the awards by end of June. Awards will be communicated individually.

Timetable for upcoming open Institute solicitation

There will be an open competition for institutes, with an expected submission deadline of February 2009, with proposals that are selected for a site visit being visited in Fall 2009 and awards made soon after that.

Update on Institute Directors searches (IMA, IPAM, MBA, MSRI)

MSRI has hired a new director: Robert Bryant. IMA, IPAM, and MBI are in the process of conducting broad searches to recruit directors.

2007 Committee of Visitors (COV) report, comments on Institute portfolio
Analysis of Institute portfolio and programs

COV meeting took place in February 2007. The report is available and was forwarded to Institute Directors. The COV reported, and NSF agrees, that the institutes are a valuable asset to the mathematical sciences community, that the balance between institute and other programs in the DMS budget is appropriate, and that the institutes should continue to be managed as a portfolio, with a premium on collaboration and cooperation among institutes. NSF also stated that achieving the right programmatic balance is a high priority for Division management of the institutes' portfolio. The COV recommended that an analysis of the complete portfolio of institute activities be undertaken as soon as possible. NSF wants to perform this evaluation soon and hopes to make a report available to the public in the next 9 months.

**NSF will consider how best to respond to need for analysis of programs, and will try to make a decision in near future.

Annual reporting requirements

** 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."

Institutes' web portal, inclusion of other institutes

NSF endorsed the institute directors' recommendation that the NSF Institutes Website will keep its focus on the seven NSF math institutes. **NSF agrees that there should be links to other institutes that receive substantial direct NSF funding on the site's left navigational bar. NSF will provide this list at the annual MID meeting. This year: BIRS, Oberwolfach, IHES will be listed. There will also be a link to a list of mathematics institutes worldwide.

Discussion of International Partnerships/Interactions

NSF encouraged the institute directors in their proposed investigation of possibilities for supporting mathematicians from developing countries.

Location and Date of MID 2008
**May 2-3, 2008 was approved. MBI has offered to host it. The meeting will begin at noon on Friday and end with lunch on Saturday.

F. PARTICIPANT SUMMARY

In fiscal year 2006-2007, IPAM offered two long programs, 21 workshops, three reunion conferences, and two summer programs. The majority of IPAM's participants attend workshops, most of which are five days long. 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 report this information to us. See table F-1.

Table F-1: Total Participants and Underrepresented Groups by Program Type

Program Type	Total Participants	Female	No. Reporting Gender	Underrepresented Ethnic Groups			No. Reporting Ethnicity
				American Indian	Black	Hispanic	
Long Programs	115	16	113	0	1	3	102
Workshops	1422	244	1353	3	12	47	1209
Summer Programs	323	80	312	0	8	14	286
Reunion Conferences	69	12	65	0	0	1	57
Total	1929	352	1843	3	21	65	1654
Percent of No. Reporting		19.1%		0.2%	1.3%	3.9%	

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	63	114
Workshops	768	1369
Summer Programs	174	317
Reunion Conferences	36	67
Total	1041	1867
Percent of No. Reporting	55.8%	

The majority (90.5%) of 2006-2007 participants of IPAM programs held academic positions (faculty, postdoc, graduate student, or undergraduate student). The remaining 184 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 programs.

Table G-1: PostDocs: Total Participants and Underrepresented Groups by Program Type

Program Type	Total Postdoc Participants	Female	No. Reporting Gender	Underrepresented Ethnic Groups			No. Reporting Ethnicity
				American Indian	Black	Hispanic	
Long Programs	15	3	15	0	0	1	15
Workshops	170	38	167	0	0	8	129
Summer Programs	25	10	25	0	2	0	21
Reunion Conferences	16	6	16	0	0	0	12
Total	226	57	223	0	2	9	177

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	5	15
Workshops	60	169
Summer Programs	6	25
Reunion Conferences	5	16
Total	76	225

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

Danny Barash (New York University): "IPAM is a must experience for every junior scientist or a postdoc in the field of scientific computing."

Paul Biran (Tel Aviv University): "My field of research is symplectic topology. When I visited IPAM I had the chance to meet many people working in my field and more importantly people working in different but related fields such as algebraic geometry. I don't usually meet such people in conferences in symplectic geometry and topology. It was very interesting for me to hear feedback from them on my work and to discuss with them various questions."

Martin Burger (Munster): "My involvement with IPAM has been beneficial for my career and research in many ways. First of all, the programmes 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!"

Wayne Hayes (UC Irvine): "The papers and presentations on Chaos in the Outer Solar System derived from conversations with William Newman of UCLA, whom I met at an IPAM workshop last year. The papers on shadowing the gravitational N-body problem grew out of talks with John Dubinski, whom I also met at IPAM. Of the two major research topics I've been working on for the past two years (outlined above), one of them (the Solar System one) would not have existed without my meeting Bill Newman at IPAM; the other existed previously, but I was spurred to continue it by people I met at IPAM."

Michael Kozdron (University of Regina): "I began a collaboration with Tom Alberts of the Courant Institute. We are currently working on the paper already mentioned and hope to release the preprint soon. While visiting IPAM I also had very fruitful discussions with Fredrik Johansson of KTH Stockholm and Kalle Kytola of CEA France. We have continued to keep in touch via email, and hope to start a formal collaboration in the near future. As a young researcher, it is absolutely vital that I have direct interaction with the leaders in the field; to learn about the most recent advances, and to learn about the important open problems facing the field. Although I only attended an IPAM program four months ago (March 2007), I have begun one formal collaboration which should lead to a preprint in the coming months."

Philipp Kuegler (Johannes Kepler University Linz): "I am currently key researcher at the project "Modeling the Dynamics of Cellular Networks using Inverse Methods" led by Peter Schuster and Heinz W. Engl and funded by the Viennese Science and Technology Fund WWTF. The idea for this collaboration was born at IPAM where I had the chance to get in contact with Peter Schuster. At IPAM I also met Bob Eisenberg with whom I am currently collaborating in organizing a workshop on "ion channels." IPAM directed my research interests into inverse problems in life sciences and inverse problems in flight control. I am currently key researcher in the WWTF-project mentioned above, project leader within a PhD-programme on "moleculare bioanalytics" at the University of Linz and co-organizer of the RICAM special semester on "quantitative biology analyzed by mathematical methods", to be held in Linz, October 1, 2007 - January 27, 2008, also covering the workshop mentioned above."

Robert McCann (University of Toronto): "It was very useful for my postdoc Young-Heon Kim and I to be able to attend the IPAM workshop on Random Shapes, Surfaces and Transport and the first opportunity to present our joint work to an international audience, including visitors such as ST Yau. Following the presentation, a key question was raised which may play a role in determining our future research direction. The exposure was particularly relevant to Young-Heon since he is two years out of his PhD and will be looking for a tenure-track position next year."

Yassir Moudden (CEA Saclay): "The notion of sparse representation and compressed sensing developed at IPAM-MGA were a source of great inspiration, leading to collaborations with Michael Elad (Technion), David Donoho (Stanford), Jean-Luc Starck (CEA) and Bedros Afeyan

(Polymath). Publications in 2005, 2006 and 2007 result from these collaborations. My stay at IPAM had a great impact on my career and research direction. I am since then and still currently involved in research projects that are in the continuation of the MGA program. The fruitful and productive research that followed the MGA program is in fact so exciting that I was a offered a permanent position at CEA-Saclay just one year after the completion of the MGA program."

Tobias Preusser (International University Bremen): "My stay at IPAM has not only initiated some contacts and collaborations with the participants of the cm2006 program. It has also given me the opportunity to interact with the people at the math department of UCLA. In particular I am still in contact/collaboration with:
* M. Droske (formerly in the group of Andrea Bertozzi): Phase field model for the simultaneous segmentation and optical flow computation of images (yield two publications)
* C. Navasca (formerly in the group of Stanley Osher): Optimization of the radio-frequency ablation
* S. Srinivasan (participant of cm2006): Modeling the growth of the choroid plexus in mice
Moreover during my stay at IPAM I was able to intensify my collaboration with R. M. Kirby from SCI, University of Utah. Our joint effort has yield two papers which will be sumitted to journals within the next 6 weeks. The participation in the cm2006 program at IPAM has affected my career in several ways. First, as already described above, it has been a very fruitful time in terms of collaborations and publications. Being away from the usual obligations has boosted my research. For me as a mathematician it was a very good experience to be among such a heterogeneous group of scientists which are interested in similar topics. Finally it was great to interact with the people at the math department, attend the Levelset-Collective and the Tony Chan meeting. I had the opportunity to give several tasks in which I presented my former and actual research."

Susana Serna (UCLA): "I am collaborating with some scientists I met at IPAM during my participations in the 2005 and 2006 spring programs: In spring 2005 I started a collaboration with Prof JM Marti of the Department of Astronomy and Astrophysics, University of Valencia, Spain, during the "Grand Challenge problems in Computational Astrophysics" program. He was speaker in one of the workshops. I met Dr CC Wu, Institute of Geophysics and Planetary Physics, UCLA, during one of the workshops of the Grand Challenge problems in Computational Astrophysics program. I've visited him from Dec2005 to Nov2006 and introduced me into MHD numerical problems. I am collaborating with MD Maria P McGee (Wake Forest University) and Prof Howard A Levine (Iowa State University) since we met during the Cells and Materials program. The 2006 spring program gave me the great opportunity to learn on biomathematics and start a new project and collaboration on coagulation problems under the direction of MD Maria P McGee.

"The experience of participating in the IPAM programs has had a great impact in my career. These experiences have given me the opportunity to get wide knowledge of recent trends in applied mathematics and the opportunity to learn the importance of the interaction of mathematics in general and scientific computing in particular, with other basic sciences and engineering. During my participation in different programs I have found very interesting problems from my research field point of view in which I've been working since and will work in the future in collaboration with other researchers met at IPAM. I am thankful to IPAM for giving me the opportunity to widen my research interests and promoting and supporting scientific

collaborations for new projects. My formation, experience and CV has permitted me to apply to different postdoctoral contracts with the following results: In 2005 I was awarded by the Research Council of Spain with a MEC/Fullbright postdoctoral contract to join the Institute of Geophysics and Planetary Physics, UCLA from December 2005 to November 2006. In 2006 I was awarded by the Research Council of Spain with a MEC/Fullbright postdoctoral contract to join the Department of Mathematics, UCLA, from December 2006 to November 2007. In July 2006 I got selected (Research Council of Spain), in the 2006 international competition, for a three years postdoctoral contract (named "Juan de la Cierva") to join the Department of Mathematics of the Aeronautics School of the Universidad Politecnica de Madrid starting on December 2007. In July 2007 I've been selected (Research Council of Spain), in the 2007 international competition, for a Ramon y Cajal national research contract (tenured). I've been invited by the Department of Mathematics of the Universidad Autonoma de Barcelona to enjoy this position in their Department joining their PDE's research group."

Mira Todorova (University of Sydney): "The participation in the IPAM long-term program "Bridging Time and Length Scales in Materials Science and Bio-Physics" has been quite important to my professional developement. It provided a platform to get into contact with other scientists working in the broad area of multi-scale modelling. It allowed me to broaden my knowledge of areas, in which the combination of different methods, in the sense of multi-scale modelling approaches, is important and helped me learn more about certain methods (e.g. Transition Path Sampling), which are or might be important in my particular area of reasearch - surface and materials science. The active involvement in the organization and preparation of the practical sessions of "WORKSHOP III: Density-Functional Theory Calculations for Modeling Materials and Bio-Molecular Properties and Functions - A Hands-On Computer Course" provided me with an invaluable opportunity to acquire and train much needed skills, in terms of teaching and preparation of scientific meetings."

Yalin Wang (UCLA): "I am constantly involved in IPAM activities for years. The professors and students I met in IPAM always give me lots of fresh ideas for my own research. IPAM has a quiet and comfortable environment. I enjoy every minute I spent in IPAM. A good thing about IPAM is that you can always find the research leaders in any research areas and have a chance to learn their newest development. I think it is the most important thing. The current "random shape" series give me lots of new ideas on brain mapping research."

Daniel Zuckerman (University of Pittsburgh): "I attended the IPAM meeting as a very junior faculty member, and so it was a tremendous opportunity to get to know some senior (and junior) scientists in the field. I have maintained a number of these contacts -- in fact, I just saw Mike Thorpe this morning. The meeting also exposed me to some of the more mathematical possibilities in biomolecular modeling. The field is currently dominated by theoretical chemistry ideas, and it is healthy to have an injection of quantitative sophistication now and then!"

H. GRADUATE STUDENT PROGRAM SUMMARY

Graduate Students may participate in any IPAM program, including long programs, with the exception of our undergraduate summer programs. 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

Program Type	Total Grad Student Participants	Female	No. Reporting Gender	Underrepresented Ethnic Groups			No. Reporting Ethnicity
				American Indian	Black	Hispanic	
Long Programs	32	6	31	0	1	0	28
Workshops	461	98	447	1	10	11	397
Summer Programs	160	43	158	0	3	9	143
Reunion Conferences	8	1	8	0	0	0	7
Total	661	148	644	1	14	20	575

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	14	32
Workshops	199	457
Summer Programs	75	159
Reunion Conferences	3	8
Total	291	656

IPAM's Graduate Summer School "Probabilistic Models of Cognition: The Mathematics of Mind," held in July 2007, was a great success. It attracted over 200 applications for support, and had over 200 attendees. We received an additional $100K in funding from NSF's Division of Research on Learning in Formal and Informal Settings and an additional $25K as an anonymous donation from a foundation.

IPAM offered the 3-day workshop "Sparse Representations and High-Dimensional Geometry" in May 2007. This innovative "short course" was deliberately designed as a precursor to the AMS Von Neumann Lectures in July 2007 to provide students and postdocs with the background needed to get the most out of the July program. The lecturers were all fairly junior, and the target audience was graduate students and postdocs.

Below you will find some comments from graduate student participants of IPAM programs:

Amy Bauer (University of Michigan): "The IPAM workshop I attended provided the atmosphere for developing several key relationships (>3) that have resulted in a significant collaboration or contact that has furthered my scientific career."

Anna Cai (University of Melbourne): "I have met Professor Qing Nie who I will be working with for postdoctoral research. The workshops in IPAM were of excellent quality and have significantly affected my career direction."

Nikhil Chopra (University of Illinois at Urbana-Champaign): “The swarming workshop in 2006 was very helpful in my growth as a researcher. I became aware of the very latest ongoing work in different groups. This helped me in shaping up my future research directions. I will shortly be joining the faculty of Mechanical Engineering at University of Maryland at College Park. I believe that the workshop on "Swarming by Nature and by Design" in 2006 played an important role in my personal growth from a graduate student to a faculty in a renowned university.”

Erin Conlon (University of Massachusetts Amherst): “I was a participant in the first IPAM program in the Fall 2000, studying Functional Genomics. This was a relatively new and growing field at the time. Many of us participants were postdoctoral researchers and graduate students while at IPAM, and a large fraction of us have continued on in academics and industry. The contacts and friendships I started at IPAM have continued, now seven years later. Many of us still collaborate, invite each other to give talks in our departments and at conferences, and to referee manuscripts (since many participants now have editorial functions on journals). I met my future postdoctoral advisor while I was at IPAM,when he was invited to give a talk. This postdoctoral fellowship led to my current position; I am currently finishing my fourth year of a tenure-track faculty position. I believe strongly that IPAM contributed greatly to my career growth, and gave me a strong base of training and professional contacts that have made a great deal of positive difference in my career path. I continue to strongly recommend IPAM to potential participants, and am most enthusiastic about my experience.”

Sava Dediu (North Carolina State University): “I think the IPAM experience had a great influence on my career and it helped me shape my research interests in the years that followed. I was a graduate student at RPI in the fall of 2003 when I was selected to be a full time participant of the program “Inverse Problems: Computational Methods and Emerging Applications”. This program was a full semester international symposium sponsored by NSF and focusing on computational methods and applications of inverse problems. It enjoyed the participation of the top and the most internationally respected scientists in the field, and it included of the whole spectrum of scientific events like conferences, workshops, industrial problems study groups, tutorials etc. For me as a graduate student pursuing my PhD in Inverse Problems at that time, this was one of the greatest learning opportunities one can hope for. Looking back now few years after, I can certainly say that my career was influenced in the most positive way, and I am very grateful to IPAM for that program and the subsequent conferences it organized in Inverse Problems in 2005 and 2006.”

Michael Elad (Technion): “My work with Jean-Luc Starck has directly started after meeting in IPAM. I also met there Roland Coifman with whom I later published a paper. I believe that IPAM has affected my career in a very clear and positive way. The periods of time I spend in IPAM gave me an opportunity to meet the leading people in my field, start productive collaborations with them, and get to hear of the up-to-date developments in my fields of interest.”

Dargan Frierson (Princeton University): “During my visit to IPAM for the MAMAOS summer school in 2003, I developed several collaborations which have continued to this day. I worked with Andy Majda on a project which we eventually published, and we have recently submitted a follow-up paper to the first study. I additionally was able to meet a large number of young

researchers and more senior scientists, many of whom I continue to see at conferences. This has led to many fruitful scientific discussions. The MAMAOS summer school was very instrumental in shaping my research directions for the rest of my graduate school career, and my postdoctoral career. It was quite useful for me to be exposed to such a wide range of research topics at a relatively early stage in my career. The speakers at the summer school spoke on topics ranging from observations of the atmosphere, to simple models of atmospheric phenomena, to applied mathematical techniques in several different areas. Exposure to this diverse set of ideas helped me identify both the problems of greatest importance in the various fields, and the type of problems I was most interested in studying."

Lorenzo Granai (EPFL): "I have highly appreciated my time spent at IPAM. Indeed it is a very active and interesting institute, open to international collaboration and worldwide known."

Minh Ha Quang (University of Chicago): "Significantly. I met my PhD thesis advisor at a workshop at IPAM. Please keep up with all the great programs! Many thanks!"

Dan Kushnir (Weizmann Institute of Science): "My involvement with IPAM has exposed me to various state-of the art research projects done in my field of interest. It has gave me an exceptional opportunity to learn and collaborate with other researches in my field, by creating the optimal environment for meeting and talking with other researchers. Within the time period I spent at IPAM, I have found new applications for the tools that I was developing. Along this ongoing project we have published a paper."

Helen Lei (UCLA): "At IPAM 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. This was a wonderful collaboration: On the one hand we still had to derive a few percolation type facts, which I was quite familiar with, and on the other hand I learned from Ilia many things, e.g. SLE, with which I was not so familiar until the Random Shapes program. We also began to work on another (difficult) problem and there are quite a few more ideas for future collaborations! The Random Shapes program was a very positive experience for me. From the workshops I learned about many aspects of conformal invariance which I was not aware of. The opportunity to have meaningful interactions with both junior and senior researchers in an open, friendly and productive environment was invaluable. Having done a little work before in the area of conformal invariance almost by chance, I now have a much better appreciation of the key issues and questions of interest and feel inspired to try to do more work in the area."

Paul Macklin (UC Irvine): "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 (to do joint biological/medical/mathematical/computational research), which I had not previously considered."

Andrew Mills (University of Texas at Austin): "It is far more efficient to meet with the experts in person and talk with them in small groups than it is to try to learn by reading their papers alone.

This will help me finish my PhD and increase my chances of someday getting a postdoc or faculty position."

Bjorn Ostman (Keck Graduate Institute): "It was at IPAM that I through other participants got accepted to two different Ph.D. programs, one of which I accepted. A number of topics opened up to me while at IPAM (systems biology, networks, mathematical modeling of gene regulation), all of which are part of my current thinking and/or research."

Pawel Romanczuk (TU Berlin): "My participation in the IPAM workshop "Swarming by Nature and Design" played a significant role in my decision to pursue a Ph.D.-thesis in the respective field."

Tanya Roosta (UC Berkeley): "I have been in touch with one of the presenters at IPAM, Professor Cybenko, over the past two years, and currently I am collaborating with a post doc who was his graduate student. I got to know a number of people who helped me with my research. Also, I learned about a field that I didn't know much about and now it has become part of my Ph.D. thesis thanks to IPAM. I had a great time and I have been telling everyone in my research group to attend IPAM workshops."

Alon Schclar (Tel-Aviv University): "My IPAM-initiated collaborations are two-fold:
1) In the field of diffusion precesses in machine learning, I have been collaborating with Prof. Ronald Coifman and Stephane Lafon, and; 2) In the area of compressed sensing I have collaborated with Y. Tsaig. I have only but praise for IPAM in general and the program I attended. The vast amount of knowledge I obtained there is invaluable and it has been proving to be fruitful ever since. I started numerous collaborations and had a rare opportunity to meet many colleagues in my fields of research. If I had the opportunity, I would enthusiastically attend other IPAM workshops which are relevant to my research."

Alexander Small (NIH): "My advisor had told me to get involved with angiogenesis research, but the projects going on in the group weren't appealing to me, and it seemed like there was already sufficient manpower devoted to those projects. Attending IPAM gave me ideas that have sparked a stream of projects. Actually, before the workshop I was pretty burned out on research, and more interested in pursuing a teaching career. But getting ideas that can lead to a stream of projects got me excited again. All in all, one of the most useful scientific events I've ever attended."

Yi Sun (Princeton University): "I found a postdoc position at Courant Institute at NYU."

Alexandre Tkatchenko (Fritz Haber Institute): "I have maintained a close collaboration with Dr. Anatole von Lilienfeld, which started at the final Lake Arrowhead retreat. I have visited him twice in New York and Sandia National Lab. So far, we have published one paper and we are in the process of writing up another one. I have also maintained contact with Dr. Denis Andrienko from Max-Planck Institute for Polymer Research. Moreover, I have been influenced quite a bit by the work of Prof. D.J. Wales, whom I've met at IPAM. At least two of my publications have been produced due to this influence. The impact of my involvement with IPAM has been paramount. It has opened many new directions for my research, unforeseeable before my long-

term participation in the IPAM program. It has also allowed me to accelerate my career development and meet many exciting people. Along the way, I have been offered a position as a postdoc in the Prof. Matthias Scheffler group at Fritz Haber Institute in Berlin, starting in June 2007."

Magnus Ulfarsson (University of Michigan): "The friendly atmosphere, great speakers of the IPAM summer school motivated me greatly in my Ph.D. work."

Michael Wakin (Caltech): "As a graduate student, my semester at IPAM had a major impact on my research and career. In addition to the collaboration with David Donoho on studying the multiscale structure of image manifolds, we have started a concentrated research effort in the area of Compressed Sensing, a new framework for efficiently storing and measuring information. CS was originated by Emmanuel Candes and David Donoho, who were both MGA organizers, and much of the early CS theory was introduced at the MGA program. These relationships are still ongoing -- David Donoho was a member of my Ph.D. committee, and I currently working Emmanuel Candes as an NSF Postdoctoral Fellow."

Andrew Wan (Columbia University): "I have been working on a project about the complexity of learning parity with noise. The collaboration began at IPAM with Adi Akavia. I was exposed to many new areas and started working on a new project with another student. This summer I will go to Israel to continue collaborating with this student and her advisor."

Daniel Whalen (UC San Diego): "I was able to meet a lot of good people doing cosmological radiative transfer and become acquainted with their work. I later received a postdoc job offer from one of the participants."

Igor Yanovsky (UCLA): "During summer of 2004, I participated in the Graduate Summer School on Mathematics in Brain Imaging, where I met several leading researchers in the area. In particular, while collaborating with the Lab of Neuro Imaging, we introduced novel frameworks and computational models for image registration and segmentation of deformation. We use our models not only to predict onset and monitor progression of diseases, but also to discover new information about certain anatomical abnormalities. During this program, I had met several researchers from the Lab of Neuro Imaging (LONI), and have been collaborating with two groups from the Lab since then. The goal of this interdisciplinary collaboration is to develop mathematically and computationally stable, reliable, and efficient models that are useful for the medical imaging community, as well as to prove and analyze the underlying computational and mathematical concepts."

Joanna Zumer (UC San Francisco): "I have continued to be interested in the topics discussed at the IPAM Summer School in 2004. I have applied to work as a postdoc under one of the speakers, which I probably would not have done otherwise, since I would not have been as familiar with his work and personality otherwise."

I. UNDERGRADUATE STUDENT PROGRAM SUMMARY

Undergraduate students only participate in our summer RIPS programs (both RIPS-LA and RIPS-Beijing), so "summer programs" is the only category included in the tables below.

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

Program Type	Total Undergrad Participants	Female	No. Reporting Gender	Underrepresented Ethnic Groups			No. Reporting Ethnicity
				American Indian	Black	Hispanic	
Summer Programs	55	19	53	0	3	3	52

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

Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency
Summer Programs	33	55

This year, there were 298 applicants for RIPS, from which 36 were chosen for RIPS-LA and 10 were chosen for RIPS-Beijing. Microsoft Research Asia, our partner in RIPS-Beijing, then selected 10 Chinese students to team up with the Americans. IPAM was awarded an IRES grant through NSF ($41K per year) to help support the U.S. students chosen for RIPS-Beijing. 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 2006 through July 2007.

Please note that three of IPAM's workshops in 2006-2007 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 300-seat auditorium and were publicized widely. The 2006-2007 public lectures are included in the description of the relevant workshops.

***Affiliate Workshop*: Satisfiability Solvers and Program Verification**
August 10 - 11, 2006

Organizing Committee: Dimitris Achlioptas (University of California, Santa Cruz), Byron Cook (Microsoft Research), and Moshe Vardi (Rice University)

This was a 2-day meeting incorporated into the Federated Logic Conference (FLoC) in Seattle, affiliated with Microsoft Research. It is a timely and important application of a branch of mathematics, logic, which is not traditionally thought of as being applied.

Software verification is a problem with economic implications on a scale of billions of dollars. This prevalence of software flaws is exacerbated by the increasingly ubiquitous and connected environment in which software executes. Formal verification uses mathematical techniques to guarantee the correctness of a software program (or hardware design) for the specified behavior. Formal-verification tools have enjoyed a substantial and growing use over the last few years, showing ability to discover very subtle flaws.

The meeting built on real advances that have recently been made. For example:

- NASA is developing mathematics-based tools that verify the correctness of aerospace software.
- Intel and AMD use both human-guided and automatic proof engines to verify the correctness of their mathematics software libraries.
- Numerous companies and research groups have released powerful tools that verify the correctness of specialized software domains, such as railway switching software or device drivers.

The impact of such projects has encouraged computer scientists to search deeper into mathematical logic for techniques that will work for larger and more complex software. At the same time, researchers have been trying to come up with a theoretical understanding for the success of certain algorithms that have been particularly effective in practice. To extend the applicability of model checking, it is crucial to recognize that numerous problems in model checking are specific instances of constraint satisfaction, a canonical form of which is the satisfiability problem of propositional logic. Indeed, satisfiability is also a dramatic example of the symbiotic relationship between theory and practice in this field. Throughout the 1990s, applied researchers made dramatic improvements in the performance and scalability of satisfiability solvers, enabling the use of satisfiability as a viable alternative in increasingly non-trivial contexts. This, in turn, motivated renewed theoretical interest in propositional satisfiability and a plethora of new results. Satisfiability-based program verification has emerged as a rapidly advancing area.

Affiliate Workshop: Computational Methods in Transport

September 9 - 14, 2006

Organizing Committee: Marvin Adams (TAMU), Tom Manteuffel (University of Colorado), Tony Mezzacappa (ORNL), Anthony Davis (LANL), John Castor (LLNL), Frank Graziani (LLNL), David Keyes (Columbia University), Ivan Hubeny (University of Arizona)

This workshop was sponsored jointly with ISCR/B-division of Lawrence-Livermore National Lab, held at the Granlibakken Conference Center in Lake Tahoe. It followed up on a very successful joint IPAM-LLNL workshop on Computational Transport in 2004. Once again, an

unusual feature of the workshop was that it brought together researchers studying transport from different perspectives, but often with related methods, in a very broad range of disciplines.

The Computational Methods in Transport Workshop provided a forum where computational transport researchers in a variety of disciplines communicated across disciplinary boundaries their methods and their methods successes and failures. At the 2004 workshop, researchers from a variety of disciplines met and exchanged information and established new collaborations. The 2006 meeting also tried to address the problem that numerical methods used in a given field are communicated to other researchers in that field but rarely are the methods communicated outside of that specific field. The goal of the Computational Methods in Transport Workshop was to open channels of communication and cooperation so that (1) existing methods used in one field can be applied to other fields (2) greater scientific resource can be brought to bear on the unsolved outstanding problems.

The topic of the 2006 workshop - verification and validation in the field of particle transport - cut across disciplinary boundaries. Verification addresses the question: are we solving the equations correctly while validation addresses the question are we solving the correct equations? Therefore, the focus was trying to understand quantitatively how good the answers we get from our transport code really are given the physical and numerical uncertainties inherent in any simulation. In other words are our simulation results a true representation of reality or are they just a "computer game". At this workshop, we considered what the astrophysicist, atmospheric scientist, or nuclear engineer do to assess the accuracy of their code. What convergence studies, what error analysis, what problems do each field use to benchmark their codes are some of the questions each of us are confronted with in our simulations. Is there a need for new benchmark problems? Are there experiments that can be used to help validate the simulation results? If not, can we propose new experiments in facilities such as NIF, OMEGA, or Z that could address these issues?

Attendees were from national laboratories, academia and industry. Attendance at the conference was limited to 100; we intentionally kept the conference small to preserve the level of interaction and discussion among attendees.

The program began with a keynote address Saturday evening and it ended on Thursday with lunch. In between, we offered outstanding speakers and provide ample time for discussions. We believe this workshop provided an excellent venue to network with colleagues and relax in the beautiful surroundings of Lake Tahoe and the High Sierras.

Due to the interdisciplinary nature of this workshop, Sunday was devoted to a series of talks devoted to the science of verification, validation, and uncertainty quantification. The remaining sessions were invited talks targeted towards a diverse audience. Most days closed with a monitored discussion session. We held a poster session on Tuesday afternoon.

Anthony Davis (Los Alamos National Laboratory): "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 atmospheric applications, rather than an atmospheric

scientist that uses radiative transfer theory. This opens many new possibilities, and possibly a big career shift."

***Fall Long Program*: Securing Cyberspace: Applications and Foundations of Cryptography and Computer Security**
September 11 - December 15, 2006

Organizing Committee: Rafail Ostrovsky, Chair (UCLA, Computer Science), Don Blasius (UCLA, Mathematics), Dan Boneh (Stanford University, Computer Science), Shafi Goldwasser (Massachusetts Institute of Technology, Computer Science), Eyal Kushilevitz (Technion – Israel Institute of Technology, Computer Science), Arjen Lenstra (Lucent Technologies Bell Laboratories, Computing Sciences Research Center), and Joseph Silverman (Brown University, Mathematics)

Cryptography represents one of the most amazing unanticipated applications of pure mathematics to the real world. Without it, internet commerce would be unthinkable. Mathematical tools, in combination with theoretical computer science, have become a critical cornerstone for many Internet-based and wireless applications. Indeed, security, privacy and fault-tolerance have become key requirements for many emerging applications.

As remarkable as the first generation of insights into cryptography and computer security were, they have not in fact brought us bullet-proof security, as new challenges and attacks has arisen. The setting of the Internet-based applications has become far more complex; the potential attacks more numerous and sophisticated. Initial "stand-alone" requirements for security were replaced by a need for security in far more complex environments, where complicated interactions with multiple participants and with multiple and often diverse goals must nevertheless be made resilient against sophisticated attack models. As our society becomes ever more "paperless" in areas that include medical applications, taxation, information exchange, and even household electronics and appliances, the issues of security and privacy become ever more important. Examples include electronic voting and election protocols, zero-knowledge proofs, on-line shopping, electronic cash, stronger notions of encryption and of electronic bidding protocols, data mining and more general multi-party computations with strong security and composability notions. Often, deep mathematical results are used from diverse areas to analyze security and robustness of these protocols, including algebra, combinatorics, number theory, arithmetic algebraic geometry, probability theory, and coding theory. The purpose of this program was to crystallize fundamental problems that are posed by cryptographic applications and stimulate cross-disciplinary exchanges which will accelerate research-both on mathematical foundations needed by cryptographers and on cryptographic applications.

***Long Program Tutorials:* Securing Cyberspace**
September 12 - 15, 2006

Organizing Committee: Rafail Ostrovsky, Chair (UCLA, Computer Science), Don Blasius (UCLA, Mathematics), Dan Boneh (Stanford University, Computer Science), Shafi Goldwasser

(Massachusetts Institute of Technology, Computer Science), Eyal Kushilevitz (Technion – Israel Institute of Technology, Computer Science), Arjen Lenstra (Lucent Technologies Bell Laboratories, Computing Sciences Research Center), and Joseph Silverman (Brown University, Mathematics)

We offered tutorials in the first week of the long program, giving an introduction to the relevant problems as well as to the relevant mathematical and computational concepts. The goal was to familiarize participants with an overview of the issues and techniques involved in computer security and cryptography, and to create a common language among participants coming from different fields.

The program included six beautifully-crafted 3-lecture series by world experts enunciating the major themes of the program: Dan Boneh on "Pairing-Based Cryptography," Jonathan Katz on "Black Box Reductions, Impossibility Results, and Efficiency Lower Bounds," Rafail Ostrovsky on "A Survey of Private Information Retrieval," Kobbi Nissim on "Database Privacy," Yuval Ishai on "Randomization Techniques and Parallel Cryptography," and Ran Canetti on "Security and Composition of Cryptographic Protocols."

Long Program Workshop I: **Number Theory and Cryptography - Open Problems**
October 9 - 13, 2006

Organizing Committee: Arjen Lenstra, Chair (École Polytechnique Fédérale de Lausanne), Don Blasius (UCLA), Kristin Lauter (Microsoft Research), Alice Silverberg (University of California, Irvine), and Joseph Silverman (Brown University)

Cryptography depends on a continuing stream of new insights and methods from number theory, arithmetic algebraic geometry, and other branches of algebra. In the past, there have been important developments in primality testing, factoring large integers, lattice-based cryptography, sieve methods, elliptic curve cryptography, ECPP, torus-based cryptosystems, discrete log problems, Weil pairing, cyclicity of elliptic curves and hyperelliptic cryptosystems. The content of this workshop was based on emerging developments and discussion of open problems posed by applications.

This workshop succeeded in its interdisciplinary mission, bringing together leading cryptographers, including Ron Rivest, with number theorists such as Gerhard Frey, Wayne Raskind, Joseph Silverman, Neil Koblitz.

Long Program Workshop II: **Locally decodable codes, private information retrieval, privacy-preserving data-mining, and public key encryption with special properties**
October 25 - 28, 2006

Organizing Committee: Eyal Kushilevitz, Chair (Technion - Israel Institute of Technology), Dan Boneh (Stanford University), Yuval Ishai (Technion - Israel Institute of Technology), Jonathan Katz (University of Maryland), Rafail Ostrovsky (UCLA)

The topics of private information retrieval and privacy-preserving data mining have emerged recently as highly compelling research topics, with important applications. This workshop was designed to bring together several related areas.

- Recently, a remarkable connection was established between two initially unrelated communities: the community of mathematicians working on error-correcting codes and the community of people exploring private information-retrieval (PIR) protocols. Roughly, these are protocols that allow you to retrieve information from databases while preserving privacy. A strong connection between coding theory and PIR protocols (as well as PCP) was established-where better bounds in one area lead to strong bounds in the other. The workshop brought together these two communities, and facilitated the exchange of ideas, tools, and terminology that will allow further collaboration.
- In the 1980s and 1990s, basic notions of public-key encryptions were developed and understood. In today's applications, however, additional requirements are needed, such as operations on encrypted data. How do we search on encrypted data, determine winners of encrypted election votes, or have more complicated "identity-based" encryption schemes? There are many answers that are known, however a wide number of unresolved issues remain. At their core, many of the cryptographic protocols can be formulated as specific problems in computational number theory. This theme brought together cryptographers and number theorists to formulate problems needed for these applications and explore the strength of the underlying hardness assumptions needed.
- Over the last two decades cryptographic tools have been developed to preserve individual and group privacy. These tools go beyond mere encryption. For example, if an eavesdropper learns that a medical patient accesses a database on HIV testing, this information alone, even if all information is encrypted, reveals certain information about the user. The issue of preserving individual privacy and anonymity without impairing the ability to use various web resources is an important building block in making cyber-infrastructure secure and more usable. In this workshop we brought together both experts in various forms of privacy and anonymity issues, and users who are looking for particular applications-ranging from privacy-preserving data-mining to patient privacy. The workshop elucidated the main technical challenges, and the underlying mathematical tools needed to solve these challenges.

***Long Program Workshop III*: Foundations of secure multi-party computation and zero-knowledge and its applications**
November 13 - 17, 2006

Organizing Committee: Amit Sahai, Chair (UCLA), Boaz Barak (Princeton University), Dan Boneh (Stanford University), Ran Canetti (IBM Thomas J. Watson Research Center), Ronald Cramer (CWI, Amsterdam & Math Inst, Leiden University), Shafi Goldwasser (MIT/Weizmann Institute), Yuval Ishai (Technion - Israel Institute of Technology), Eyal Kushilevitz (Technion - Israel Institute of Technology), and Rafail Ostrovsky (UCLA)

Cryptography has achieved a remarkable success in showing that everything that can be computed can be computed privately—that is, in a way where nothing is revealed about the individual's private input except the joint output of the function being computed. The classical example is Yao's "millionaire" problem, where several millionaires wish to find out who is richest, without revealing to each other their net worth. While in principle it shows that any polynomial-time computable function can be computed with strong security guarantees, the solutions are not practical. In recent years, more practical solutions for specific functions were developed that are far more efficient. This workshop explored in depth many settings of this general problem, and investigated which tasks can be efficiently computed. The stress was to discuss rigorous foundations and algebraic assumptions needed to achieve greater efficiency.

***Long Program Workshop IV*: Special purpose hardware for cryptography: Attacks and Applications**
December 4 - 8, 2006

Organizing Committee: David Naccache, Co-Chair (École Normale Supérieure), Nigel Smart, Co-Chair (University of Bristol), Cetin Koc (Oregon State University), Arjen Lenstra (École Polytechnique Fédérale de Lausanne), Christof Paar (Ruhr-Universität Bochum), and Eran Tromer (Weizmann Institute of Science)

Much of what drives the field of computer security and cryptography is the advent of new technologies in the form of new hardware. This creates both new opportunities and new security challenges. With the rapid development of sensor networks, palm pilots, hand-held GPS and other "gizmos," there is a great need to "miniaturize," not only the devices themselves, but also cryptographic modules installed on such devices. The task is a challenging one, as just reducing key-size or other security properties makes such small devices much easier to attack. In this topic we explored various ways to "miniaturize" cryptographic primitives, so that they are deployable, both at the sensor and hand-held device level, without sacrificing security and also explore novel attacks on such devices.

This topic brought together experts working in this area of cryptography and cryptanalysis, as well as the practitioners who need security for these tiny devices.

Long Program Culminating Workshop at Lake Arrowhead
December 10 - 15, 2006

Organizing Committee: Rafail Ostrovsky, Chair (UCLA, Computer Science), Don Blasius (UCLA, Mathematics), Dan Boneh (Stanford University, Computer Science), Shafi Goldwasser (Massachusetts Institute of Technology, Computer Science), Eyal Kushilevitz (Technion – Israel Institute of Technology, Computer Science), Arjen Lenstra (Lucent Technologies Bell Laboratories, Computing Sciences Research Center), and Joseph Silverman (Brown University, Mathematics)

This 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.

Comments from participants in the Securing Cyberspace long program and related workshops:

Jean-Marc Couveignes (University of Toulouse): "I had very inspiring discussions with several researcher whom I would not have met that easily in Europe, e.g. Alice Silverberg, Kristin Lauter, David Freeman (I discovered that the latter two and I were facing very similar mathematical difficulties about jacobians of curves). The IPAM seminar was also a good opportunity to discuss with people from cryptography (Paillier and Joux) and to learn more about the program developed by Frey, Huang and other toward computing discrete logarithms. I believe I am more aware of applications to crypto than I was before and I have now new contacts with researchers in the crypto world."

Luis Dieulefait (University of Barcelona): "I worked/am working with J. Jimenez Urroz, who attended IPAM during one of the workshops, on some problems that were formulated during this workshop and/or during the first week tutorials, concerning explicit arithmetic with applications to cryptography. I discussed with other participants to the workshops (Raskind, Frey) several important problems. I started a collaboration with I. Burhanuddin (USC) on computations with modular forms. I obtained during my stay at IPAM new results on the images of families of Galois representations that led recently to a collaboration with Gabor Wiese (Essen). I learned a lot (I knew the basics, now I learned the advanced part and current research interests) and started to work in Cryptography, which was my first goal. This is a new research direction for me. This is related to algorithmic number theory, a field I have previously worked in, and at IPAM I also started new collaborations in this field."

Yevgeniy Dodis (New York University): "Was a great visit. I learned a lot, got many ideas, and enjoyed the experience a great deal."

David Freeman (UC Berkeley): "At IPAM I had the opportunity to meet Dan Boneh in person for the first time, and we are now collaborating on a paper that we intend to submit to Eurocrypt '08. During my stay at IPAM, I was able to form new connections with many of the leading researchers in my field, and develop existing relationships with many others. People I was able to talk to at IPAM who I do not usually have the opportunity to talk to in person included Joe Silverman, Renate Scheidler, Everett Howe, Kristin Lauter, Jean-Marc Couveignes, and Alice Silverberg. As I enter my final year of graduate studies, I hope to use these relationships to help further my research and to help me find a post-graduate position in my field."

Simson Garfinkel (MIT): "It's made me more committed to explaining computer theory to non-theorists. It's gotten me really, really interested in private information retrieval."
Mark Gondree (UC Davis): "My personal PhD work has entirely changed topics, based on a better understanding of my interests."

K. Gopalakrishnan (East Carolina University): "My involvement with IPAM has definitely reinvigorated my commitment to research in Cryptography and Information Security. I teach in a small teaching university. We don't even have weekly colloquiums in my department. Further

there is no one around in 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. Although I cannot give you any tangible outcome of my visit to IPAM at this point (I am sure I will be able to show in an year or so), I personally feel that my IPAM visit is a definite turning point in my career."

Vipul Goyal (UCLA): "I had a chance to interact with a lot of researchers during my stay at IPAM. Two papers are a result of collaboration which started at IPAM. I met these researchers initially at IPAM only and then started working with them. 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."

Daniel Holcomb (University of Massachusetts Amherst): "It has helped to 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 within the University of CA system (@ Berkeley)."

Jorge Jimenez Urroz (Universitat Politecnica de Catalunya): "The paper On the Malleability of RSA moduli grew as a collaboration with L. Dieulefait during my stay at IPAM. In the conference of cryptography in October at IPAM, P. Pailler raised the question we answer in that paper. We show some results about Modulus RSA being malleable, which is against the conjecture formulated by P. Pailler and J. Villar in Asyacript 2006."

Jonathan Katz (University of Maryland): "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 already to 3 publications (in addition to other papers currently under submission). I also feel that I learned a lot from the weekly seminars as well as the four workshops that were held throughout the semester."

Iordanis Kerenidis (CNRS): "Influenced by the talks at the cryptography workshop at IPAM, I have started two different research projects on the topic of quantum cryptography. It was a great experience to meet and talk to researchers who are close but not necessarily in my area. The introductory talk I gave at IPAM was also invited to a conference from a member of the audience at IPAM."

W.C. Winnie Li (Pennsylvania State University): "It has greatly broadened my horizon in knowledge and scope of the subject I was/am interested in. I met many people in related areas for the first time, and with some of them I set up regular contact."

Steve Lu (UCLA): “As a math graduate student in cryptography, this IPAM session has truly been of tremendous value to me. Being able to interact with a variety of researchers from around the world has been a great experience for me. During those months we generated new collaborations and new ideas, many of which I am still actively exploring. I am very thankful to have had this opportunity during the course of my PhD studies.”

Keith Mayes (Royal Holloway and Bedford New College): “I met Patrick Baier and Chris Gai. I subsequently obtained funding for Patrick to spend a week at the Smart Card Centre and ISG - here at Royal Holloway University of London. As a result I am now exchanging emails with Patrick/Chris on potential collaborative tasks.”

Payman Mohassel (UC Davis): “t has had a tremendous positive impact on my research career. I have much better sense of the cryptography community and the important research problems in the area. I would love to see a similar event take place again and would think that it is a great opportunity for any graduate student that does research.”

Kirill Morozov (National Institute for Advanced Industrial Science and Technology): “Involvement with IPAM greatly facilitated my research and opened the new research directions for me. Of the two joint works mentioned above the first two were the new subjects on which I started to work at IPAM. Besides of the above mentioned works and presentation, IPAM was an excellent opportunity to meet the people from all over the world, a lot of prominent researchers among them. Last but not least, it was the first opportunity for me to observe the daily life of the US university "from inside" which was also quite interesting. A few words on where the words "greatly" in the first sentence come from: the geographical location and an informal atmosphere at IPAM was creating the environment where I could easily access all the researchers and find a space for communication not only in the offices but also in the common hall which is conveniently equipped with whiteboards and soft arm-chairs. IPAM staff was always polite and helpful. Organization of the receptions and the meals was always meeting the highest standards. The services concerning application for the US Visa were arranged in an excellent way. The first outing in Malibu provided the participants with an excellent opportunity to meet in a relaxed atmosphere, to get acquainted to each other and to arrange the later running of the IPAM research seminar as well as other miscellaneous issues. The series of cryptography related workshops helped me to keep up with the state of the art in the area as well as to understand the current trends of its development. The culminating workshop at Lake Arrowhead was a wonderful opportunity for everyone to get together for the last time, to meet one's friends again, to try to finish up some research and to prepare oneself for the returning to the real world which is so much imperfect compared to what I got used to in those three months.”

Kobbi Nissim (Ben Gurion University): “For now, the time period I spent at IPAM turned to be very productive, and two of the research projects from IPAM were already accepted to conferences. The third is still in preparation. Furthermore, I had a wonderful opportunity to learn first hand about new result and got a quite few opportunities to present my own work, discuss it, and get feedbacks from researchers whose opinion I care about.”

Omkant Pandey (UCLA): “I got exposed to excellent and cutting-edge research works and it was truly amazing to learn about them. There were so many reputed and well known researchers

around and it led to making good connections which will be useful in future for research collaborations, it gave students more visibility in the research community, and so on."

Olivier Pereira (Universite Catholique de Louvain): "This week spent at IPAM was a wonderful occasion to discuss with many researchers. Those interactions consolidated different collaborations, and motivated at least two visits to other participants' institutions, and from other participants at UCL."

Sofya Rashkodnikova (Weizmann Institute of Science): "The IPAM program that I participated in significantly broadened my research program. I started working on private data analysis and its connections to sublinear algorithms, my main research area. I also got involved in an implementation project on photonics. I collaborated with participants of the IPAM program and also (unexpectedly) with an assistant professor in Mechanical and Aerospace Engineering at UCLA."

Leonid Reyzin (Boston University): "I have ongoing collaborations with: Juan Garay on key establishment, with Sofya Raskhodnikova and Eric Chiou (of UCLA) on an algorithmic problem arising out of biophotonics, with Jonathan Katz and Adam Smith on extension of fuzzy extractors. It has been a wonderful opportunity to exchange ideas and focus exclusively on research, away from the daily demands of faculty life. It has lead to unexpected collaborations, as well as to more effective continuation of ongoing ones."

Amit Sahai (UCLA): "My stay at IPAM was very useful for growing collaborations; in particular it was instrumental in a number of collaborations with Yuval Ishai and Eyal Kushilevitz of Technion, and thanks in part to these collaborations, Yuval Ishai will spend his sabbatical with us at UCLA next year. The semester at IPAM was wonderful; I have started investigations jointly with other participants on a number of fascinating new research problems which came out of the program."

Joseph Silverman (Brown University): "Visiting IPAM and participating in an IPAM workshop has always helped me stay abreast of current research and suggested possible areas for further research. In particular, the workshop in fall 2006 led to my work with Chen and Hsia."

Martin Simka (Sentivision): "As most of the speeches at the workshop presented the latest research results it was unique chance to get information on promising directions in cryptography. Fruitful were also the discussions with other participants."

Adam Smith (MIT): "The stay at IPAM was a significant boost to my career in several ways: 1) the research I began at IPAM with Raskhodnikova and Nissim is the basis of a much larger effort now under way at Penn State University; 2) the workshops allowed me to present my work and communicate new results to a large, influential audience; 3) the workshops also gave me a chance to see a cross-section of work currently going on in cryptography, and to understand the major trends in the field, and; 4) I met my collaborators Vipul Goyal and Payman Mohassel at IPAM. Altogether, I consider my stay at IPAM to have been extremely valuable to my career. I highly recommend the experience."

Martin Strauss (University of Michigan): "The Fall, 2006, program on data privacy has influenced my work and given me ideas which I plan to flesh out over the next few years."

Jose Voloch (University of Texas at Austin): "I have learned a number of new things which I am sure will influence my work in the future."

Hoeteck Wee (UC Berkeley): "I have been interested in a research career in the area of cryptography even before participating in the IPAM program. The program gave me the opportunity to interact with many more people in the area, thereby allowing me to learn more about other research directions within cryptography, laying the grounds for some of my current collaborations, and reaffirming my interest in the subject both for current research and a career upon graduation."

Sergei Yekhanin (MIT): "While at IPAM I have met a number of researchers (in my area) that I have not known previously. Most notably these are: Alex Samorodnitsky, Ronald deWolf and Moni Naor. I have learned a lot from these people. I believe they may have an impact on my future career."

Reunion Conference: Grand Challenge Problems in Computational Astrophysics
December 10 - 15, 2006

Organizing Committee: Willy Benz (Bern, Physikalisches Institut), Phillip Colella (Lawrence Berkeley National Laboratory, Mathematics), Richard Klein (University of California at Berkeley/Lawrence Livermore National Laboratory, Astronomy), James McWilliams (UCLA, IGPP & Atmospheric Sciences), Joseph Monaghan (Monash University, Australia, Mathematical Sciences), Mark Morris (UCLA, Physics & Astronomy), Stanley Osher (IPAM, Mathematics), Chi-Wang Shu (Brown University, Applied Mathematics), and Harold Yorke (California Institute of Technology, Astrophysics)

This was the first 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 18 months earlier. Presentations were given by all participants, with plenty of time between talks for discussions and collaborations. The presented talks connected the numerical methods used in many astrophysical fields highlighting algorithms and modern computer architectures. This broad view is particularly helpful as the different fields tend to develop their own solutions that often turn out to be similar. One example of this is radiative transfer, where fix-point iterations are known to mathematicians, while astrophysicists have independently developed the lambda-iteration. Examples of the new and ongoing collaborations and highlights of the reunion include the following:

- Mike Norman and co-workers in 2005 presented their numerical effort to simulate the cosmological development of the universe to model the first formation of galaxies. This lead to a collaboration with scientists from Germany (Niemeyer, Klingenberg et. al.) to use their code, ENZO. They proceeded to introduce a subgrid model into ENZO giving more accurate modeling of structure formation in the interstellar medium, which was presented at Lake Arrowhead in by Klingenberg. As part of this effort the German team

had devised an improved Riemann solver, which is a core numerical ingredient for advecting the nonlinear features of the flow.

- These results were of high interest to Michael Knoelker (director of HAO at NCAR), because his group needed improved numerical results to match their newly gathered data of the sun.
- As a direct consequence of this, Knut Waagan succeeded in 2007 to obtain a coveted post-doc position at NCAR. Knut Waagan had been a recent doctoral student of Klingenberg, and was involved in the above mentioned activity, At NCAR he will now implement and improve the numerical methods developed in his thesis.
- Richard Klein and Juergen Steinacker continued there successful collaboration on performing massive parallel MHD simulations of 3-dimensional radiative transfer.

There was collective agreement among the participants that the UCLA conference center at Lake Arrowhead is a perfect environment to hold the reunion conference and to address the challenges in numerical astrophysics. In particular, it was noted that there was ample time for personal discussions of critical issues.

Comments from participant of the Astrophysics Reunion workshop:

Giuseppina Nigro (Naval Research Laboratories): “Thanks to the 'Grand Challenge Problems in Computational Astrophysics' program I have had the possibility to improve my computational skill and my knowledge in Astrophysics. I have had also the possibility to meet many interesting scientists so that I could start collaborations. Right now I have a post doc positions in one of the most important research laboratories in the United States (Naval Research Laboratory, Washington DC).”

Workshop: **Mathematical Challenges and Opportunities in Sensor Networking**
January 8 - 12, 2007

Organizing Committee: Richard Baraniuk (Rice University, Electrical and Computer Engineering), Mark Hansen (UCLA, Department of Statistics), and Robert Nowak (University of Wisconsin-Madison, Electrical and Computer Engineering)

Sensor networking is an emerging technology that promises an unprecedented ability to monitor our world via spatially distributed networks of sensor nodes. The nodes may sense the physical environment in a variety of modalities, including acoustic, seismic, thermal, and infrared, or may be deployed throughout engineered systems such as the Internet for the purposes of monitoring or surveillance. A wide range of applications of sensor networks have been envisioned, including environmental monitoring, homeland security, and medical diagnostics. While the practically unlimited range of applications of sensor networks is quite evident, our current understanding of their design and management is far from complete. Since sensor networks collect data in a spatially distributed fashion, data analysis problems in sensor networks present a distinct new challenge. In addition to all the common issues associated with data analysis and modeling, limited energy and/or bandwidth resources place a very high cost on the sharing and fusing data

within the network. Consequently, new theories and methods for data analysis, modeling, and communication will play a central role in the development of this exciting new field.

There were two explicit goals of the IPAM workshop. The first goal was to introduce sensor networking to mathematicians and scientists who work in the related areas but are not currently involved in the field. The nascent research community in sensor networking has already drawn heavily on a variety of mathematical theories and techniques originating from areas such as signal processing, statistics, stochastic modeling, machine learning, and computer science, and we anticipate that the future directions and successes in this field will be largely shaped by a healthy and vibrant interdisciplinary approach to the research. The second goal was to outline future directions for the mathematical and statistical development in the theory and methods employed in sensor networking. This was achieved by complementing technical and overview presentations "brainstorming" sessions in which mathematicians, engineers, and computer scientists will be brought together in groups to define the big issues and the possible directions of research that might resolve them. Since sensor networking is still a very new field, with only a handful of fielded systems in existence, now is an ideal time to attract mathematical experts from all areas to shape and contribute to the future of this unique application domain. An added resource for this workshop was the presence of the Center for Embedded Networked Systems (CENS) at UCLA, which is one of the premier sensor networking research groups in the world.

The breakout sessions were quite successful. The primary purpose of these sessions was to define a set of theory problems in sensor networks that if solved would have significant practical impact. To this end there were seminar presentations covering both deployed sensor networks and theoretical work, and a set of breakout sessions. Breakout sessions were held on Reliable and Efficient Inference from Data and Models, Data Integrity, Iterated Model Construction, Dealing with Intractability of Traditional Network Information Theory, Sensor Network Constraints Taxonomy, and Community Support Mechanisms.

Comments from Participants in the Sensor Networks Workshop:

Richard Baraniuk (Rice University): "An IPAM event is always like a breath of fresh research air that gives me new ideas for research."

Jan Kleissl (UC San Diego): "Broadened my scope for mathematical technique for sensor networking. The workshop I attended was of outstanding quality and provided possible links to researchers in a field which I am just starting to explore."

Greg Pottie (UCLA): "Research ideas from the January workshop have already affected how questions are framed for my group of Ph.D. students. The workshop also broadened the set of papers my students are looking into, and I expect this will have a positive influence on their research."

Tony Quek (MIT): "The workshop that I attended at IPAM gave me many new perspectives on research areas in sensor networks. Moreover, I am able to identify some important mathematical tools that are useful for my future research work."

Christopher Rozell (Rice University): “Being at the beginning of my career, it is invaluable to interact and make contacts with the leaders in a 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!”

Akbar Sayeed (University of Wisconsin): “Attending the IPAM workshop on sensor networks exposed me to a variety of complementary research directions being pursued in the field. It was certainly helpful in directing my future research in the area of sensor networks.”

Workshop: **Crime Hot Spots: Behavioral, Computational and Mathematical Models**
January 29 - February 2, 2007

Organizing Committee: P.Jeffrey Brantingham, Chair (UCLA, Anthropology), Andrea Bertozzi (UCLA, Mathematics), Kate Bowers (University College London, Jill Dando Institute of Crime Science), Lincoln Chayes (University of California, Los Angeles (UCLA), Mathematics), George Rengert (Temple University, Criminal Justice), and George Tita (University of California - Irvine, Criminology, Law and Society)

This was a groundbreaking workshop which had a very diverse group of speakers and participants, ranging from statisticians like Richard Berk, mathematicians like Andrea Bertozzi and Lincoln Chayes, physicists like Henri Berestycki and Sidney Redner, anthropologists like Jeffrey Brantingham, criminologists like Marcus Felson and Michael Townsley, and law enforcement officials such as George Gascon. The collective response from this group was enthusiastic.

It has long been recognized that crime tends to cluster in time and space, forming so-called crime hot spots separated by areas where there is little or no crime. Advances in digital mapping technologies over the past decade have dramatically improved our ability to recognize and also quantify some of the spatial properties of crime hot spots. The dynamic aspects of crime hot spot formation, persistence and dissipation, however, are poorly understood.

The purpose of the IPAM short program conference Crime Hotspots: Behavioral, Computational and Mathematical Models was to bring together researchers studying the micro-scale behavioral and environmental bases of criminal activities with those who have approached the emergence of crime pattern formation, or similar problems in other domains, both computationally and mathematically. The intent was for the workshop participants to learn about crime pattern formation for a variety of different perspectives, to stimulate novel approaches to the study of crime and to provide an opportunity to forge new research collaborations.

Crime hot spots are defined as geographical areas with clusters of criminal offenses occurring within a specified interval of time. Hot spots may consist of clusters of property crimes such as burglaries or auto thefts, or violent crimes such as homicides, which occur on time scales ranging from hours to months. Law enforcement strategies are increasingly aimed at quickly identifying and targeting hot spots as a primary means of fighting crime. However, many fundamental questions remain unanswered concerning the generation of crime hot spots, how they should be

measured and interpreted, and how hot spots might be used for predicting future distributions of criminal offenses.

This conference brought together leading criminologists, mathematicians and computer scientists for the purpose of discussing the behavioral basis of criminal activities and exploring mathematical and computational approaches to modeling crime hot spots. A great deal is known about the micro-scale behaviors of offenders and victims as well as the environment attributes that tend to either create or restrain criminal opportunities. With a few exceptions, however, research in these domains has proceeded with only limited connection to recent developments in computational and mathematical approaches to studying emergent pattern formation. The biological sciences, by contrast, have embraced broadly the idea that simple deterministic and stochastic processes, operating at local scales, may lead to incredibly rich pattern formation at higher scales. Recognition and analysis of self-organization in biological systems has had major consequences for understanding the dynamics of ecosystems, the causes of biodiversity and, importantly, the local and global processes that may interfere with such complex systems, leading to dramatic system changes.

Part of the motivation for this workshop derives from advances in agent-based or multi-agent computational modeling and GIS crime mapping. Such computational tools provide scientists the opportunity to model offender behavior at a low-level, consistent with empirical observations, explore how collections of offenders interact with their environments and assess whether such interactions lead to the generation of crime hot spots. Formal mathematical approaches are necessary for grounding computational approaches and offer tremendous potential for developing additional insights into the nature of crime hotspots.

The five-day program incorporated presentations and discussions covering several topical areas:

- Low-level behavioral models and evidence: offender search behavior; Lévy and biased random searches; target/victim selection; environmental constraints on crime; random walks on graphs and street network topology; path-finding; environmental heterogeneity and criminal opportunities.

- Locally and globally emergent patterns: quality of geospatial data on crime; mining of large, geospatial databases; defining and mapping short-lived hotspots; criminal social networks; spatially explicit epidemiological models; near repeat victimization; swarming and long-range crime attractors and repellors; hotspot dissipation and collapse; displacement and diffusion processes; massive multi-agent systems; crime forecasting; geographic profiling; hotspot policing and police patrol strategies.

<u>Comments from participants of the Crime Hot Spots workshop:</u>

Eli Ben-Naim (Los Alamos National Laboratory): “The crime hot spot conference was truly visionary and excellent in quality.”

Aaron Clauset (Santa Fe Institute): “My involvement with IPAM has put me in contact with a variety of potentially new collaborators, and has exposed me to several new ideas.”

John Eck (University of Cincinnati): “I am delighted to have met you this week and even more delighted to attend the sessions on crime hotspots. Without the slightest exaggeration I can say I have never attended an academic meeting as stimulating, useful, and enjoyable as this weeks meeting. The mixture of mathematicians, physicists, and criminologists was ideal. I have a notebook of ideas and a list of new e-mail addresses for potential collaborators. By Thursday evening a long term collaborator (Lin Liu) and I had sketched out a new research program based on models discussed at the conference.

“Interestingly, it focuses on a crime topic we did not discuss -- fear of crime. We also outline a new course for our criminology and geography department to introduce models and simulation. I have never attended all presentation at any conference. I did so here. Even the presentations on topics I was already familiar were interesting. I cannot say I understood most, or even half of the math, though I did follow a surprising amount. I should also thank the IPAM staff for there friendly assistance throughout.

“There were none of the glitches I normally associate with meetings. Let me close with a suggestion. As useful as this session was, I suspect that the crime researchers and the mathematicians have only just introduced each other. As stimulating as this session was, I wonder if a single meeting is sufficient to stimulate greater use of mathematical models and simulations of crime problems. Follow-up sessions to build on this foundation and discuss specific problems would be very useful. Again, thank you very much for a very productive week.”

Henk Elffers (Netherlands Center for the Study of Crime and Law enforcement): “Also on behalf of my colleague Wim I would like to thank you very much for the opportunity to meet so many colleagues from mathematics and physics, as well as from anthropology and criminology at the conference. We felt that it is both reassuring and stimulating that 'out there' in those different fields people live with an interest in our field, that use methods that we can understand -with some help-, and whose approach is opening new pathways for us. Also we felt that people were genuinely interested in the way we are theorizing and applying methods in our own field! The program style, with the ample breaks and room for discussing, plenary and in private setting, was very helpful. Please relay our thanks to Mark Green and the supporting staff of IPAM: an impeccable conference organization!”

Marcus Felson (Rutgers University): “I will train crime analysts at the International Association of Crime Analysts annual meeting, Pasadena, California, September 24-27, 2007. This invitation resulted from the IPAM meeting, where some crime analysts heard my talk. My visit is co-sponsored by the California Crime and Intelligence Analysts Association. I will give the keynote address and two training sessions.”

Yushim Kim (Ohio State University): “I submitted a panel abstract of *Agent-Based Models of Illegal and Violent Behavior for Association* for Public Policy Analysis & Management (APPAM) this year along with Dr. Groff. I will start my academic career as an assistant professor at Arizona State University School of Public Affairs this fall. The position was designed for Policy Informatics. My professional experience and IPAM have been important factors for the position.”

Michael O'Leary (Towson University): "It provided a wonderful opportunity to me as a mathematician to meet and mingle with a number of experts in criminology that I would not have otherwise met."

Michael Porter (North Carolina State University): "I found that several of the criminologists were exploring self-excited point processes without knowing there was developed theory in this area. I was immediately able to point them to the relevant material. From this interaction, I am now working with M. Townsley at Jill Dando on using point process models for studying crime. [It has affected my career] in a big way. After getting acquainted with the types of problems in criminology and their desire for improved spatio-temporal methodologies, I have started to focus my research into this area (I am in statistics with a main research interest in space-time point processes). This is directly due to the IPAM workshop."

Sid Redner (Boston University): "I participated in two IPAM programs this past spring. The one on crime was less connected to my current research, but I was able to formulate some ideas that may lead to new research projects in the very long term. I also participated in the program on networks that is more closely connected to my current research. From this last program, I also got a few ideas for good shorter-term research projects."

Roy Stone (Long Beach Police Department): "Since my stay at IPAM, I've come to appreciate that in my struggle to appeal to all levels of my audience, my unique perspectives are quickly understood and lauded by those in academia. This positive feedback has allowed me to further "push the envelope" with respect to looking at data from all perspectives. A classic example is the reception I received at IPAM to a "donut" map I developed. This is the map I intend to submit to the upcoming Twenty-Seventh Annual ESRI International User Conference, in the category of "Most Unique." Some of the criteria for the "Most Unique" category is "Unconventional and innovative ways of presenting the subject"; "Uniqueness of the idea or subject being presented." Thanks to my stay at IPAM, I have the added confidence to submit this type of map as well as continuing to "push the envelope" in developing these kinds of maps."

Lucia Summers (University College London): "IPAM not only gave me the opportunity to get in touch with professionals from other disciplines, but also contributed to the consolidation of existing relationships with those within my discipline. The format, length and structure of the event allowed for plenty of opportunities for networking, from which I really benefited. My involvement at IPAM has affected my research career in two distinct ways. On the one hand, it has given me plenty of ideas for my PhD in homicide prevention, which I plan to implement and disseminate in the form of published articles over the next few years. On the other hand, the materials presented during the conference helped us have a better idea of the types of models that could (or could not) be applied to the study of acquisitive crime prevention. The modeling and simulation of this type of crime is a major part of our research at the UCL Jill Dando Institute, so to be able to discuss these issues with professionals from other disciplines was incredibly helpful. I would have not been able to self-finance my attending so it was UCLA helping with the costs that enabled me to attend. I got so much out of the event and I'm incredibly helpful to UCLA for providing me with this assistance."

Michael Townsley (University College London): “I consider it a great privilege to have had the opportunity to attend an IPAM meeting. It has considerably helped me in thinking about approach research problems in my area. I've met, talked and now worked with I never would have. I imagine my work will have a much larger impact. For instance, I recently wrote to a fellow IPAMer about a research topic I wanted to give a student. I was only trying to work out what skill level was required (undergrad, MSc, etc) but he wrote back with a three page note (complete with math formulae) enhancing the existing method. The final sentence of the note was something like, “This now puts us in a position to start tackling your question. We're in the process of writing his method up, which has a number of advantages over the existing method.”

Jeffrey Walker (University of Arkansas): “I strengthened my resolve to make the study of crime under the principles of complex systems as a major focus of my research. It also provided me some additional tools and analysis methods from complex systems to undertake the research. It also strengthened my understanding of the extent of research in environmental crime and the potential for this paradigm to become a major part of explanations of crime. Collaboration on using crime data in complex systems analyses with Ira Schwartz from the Naval Research Lab. Further collaboration with Pat Brantingham on the influence of complex systems in environmental criminology research.”

Workshop: Small Scales and Extreme Events: The Hurricane

February 12 - 16, 2007

Organizing Committee: Kayo Ide (UCLA, Atmospheric Sciences), Rupert Klein (Freie Universität Berlin, Department Numerical Analysis and Modeling), Andrew Majda (New York University, Courant Institute of Mathematical Sciences), Michael Montgomery (Naval Postgraduate School), Bjorn Stevens (UCLA, Atmospheric Sciences), and Joseph Tribbia (National Center for Atmospheric Research)

Two central issues in the predictability of geophysical flows are how to predict extreme events, and how to represent the collective effects of small-scale energetic processes. These grand themes are well illustrated by the tropical cyclone, a large-scale convective storm system in the tropical atmosphere that rotates counterclockwise in the northern hemisphere and draws its fuel principally from the evaporation of ocean water when the low-level winds attain sufficient strength. Intense tropical cyclones over the Atlantic are called hurricanes; similar storms in the North Pacific are called typhoons. Hurricanes and typhoons are among the fiercest storms conjured by nature, whose destructive power has become apparent to all over the last several years. From the perspective of climate science the frequency and average intensity of tropical cyclones is also a question of great importance. The former requires an understanding of the mechanisms of cyclogenesis, a long standing and enigmatic problem in both tropical meteorology and geophysical fluid dynamics; the latter demands an understanding of how various physical processes interact to regulate intensity variations in storms. Both are questions at the forefront of contemporary research on the fluid dynamics and thermodynamics of tropical storms. Both are also challenging problems in moist vortex dynamics, the dry counterpart of which has a distinguished tradition within applied mathematics. The topic of this workshop was

therefore well suited for an IPAM workshop, and might in fact be revisited in the near future as (part of) a longer program.

The workshop consisted of 23 talks by 20 speakers over five days. One of the talks was a public lecture (see below). The organizing committee consisted of six individuals (two from math departments) and was chaired by B. Stevens of the UCLA Department of Atmospheric and Oceanic Sciences. Of the speakers nine came from math departments. Three speakers came from traditionally under-represented populations, and two had primary affiliations at non US institutions. The workshop consisted of roughly five 50 minute lectures per day, organized following disciplinary themes (information theory, vortex problems, numerical strategies, data assimilation, etc). Both the public lecture and two extended lectures on the first morning served the purpose of tutorials. The daily schedule was front loaded, with an early start and three lectures in the morning followed by two late afternoon lectures. The organizers built in an early start and a long lunch both to provide space for collaborations and to be mindful of jet-lag, as most participants traveled from the east. All the workshop presentations, both as PDF and as a podcast are available on the workshop website.

The workshop attracted broad interest in both the Mathematical and Atmospheric Sciences community, with significant local participation (both from UCLA and Caltech). Among those not invited to formally present a lecture, there was also significant participation by PhD students and recent post-docs. With these participants in mind, space was made available for posters. The posters, which were left standing for most of the week in a readily accessible space near the refreshments, served as a focus for many interactions, and provided a useful venue outside of the lectures for participants to exchange ideas and results. Students and post-docs were also asked to chair individual sessions, at the start of which they introduced themselves, and briefly mentioned their work and interests. IPAM also made office space with computer access available on request. This also benefited the workshop as it provided private space for pursing collaborations, but also made for a more comfortable working environment thereby encouraging participation by lecturers for the full span of the workshop, indeed despite being during the academic term almost all of the participants stayed for the entire workshop.

The workshop worked best in fostering and extending ongoing collaborations (for instance, between Emanuel, Montgomery and Smith). Among these, perhaps predictably, interactions within disciplines remained strongest. Nonetheless there was notable success in breaking down some disciplinary boundaries, for instance on the numerical methods side the workshop helped bridge gaps between atmospheric science practice using multi-scale methods (Randall and Grabowski) and mathematical developments in the field (Engquist). In this respect we expect the workshop to be looked back upon as the starting point for deeper interactions between the NSF science and technology center represented by Grabowski and Randall, and the work of Engquist and colleagues. The workshop also was successful in introducing new work/scientists. Among these the potential applicability of asymptotic approaches of Klein and Majda, and the broader appreciation and basis for collaboration with emerging young scientists (Korobsiero, and perhaps Biello) stand out.

IPAM sponsored a public lecture and reception, featuring workshop speaker Kerry Emanuel. The lecture was entitled “Divine Wind: The History and Science of Hurricanes.” Approximately 160

people attended, including students, postdocs, faculty, alumni, and members of the community. The lecture was held on the evening of the first day, and co-sponsored by several other institutes at UCLA (Atmospheric and Ocean Sciences, the Institute for the Environment (IoE) and the JPL-UCLA Joint Institute for Region Earth System Science and Engineering (JIFRESSE)). The public lecture succeeded in its goal to have an event for a broader community so that the workshop (and IPAM) would attract broader attention and awareness.

Comments from participants of "Small Scales and Extreme Events: The Hurricane" workshop:

Kristen Corbosiero (National Center for Atmospheric Research): "As I will be joining the faculty of the Atmospheric and Oceanic Sciences department at UCLA this fall, my time at IPAM introduced me to staff at IPAM and the many excellent programs that take place there. By attending the Hurricane workshop, I learned of recent developments in the field and started collaborations with other attendees."

Bjorn Stevens (UCLA): "As in the past the professionalism and efficiency of the IPAM staff, and the quality of the physical surroundings (the IPAM building is a tremendous asset) greatly helped to focus participants on the scientific questions being addressed."

Affiliate Workshop: Software for Algebra and Geometry Experimentation (SAGE)
February 17 - 21, 2007

Organizing Committee: Craig Citro (UCLA, Math), David Joyner (U.S. Naval Academy), Kristin Lauter (Microsoft Research), Nathan Ryan (UCLA), and William Stein (University of Washington, Mathematics)

One of the major roadblocks to involving algebraists in computational questions is that in many domains there is a lack of appropriate software, and there is a need for an open platform that can grow to incorporate the growing body of algebraic techniques that are important in applications. SAGE is an attempt to supply such a tool, and to make it available for use in education so as to promote a culture of using the computer to do algebraic calculations.

SAGE is free and open software that supports research and teaching in algebra, geometry, number theory, cryptography, and related areas. Both the SAGE development model and the technology in SAGE itself are distinguished by an extremely strong emphasis on openness, community, cooperation, and collaboration. A key mechanism by which SAGE is developed is the biennial workshop known as SAGE Days, a meeting of SAGE programmers and researchers who use the software in their work. SAGE developers consist of people at every level, from undergraduates to graduate students and postdocs, up to permanent faculty.

Over the first year of its life, SAGE development has mostly focused on implementing basic functionality. This has involved creating a basic infrastructure that people can easily use, extend, and improve. As SAGE matures, more attention is now being paid to making SAGE more robust, and to make its core functionality as fast as possible. The creators of SAGE hope over time to talk to people in applied mathematics and scientific computing, as well as various areas of

computer science, and learn what people already know about these types of questions. SAGE is mature enough that its developers have meaningful questions about computational linear algebra, numerical methods, and other well-studied topics. Rather than struggle with these questions anew ourselves, they intend to bring in experts who can teach them what they know, and use that expertise to improve and extend SAGE.

Workshop: **Topological Quantum Computing**
February 26 - March 2, 2007

Organizing Committee: Michael Freedman (Microsoft Research, Mathematics), Chetan Nayak (Microsoft Station Q, UCLA Physics), and Zhenghan Wang (Microsoft Research)

The existence of topological phases, in which insensitivity to all local perturbations emerges at low-temperatures, is one of the remarkable occurrences in nature. Their mathematical description by topological quantum field theories and their connections knot theory and low-dimensional topology is an equally remarkable mathematical development. Yet another motivation for their study stems from the promise which they hold for scalable fault-tolerant quantum computing. Topological quantum computing was therefore a natural subject for an IPAM workshop, as it brought together researchers with background in mathematics, physics, and computer sciences.

The field of quantum computation has an "x- coordinate" which runs from qubit to topological and a "y-coordinate" running from physics to math/computer science. The recent IPAM meeting brought together experts from this entire plane of viewpoints. Greg Kuperberg in an erudite discourse on the abstract theory of anyonic systems and their representations took time out to personify the "x-coordinate" by placing Michael Freedman at one extreme and John Preskill at the other. Rather than rising to the bait and fight, they both agreed with Greg's real point which is that the separation of physical from software error correction is more rhetorical than real; that in fact one should be willing to explore the entire intellectual space around both ideas and see if and where the best solutions lie.

In this same spirit of setting all thing dogmatic aside, Alexei Kitaev – one of the founders of topological quantum computation – gave at talk on a somewhat related but distinct idea that has captured his imagination recently. The virtue of topological effects in quantum mechanics is that they are amazingly robust. Fractional Quantum Hall Effect (FQHE) systems presently find application in metrology – nothing in the world seems more precise than the quantization of Hall resistance. But Alexei's point was that there may be other corners of quantum mechanics where, for example, energy splitting is exponentially suppressed. He argued that a certain tetrahedral wiring of two Josephson junctions, two capacitors, and two (large) inductors (in a planar array with suitable magnetic field) could have a Hamiltonian spectrum remarkable stable to perturbation. This looks like a ground breaking observation which was first introduced at IPAM.

In the description above two talks were highlighted. But we believe that the level of all talks in this workshop was very high. There was plenty of time for discussion. We believe that students (though few) and post docs were well served. That basic terminology and concepts were

generally explained by the speakers or clarified through audience participation. The atmosphere was relaxed and people felt free to interrupt with question.

IPAM sponsored a public lecture and reception, featuring workshop speaker Michael Freedman, during the week of the workshop. The title was "How Topology Will Save Moore's Law: Quantum Computation via Exotic States of Matter." Approximately 185 people attended, including students, postdocs, faculty, alumni, and members of the community.

Comments from participants of the Topological Quantum Computing workshop:

Eric Rowell (Texas A&M University): "It has given me new contacts with physicists that I would otherwise have struggled to make. It has added significantly to my knowledge (on the physics side) of topological quantum computing."

Mike Freedman (Microsoft Research): "Let me express my thanks to IPAM and personally to you, Christian and Mark, for making this event possible."

***Spring Long Program*: Random Shapes**
March 12 - June 15, 2007

Organizing Committee: Peter Jones, Chair (Yale University, Mathematics), Igor Frenkel (Yale University, Mathematics), Richard Kenyon (University of British Columbia, Mathematics), Stanley Osher (IPAM, Mathematics), Nicholas Read (Yale University, Physics), Steffen Rohde (University of Washington, Mathematics), Bernard Sapoval (École Polytechnique, Physics), and Leon Takhtajan (SUNY Stony Brook, Mathematics)

The study of random shapes started over 100 years ago as a collection of examples, e.g. those arising from Brownian motion. It has turned out to be a meeting place for probability theory, mathematics, physics, combinatorics, computer science, and certain areas of algebra. Recent advances in areas diverse as brain imaging, astrophysics, nanotechnology, and communications and sensor networks have been driven by notions related to random shapes or motions, and random transport. The past decade has seen both an explosion of results as well as new structures (for example, O. Schramm's SLE processes) that unify various problems. The importance of this subject was of course also recognized by awarding the Fields Medal to Wendelin Werner in 2006.

While much progress has been made, this is still a very young field. For example, one is lacking a theory similar to SLE for generating random surfaces. The purpose of this program was to bring together experts from these rapidly developing areas in mathematics and the sciences to share new ideas and study new problems. In this program we were mainly concerned with structures in two or three dimensions, as they have a strong connection to biology and physics, but some of the topics that were covered concerned higher dimensional Euclidean spaces and some problems with networks may have no specified ambient dimension. We also devoted most of workshop 4 to discuss random shapes and complex geometries arising in brain mapping and astrophysics. Some of the topics that were discussed during this program included:

Mathematics: Brownian and fractional Brownian Motion; SLE and related Löwner evolution; geometry of the Gaussian free field; self-avoiding random walk; percolation; random shapes and Wiener space in representation theory; random curves, surfaces, and growth processes; random minimal surfaces; random conformal or quasiconformal mappings; random Teichmüller theory and univalent dynamics; random welding maps; random triangulations and metrics on surfaces; 3D image processing for complex geometries; PDEs related to growth processes.

Physics: Random curves and surfaces in conformal field theory, quantum gravity, and string theory; simulations of random curves and surfaces; folding, shrinking, wrinkling, and buckling of surfaces and membranes; random folding of polymers; geometry of random fields; electrodeposition and rough boundaries in electrochemistry; diffusion limited aggregation; branching structures and random transport; large scale cosmic fields and structures; random structures and diffusion in nanotechnology.

Computer Science: Random trees, circuits, graphs, branching processes, and related algorithms; random partitions and metrics; random polytopes; random routing and transport; random search algorithms; dynamic networks, graphs, and spanners; complex geometries in communication and sensor networks; 3D graphics for complex surfaces; computational geometry for random surfaces and sets.

Biology and Medicine: Applications of random shapes and theory of fractals was applied to categorizing human placentas; also, growth shapes of growing tissue were discussed, together with material scientists.

This long program provided fertile ground for a number of collaborations. Several collaborations that existed already before the program flourished here at IPAM. Most noticeable are the collaborations between Yampolsky and Braverman, Vixie, Allard, Hardt, and Schulz, and McGee and Serna. But more importantly, a number of new collaborations have developed during the program, which has already led to interesting new results, and have led to new joint proposals and research projects. They include the following new collaborations: Salafia, Vixie, Yampolsky, and Grebenkov, Mc Gee, Serna, and Grebenkow, Jones and Grebenkov, Jones, Astala, Rohde, and Saksman, and Chayes, Binder, and Lei. Moreover, the culminating workshop at Lake Arrowhead overlapped with the reunion conference of the program on “Bridging time and length scales in materials sciences and biophysics,” and some new collaborations might have developed here. We note in particularly the interactions between Salafia and Vvedensky, and Maggioni and Clementi.

We believe that the program was highly successful, and some of the successes might not even be obvious right now. Nevertheless, we would like to point a number of developments that can be regarded as particularly successful results of this program:

- The new collaboration between Binder, Chayes, and Lei gives a new approach to percolation clusters and SLE(6) traces. The approach is completely different from other known approaches (by Smirnov, Lawler, Schramm, and Werner).

- Carolyn Salafia's research focuses on the human placenta, and in particular if and how shapes (and shape abnormalities) might effect the development of humans. Her new collaborations help to connect the study of shapes of placentas with the theory of random shapes.
- Another highlight is the connection between Jones, Schul, Sapoval, and Grebenkov on the fine properties of eigenfunction concentration.
- Celcilia Clementi (who met the participants of the Random Shapes program at the final workshop at Lake Arrowhead, which she attended as a participant to the program on multiscale modeling in materials sciences and biophysics) introduced an application of diffusion geometry to protein folding. As a result she started a collaboration with Mauro Maggioni.

Comments from Random Shapes Long Program participants:

Fredrik Johansson (Royal Institute of Technology): "In any case I want to thank you for three unbelievably fun and instructive months in LA. I could not be more pleased with IPAM, the workshops, the cognac, the people, the beaches, etc."

Maria McGee (Wake Forest University): "Thank you again for making it possible for me to interact with mathematicians and physicists, it's changing my perspectives and is finally impacting the way we plan the research programs for our section."

Carolyn Salafia (Columbia University): "I want to tell you that my time at IPAM clearly is "a gift that keeps on giving", in terms of research opportunities and fruitful collaborations. Since early July, I have been working closely with the Data Driven Mining and Analysis group at Los Alamos National Laboratories (LANL); we have submitted four invention reports to the intellectual property folks at New York University School of Medicine and LANL. My work with Michael Yampolsky at the University of Toronto is now supporting one of his graduate students, and he is developing grant proposals to his national funding sources. One of the LANL summer students, David Bolme of Colorado State University, has elected to analyze placental images for his mathematics Ph.D. dissertation.

"However, more important than the network of excellent collaborators and exciting research is the knowledge that the methods and tacks we are currently taking have the potential to revolutionize how the practice of placental diagnostics is performed. Our first steps in this direction have provided evidence that more careful placental measurement can improve our understanding of how fetuses grow. We anticipate that this will contribute to our understanding of how fetal life influences lifelong health risks.

"Thank you again for the career- (and profession-) altering experience of attending the IPAM Random Shapes workshop."

Bill Allard (Duke University): "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."

Denis Grebenkov (École Polytechnique): "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 quite 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 (see projets). I'm definitely positive about these programs and I will participate in organization of the long term program "Optimal Transport" in Spring 2008."

Helen Lei (UCLA): "The Random Shapes program was a very positive experience for me. From the workshops I learned about many aspects of conformal invariance which I was not aware of. The opportunity to have meaningful interactions with both junior and senior researchers in an open, friendly and productive environment was invaluable. Having done a little work before in the area of conformal invariance almost by chance, I now have a much better appreciation of the key issues and questions of interest and feel inspired to try to do more work in the area."

Kevin Vixie (Los Alamos National Lab): "It is really hard to overestimate the importance of my time at IPAM. It really would take me to go over all the ways in which the access to the opportunities has improved my research and career path. The influence of people like Allon Percus, Peter Jones, Mark Green, Stan Osher, Tony Chan, and recently others (like Christian Ratsch and John Garnett) is significant though not always easy to quantify or summarize. What I have written in this form just scratches the surface of the positive impact IPAM has had for me."

Krzysztof Burdzy (University of Washington): "The stay at IPAM was the source of inspiration, several meaningful discussions, and likely the starting point of several forthcoming papers. It also allowed me to get familiar with the current cutting-edge research."

Long Program Tutorials: **Random Shapes**
March 13 - 16, 2007

Organizing Committee: Peter Jones, Chair (Yale University, Mathematics), Bernard Sapoval (École Polytechnique, Physics).

During the first week of the program we offered a set of tutorials. These tutorials gave an introduction to the relevant topics and problems. We alternated contributions from mathematics, physics, and computer science. The tutorial included some of the most senior participants of the program, and other experts who came explicitly to IPAM for the tutorials. We believe that we succeeded in our goal of familiarizing all the participants with the different issues and techniques involved in random structures, and of creating a common language among researchers coming from different fields. Some of the highlights of the tutorials include the following: Ilia Binder was the very first lecturer and gave a beautiful introduction to SLE. Quite a few people commented on the clarity and quality of his talk, which set the tone and style for the entire week. Rick Kenyon's introduction to his work on growth models and fast algorithms got a lot of

attention. Chris Burdzy gave a beautiful introduction to Brownian motion. He managed to give a good introduction to the non-expert, while still including some sophisticated material. Francois Meyer introduced brain imaging and some newer methodologies. Bernhard Sapoval discussed transport to irregular surfaces in many physical situations. For example, he discussed material applications to soundproofing or construction of seawalls.

Long Program Workshop I: Random Shapes, Representation Theory, and Conformal Field Theory

March 26 - 30, 2007

Organizing Committee: Greg Lawler, Co-Chair (University of Chicago), Nicholas Read , Co-Chair (Yale University), Denis Bernard (École Normale Supérieure), Krzysztof Burdzy (University of Washington), John Cardy (University of Oxford), Igor Frenkel (Yale University), Peter Jones (Yale University), Steffen Rohde (University of Washington), and Leon Takhtajan (SUNY Stony Brook)

There has been a great flurry of activity on two-dimensional systems in the last few years spurred by a number of events, most prominently the introduction of the Stochastic (or Schramm) Loewner evolution (SLE). SLE gives a way to describe boundary curves in conformal fields in terms of a growing path obtained by solving a Loewner equation with a Brownian driving function.

During the 5 days of the workshop we had a total of 22 talks. Typically three talks in the morning and two in the afternoon. We had a long break in the middle of the day, giving participants a chance to interact and collaborate. A number of the presentations discussed SLE and its applications. The talks of Lawler, Rohde, Beliaev, Binder, and Kang discussed aspects of the mathematical theory, and SLE arose in the presentations of physicists Gruzberg, Astala, and Bernard (who spoke on the appearance of SLE curves in turbulence). Two other talks deserve particular mention: Scott Sheffield's work (joint with Oded Schramm) on rigorous relationships between the Gaussian free field and SLE and Stas Smirnov's recent work giving a rigorous proof of that the Ising model approaches SLE. Other talks emphasizing mathematics were given by Bartal, Sodin, Burdzy, and Jones. The talks of Jacobsen, LeDoussal, Read, and Saluer, although not talking about SLE, were very closely related to the larger topic of critical phenomena in 2d systems. One of the exciting aspects of the recent activity is the increased communication between physicists and mathematicians in these areas. A number of other exciting areas in physics were represented by talks of Middleton, Chayes, Nienhuis.

In addition, there was a panel discussion on Wednesday afternoon led by Peter Jones. It turned into a lively discussion, with many contributions and suggestions by a number of the workshop participants.

Overall, the meeting was a great success with much interaction between the mathematicians and the physicists.

***Long Program Workshop II*: Random Curves, Surfaces, and Transport**
April 16 - 20, 2007

Organizing Committee: Bernard Sapoval, Chair (École Polytechnique), Eli Ben-Naim (Los Alamos National Laboratory), Hans Herrmann (Eidgenössische TH Zürich-Hönggerberg), Richard Kenyon (University of British Columbia), and Katepalli Sreenivasan (Abdus Salam International Centre for Theoretical Physics)

Random curves, random surfaces and random trees exist in a variety of situations. Their structures play a dominant role in many natural phenomena and industrial applications. Examples arise in diverse areas in physics but also in respiration and irrigation problems, traffic flow and catalytic activity. In this workshop we brought together mathematicians, applied mathematicians, biologists and physicists to discuss the following topics: Growth of random curves and surfaces; Folding, shrinking, wrinkling, and buckling of surfaces and membranes; Biological membranes; Fluid-fluid interfaces; Complex nanostructures; Theoretical and real optimal transport; Search trees; Properties of random trees; Traffic models; Transport on or towards random structures, diffusion, vibrations, theory and simulations; Relation with the harmonic measure of complex structures; Confined Brownian bridges.

During the 5 days we had a total of 26 talks, plus a public lecture. We had usually 3 talks in the morning, and 2 talk in the afternoon. In the middle of the day we had a long lunch break, so that participants had a chance to interact and collaborate. In addition, in the evening of the fist day, IPAM sponsored a public lecture and reception. The lecture was given by workshop speaker Benoit Mandelbrot and was entitled "The Nature of Roughness in Mathematics, Science and Art." Benoit Mandelbrot is a world renowned scientist, and is commonly referred to as the "father of fractals". Approximately 300 people attended, including students, postdocs, faculty, alumni, and members of the community. This was the third public IPAM lecture of the year.

The discussions following the talks and during the long breaks were very active. Participants appeared to be very happy in general. We therefore believe that we succeeded in the goal to bring together different communities, and to foster interactions and collaborations. The workshop also succeeded to bring together communities that usually do not interact very much, and help understand different aspects and their importance for related problems. As an example, we had two talks on optimal transport from the mathematics side. These were very interesting talks. But it also became clear in the discussions that on the mathematics side not much is known (yet) about the robustness of optimal transport against defects. On the other hand, for researchers who are interested in effective transport of living systems (for example the bronchial tree), such an information is essential as surviving systems have to achieve some type of robustness against variation of evolutionary conditions.

<u>Comments from participants of Random Shapes Workshop II:</u>

Frederic Dias (École Normale Supérieure de Cachan): "I just wanted to tell you that it was a fantastic workshop, even for a non expert in image processing for random shapes. The talks were excellent and I learnt a lot. There were a lot of private discussions, which was good. So thank

you to the organizing committee, who kindly accepted a ‘non-image’ member in its team! Hope to see you again in the future!”

Long Program Workshop III: Random and Dynamic Graphs and Networks
May 7 - 11, 2007

Organizing Committee: Elchanan Mossel, Co-Chair (UC Berkeley), Walter Willinger, Co-Chair (AT&T Labs-Research), Noam Berger (UCLA), Jennifer Chayes (Microsoft Research), Marc Mezard (Université d'Orsay), and Alessandro Vespignani (Indiana University)

`Networks lie at the core of the economic, political, and social fabric of the 21st century" (quote from the 2005 NRC report on "Network Science). Networks are encountered in biological, engineered, or social systems, at many layers of abstraction, from physical structures at the microscopic level to more logical or virtual constructs at the macroscopic level. Prominent examples include bacterial transcriptional regulatory networks, metabolic networks, cellular neural networks, the immune system, the power grid, and communication networks such as the Internet, transportation financial networks, health-care provider networks, and sexual contact networks.

To date, the mathematical study of networks has largely focused on static graph structures and their properties and has used ideas from such diverse fields as graph theory, probability theory (e.g., branching processes, infinite particle systems, Polya urns), statistical physics, computer science, etc. This workshop presented an excellent opportunity for discussion, exchange of ideas and collaboration between experts in a number of areas.

It succeeded to make real progress in the ongoing discussion on the applicability of mathematical models for networks (e.g. "preferential attachment power law" networks) to real world problems. By clearly identifying for which problems it is not a good model (e.g. the physical internet) while suggesting others for which it may be a good model (e.g. citation networks). Furthermore it has clearly identified the need in more elaborate validation methods for models, more accurate inference techniques on models and the need to develop theoretical and practical tools to study the dynamics of networks.

A key factor in choosing the topics and speakers for the workshop was a consensus among the organizers that bringing together leading researchers from different communities is the way to make real progress in the study of networks. For example, Stanley Wasserman’s discussion of exponential models in the social science came just after an excellent talk by Sourav Chatterjee about the mathematics of exponential models and needed to tackle critique by John Doyle on validation and fitting. Similarly, there was an interesting exchange on preferential attachment models between Sid Redner (physics) and the mathematicians who study these models.

The workshop had 25 invited talks and more than 100 participants. Among the speakers, about half were at the early stage of their career (and one speaker was a graduate student, Sebastien Roch). Four of the invited speakers were women (Chayes, D'Souza, Janssenm, Mihail) as well as many of the participants.

The workshop had a successful poster session where non-speakers presented their work. A panel consisting of some of the young participants of the workshop (Aaraon Clauset, Lea Popovic, Lea Shaw, Lilit Yeghizarian) all at the post-doc level, centered on the future work that is needed in the area and succeeded to lead a fascinating discussion.

The workshop evaluations forms indicated that 37/38 of the participants thought that the talks were just about the right level (with 1 marking the level as too high and none saying it was too low). 33/38 indicated that the level of the talks was high with 5/38 indicated they were medium. Other categories indicated that participants viewed it as a success (see statistics attached).

Sidney Redner (Boston University): "I participated in the program on networks that is more closely connected to my current research. From this last program, I also got a few ideas for good shorter-term research projects. I think that the main benefit of my participation in these IPAM programs is hard to quantify because they will likely occur several years in the future. Overall, I had very stimulating experiences."

Long Program Workshop IV: **Image Processing for Random Shapes: Applications to Brain Mapping, Geophysics and Astrophysics**
May 21 - 25, 2007

Supported in part by UCLA's Laboratory of Nuero Imaging (LONI)

Organizing Committee: Peter Jones, Chair (Yale University), Frederic Dias (École Normale Supérieure de Cachan), Stanley Osher (Institute for Pure and Applied Mathematics), Guillermo Sapiro (University of Minnesota, Twin Cities), Jean-Luc Starck (Commissariat à l'Énergie Atomique),Paul Thompson (UCLA), and Keith Worsley (McGill University)

Random shapes occur in many physical and biological models and applications, and image processing of these random shapes is very challenging. This workshop has brought together experts in image processing, mathematics, biology and medicine, and physical sciences. Topics discussed in the workshop included, but were not limited to: brain imaging and measures of complexity; random fields in brain science; complexity in cortex or brain morphology; shrinking and wrinkling of anatomical structures; filaments and large scale structures in the cosmos; random fields; geometry and the Gaussian free field; distribution of dark matter; 3D image processing and graphics for complex surfaces in the geophysical sciences; computational geometry for complex sets and surfaces.

This workshop consisted of 2 parts: In the first 3 days, we focused more general on image processing, and applications to geosciences and astrophysics. The last 2 days did then focus more on brain mapping and brain-imaging. These last 2 days were in close interactions with the UCLA laboratory of neural imaging (LONI). We had a total of 24 presentations over the 5 day period of the workshop, with typically 3 talks in the morning and 2 talks in the afternoon. We scheduled a long break in the middle of the day, so that participants had plenty of time to interact and collaborate. Due to the large number of different topics, and the large number of junior

participants, we had 2 poster sessions. The first poster session was in the evening of the first day, during the reception. There were a large number of posters, and the posters were well attended. The second poster session was focused on the brain mapping and imaging topics, and was held in conjunction with the reception at LONI.

Highlights of this program include:

- Jonathan Taylor gave a well received talk on Integral Geometry and its applications to brain mapping.
- The workshop led to the proposal of an IPAM summer school "Mathematics and Brain Imaging" that will be held at IPAM in July of 2008.
- The workshop was instrumental for future activities on "Tensor MRI.
- One of the highlights of the second part of the workshop was a reception and subsequent tour of the LONI facility, which was given by Paul Thompson.

Comments from Participants of Random Shapes Workshop IV:

Monica Hurdal (Florida State University): "Through the meetings and visits to IPAM, I have continued to stay involved in research involving the human brain and using mathematics to further research in this area. The meetings at IPAM that I have attended have been multi-disciplinary, which has been an asset to my career and research. Such meetings allow me to interact with potential sources of data collaboration which are difficult to obtain."

Short Course: **Sparse Representations and High-dimensional Geometry (Von-Neumann Pre-program)**
May 30-June 1, 2007

Organizing Committee: Anna Gilbert (University of Michigan), Jared Tanner (University of Utah)

The 2007 edition of the AMS Von Neumann Symposium concerns Sparse Representation and High-Dimensional Geometry, which is currently undergoing rapid advances in both theory and application. This associated short course was held five weeks prior to the 2007 Von Neumann Symposium. Speakers were in residence for the entire three day meeting and will be available to participants for in depth discussions. Intentionally, relatively junior speakers were selected with the aim of introducing the next generation of researchers to this emerging and exciting body of techniques. There were six lecture series of 3 lectures each: Joel Tropp on "Introduction to Matching Pursuits," Roman Vershynin on "Analysis of Random Measurements," Anna Gilbert on "What makes sublinear algorithms so fast," Jared Tanner on ""Convex Relaxation and Polytopes," Justin Romberg on "Uncertainty Principles and Sparse Recovery," and Jing Zou on "The Super-Fast Sparse Fourier Algorithms."

Comments from Sparse Representations Participants:

Stephane Chretien (Universite de Franche-Comte): "The Short Course: Sparse Representations and High Dimensional Geometry" at IPAM, in conjunction with the AMS 2007 Von Neumann Symposium, was a great opportunity to exchange ideas and I learnt a lot about the new directions in this field which I think will greatly influence my work in this new topic of research for the year to come. The quality of the talks was truly exceptional. I had in particular the opportunity to meet Emmanuel Candes from ACM in Caltech with whom i discussed the ideas which lead to a refined version of the algorithm presented at the ICIAM 07 conference in Zurich."

Ron Rubinstein (Technion): "The course was a great experience for me. It was a delightful combination of study, sharing thoughts, and making social professional connections. I have learned a lot, and what's more important, returned to my studies highly motivated to dive deeper into the field. The course was an interesting, exciting and joyful way to get to know the field of sparse approximation."

Jared Tanner (University of Utah): "IPAM's support over the years has been invaluable. In fact, much of what I am working on now came out of my time at IPAM. I'm confident that this summer's short course will have a similar impact on the future research of another large group of researchers."

Oksana Yakhnenko (Iowa State University): "I think IPAM is a great resource. I will be using the methods I have learned about at the VN2007 workshop (sparse representation and high-dimensional geometry) such as OMP, wavelet basis, and randomized matrix operations in my research in machine learning and nlp."

Long Program Culminating Workshop at Lake Arrowhead
June 10 - 15, 2007

Organizing Committee: Peter Jones, Chair (Yale University, Mathematics), Igor Frenkel (Yale University, Mathematics), Richard Kenyon (University of British Columbia, Mathematics), Stanley Osher (IPAM, Mathematics), Nicholas Read (Yale University, Physics), Steffen Rohde (University of Washington, Mathematics), Bernard Sapoval (École Polytechnique, Physics), and Leon Takhtajan (SUNY Stony Brook, Mathematics)

This 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. There also was some very fertile overlap with the reunion conference "bridging time and lengths scales in materials sciences and biophysics", which might have led to additional new collaborations.

Some of the highlights of the culminating workshop include:

- Greg Lawler for the first time unveiled his recent work on the parameterization problem for SLE.

- Carolyn Salafia and one of her co-workers (Simon Morgan) discussed the progress she made during the long program in her studies of placentas. In particular, the discussed the progress in geometry of the placentas, classification, image processing, and mathematical modeling.
- Cecilia Clementi (Rice University) was a participant of the reunion conference of the program "Bridging Time and Length Scales in Materials Science and Bio-Physics". She discussed her work on spectral theory applied to protein folding. This discussion led to a new collaboration with Mauro Maggioni (Duke University).
- Peter Jones, Mauro Maggioni, and Ranan Schul finished a project on diffusion geometry and Riemann mapping theorems that was started at the 2004 MGA program. This work, which explains the robustness and global (or local) stability of Laplace eigenfunction local coordinates, will appear in the Proceedings of the National Academy of Sciences (it was solicited).

***Reunion Conference*: Bridging Time and Length Scales in Materials Science and Bio-Physics**
June 10 - 15, 2007

Organizing Committee: Russel Caflisch (UCLA, Mathematics and Materials Science), Cecilia Clementi (Rice University), Weinan E (Princeton University, Mathematics), Michael Klein (University of Pennsylvania, Chemistry), Christian Ratsch (UCLA, Mathematics), Karsten Reuter (Fritz-Haber-Institut der Max-Planck-Gesellschaft, Theory Department), Matthias Scheffler (Fritz-Haber-Institut der Max-Planck-Gesellschaft, Theory Department), Klaus Schulten (University of Illinois at Urbana-Champaign, Physics and Biophysics), and Annabella Selloni (Princeton University)

This was the first reunion conference for participants of the fall 2005 long program "Bridging Time and Length Scales in Materials Science and Bio-Physics." A total of 28 people attended this reunion. Participants were a healthy mix between scientists with a background in mathematics, physics, materials science, chemistry, and biophysics. Five of the 28 participants were women. The meeting had several talks every morning, and then afternoons alternating with afternoon sessions or free time. In particular the free time was much appreciated, as it gave the participants ample time for extended discussions and deepening of existing (or new) collaborations (see below). There was also a panel discussion on Thursday night, were some fundamental scientific issues as well as the status of interactions between scientists from different disciplines were discussed.

The overall opinion among the participants was that this was an extremely successful reunion. Most talks were rated extremely highly, and the discussions were very useful. At the end of the main program 18 months ago we have identified a number of topics as "challenges and open issues" for the future. Progress has been made on a number of these issues, and the results and advancements were discussed at the reunion:

- One challenge is to put modeling techniques on a more rigorous mathematical footing and to improve the ability to rigorously estimate the numerical error of a model and

numerical simulation. Progress has been made in this area; the most noticeable contributions were by Plechac and Luskin.

- One highlight of the main program was a mini-workshop on acceleration methods. As part of this workshop, indentification of rare events was considered a big challenge. The talks by Clementi, Fichthorn, Henkelman, and Khalili discussed progress in this area for problems in biophysics and materials sciences. Moreoever, the idea of a separate new workshop in the near future has been discussed, and a proposal is expected to be submitted to IPAM by Fichthorn and others.
- Improving empirical potential is a major challenge for reliable modeling. In particular the group of Petifor and Drautz has made a lot of progress, as discussed in the talk by Drautz.
- Combining strain models with other (atomistic or continuum) models is very time consuming. Significant progress has been made, as evident from the talks by Caflisch, Katzer, Ratsch, and Smereka.

A number of collaborations have been formed during the long program 18 months ago. This meeting helped to deepen the following collaborations: Plechac and Vvedensky, Smereka and Schulz, Clementi and the group of Kremer, Caflisch and Margetis, and Andrienko and von Lilienfeld. A new collaboration between Margetis, Caflisch, and Scheffler, and Ratsch and Smereka started at this reunion. Moreover, we had some interactions with the second reunion conference of the MGA program, and the culminating workshop of the Random Shapes program, and at least 2 possible new collaborations might have started, between Vvedensky and Salafia, and Clementi, Maggioni, and (maybe) Jones.

At the end of the meeting some suggestions for the second reunion, and also suggestions for future meetings on this topic were discussed. There was a general consensus that there should be even more emphasize on open issues and problems in the presentation, rather than just highlighting the successes of one's approach or calculations. This should be one of the differences between such an IPAM reunion (or any IPAM event) and a regular conference. It was also suggested that not necessarily all attendees have to give a talk; rather, a few longer, introductory talks, and sessions focused on a topic should be considered.

Comments from participants of this reunion conference:

Denis Andrienko 9 Max Planck Institute for Polymer Research): "IPAM meeting helped me to broaden my research interest, in particular in the direction of rational compound design and various DFT methods. I have also obtained a needed background in DFT which is now one of the tools I am using in my research (charge transport in organic materials)."

Ralf Drautz (University of Oxford): "Through IPAM I established a lot of informal contacts from which collaborations may grow that certainly will influence my career and research direction in the future."

Dionisios Margetis (University of Maryland): "When I visited IPAM in Fall 2005 I was only an instructor in applied mathematics. My participation in the 3-month IPAM workshop 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."

David Pettifor (University of Oxford): "Brought to fruition the dream of an analytic interatomic potential for transition metals and their alloys that goes far beyond the EAM or Finnis -Sinclair potentials by including the electronic terms that drive relative structural stability and heats of formation."

Ignacio Plans (Universidad Carlos III de Madrid): "I had the chance to learn how is the current state of the art in multidisciplinary research fields related with multi-scale problems, as well as have really useful feedback on my own work."

Alexander Tkatchenko (Fritz-Haber-Institut der Max-Planck-Gesellschaft): "The impact of my involvement with IPAM has been paramount. It has opened many new directions for my research, unforeseeable before my long-term participation in the IPAM program. It has also allowed to accelerate my career development and meet many exciting people. Along the way, I have been offered a position as a postdoc in the Prof. Matthias Scheffler group at Fritz Haber Institute in Berlin, starting in June 2007."

Art Voter (Los Alamos National Laboratory): "I think the IPAM conference center offers an excellent environment for discussing science and making scientific contacts. I have always enjoyed my time there. I think the discussions I have had with other scientists at IPAM have probably influenced my research directions in ways that are not reflected in the simple lists of papers and collaborations above. IPAM is a truly valuable resource for the scientific community."

Dimitri Vvedensky (Imperial College): "It has in the sense that it has made me more aware of the mathematical issues that lie at the foundation of my work on stochastic PDEs."

Undergraduate Summer Program: Research in Industrial Projects for Students – Los Angeles (RIPS-LA)

June 24 - August 24, 2007

Although this program spans two reporting periods, we have chosen to report on the entire RIPS 2007 program in the 2006-2007 annual report. The Finance Support List and Participant List reflect all participants of the program and all individual financial transactions associated with the program.

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.

Projects are selected to have a major mathematical component and to be something that will pose an interesting challenge to talented undergraduates. Sponsors tend to be organizations that are reliant on sophisticated technology. RIPS 2007 sponsors and projects are listed on the table below.

RIPS-LA 2007 Sponsors and Projects		
Sponsor	**Title of Project**	**New/ Returning**
Accelyrs	Modeling the Morphology of a Crystal Grown from Solution	New
Amgen	Increasing the Applicability of a Medical Ontology	New
Arete	Automatic Registration and Stabilization of Video Images	Returning
Cedars Sinai	Finding Protein Identities in Liquid Chromatography-Mass Spectrometry (LC-MS) Experiments	New
JPL	Visualizing Invariant Manifolds for the Planar Restricted Three Body Problem	Returning
LANL	Cooperation Among Autonomous Robots and Occlusion Video Tracking	Returning
LLNL	Computer Experiments for Function Approximations	Returning
Pixar	Statistical Filtering of Global Illumination for Computer Graphics	Returning
Symantec	A Webpage Reputation Scoring System	Returning

Other features of RIPS-LA include the following:

- Each team has a faculty mentor to ensure that students are put in contact with the latest techniques to apply to their problem.
- Each team has one or more industry mentors from the sponsor, who provides ongoing feedback about how well the work being done fits the sponsor's needs.
- Teams make a site visit to the sponsoring organization to present their work.
- Students learn how to give a polished technical presentation, which they present as a team on Projects Day.
- Students gain experience in how to write a polished technical report, which often serves as a valuable reference document for the sponsor.

IPAM publicizes RIPS through mass mailings to Historically Black Colleges and Universities (HBCU) and Hispanic Association of Colleges and Universities (HACU), as well as other universities across the country.

Admission to the program is highly competitive, with applicants coming from all over the world. In 2007, IPAM received 272 applications, out of which 36 were selected. Fifteen (43%) of the students were female. Six (18%) were members of underrepresented ethnic groups. Most were rising seniors or 2007 graduates. The students came from a diverse range of undergraduate institutions, from small liberal arts colleges to internationally renowned research institutions.

Beginning in 2002, IPAM received additional funding for RIPS from the National Security Agency.

Comments from RIPS-LA participants:

Natth Bejraburnin (Stanford University): "RIPS is like a research playground that has a bunch of interesting equipment … for me to explore. We don't have a 'boss' or an 'instructor', but we do have 'mentors' who let us 'own the projects,' and explore things ourselves. This setting brings about motivation from such ownership and it tends to stimulate creativity and ingenuity out of the students. It is a remarkable start to my research career which reserves some intellectual fun for my undergraduate life."

Allison Chang (MIT): "RIPS gave me a taste of what it would be like to work in industry, and I am now more confident in my ability to keep up with a fast-paced industry job. If I do decide to work in industry after graduate school, I know I will be better prepared to handle the pressure of meeting deadlines because I went through RIPS."

Katherine Hoff (MIT): "I definitely learned a lot, not only about the subject of my research but about all the other teams' projects too. The collaborative atmosphere is great, I could learn about so many interesting projects all at the same time just by going to tea time."

Neil Katuna (Princeton University): "Never could I have imagined that I would learn so much from one short 9-week program. RIPS not only helped to remove my pure math blinders exposing me to many different fields of applied math, but also to teach me about the leadership required to work effectively in industry."

Eli Kupperman (Harvard University): "RIPS is an amazing place for undergraduates to get the type of research experience that is not normally reserved for undergraduates. We were given the challenge of our own research project to be worked on at our own pace and with our own ideas. It is a program unlike any I have seen for undergrads."

Shaun Maguire (Stanford): "I learned an incredible amount during my nine weeks at IPAM – and not only math. I learned how to work in a team, investigated wavelets, became exposed to image processing and improved my programming."

Karamatou Yacoubou Djima (College of Staten Island, CUNY): "My project proved how mathematics concepts could be applied to a large palette of real life problems. The tasks were pretty challenging, and at first you may not even be familiar with the topic (that was my case). But somehow your mind adjusts and it's actually amazing to see yourself, your teammates and others come up with all types of interesting ideas. Another group work may even be inspiring for yours."

Undergraduate Summer Program: **Research in Industrial Projects for Students-Beijing (RIPS-BJ)**
July 1 - August 24, 2007

Although this program spans two reporting periods, we have chosen to report on the entire RIPS-Beijing 2007 program in the 2006-2007 annual report. The Finance Support List and Participant List reflect all participants of the program and all individual financial transactions associated with the program.

In 2007, in addition to our annual RIPS program held on the UCLA campus, IPAM also debuted RIPS-Beijing. In collaboration with Microsoft Research Asia (MSRA), ten U.S. students and ten Chinese students were chosen to work on cross-cultural teams on five projects, each sponsored by an MSRA research group. The dates and basic format of the program are the same as RIPS-LA. English is the only language required for participation. U.S. citizens and permanent residents applied through IPAM. Chinese participants applied through MSRA.

Projects for RIPS-Beijing were sponsored by five MSRA research groups. The projects included: "Semi-supervised Support Vector Machine for Relation Extraction," "Maximum Mutual Information Partition for Confidence Measures in Speech Recognition," "Stochastic Modeling and Analysis of Broadcast Algorithms," "The Disktop: A Hyperbolic Task Manager," and "Analysis of PageRank Computation Methods and Induced Webpage Ordering for Google Matrices."

Comments from RIPS-Beijing participants:

Laura Tupper (Swarthmore College): "RIPS-Beijing was a valuable experience, academically and personally – a great chance to learn about math and China at the same time. I've learned a great deal about my subject, but more about the experience of working and doing research in a large company."

Erica Newland (Yale University): "RIPS-Beijing was an amazing opportunity to travel to one of the most exciting places in the world and experience a different research culture with smart and fascinating students."

Justin Gilmer (Washington University): "The project was challenging but I learned more about the field in just two months than I would have in a year of class. It definitely turned me on to the field of machine learning."

Zhou Fan (Harvard University): “I feel the cross-cultural aspect really defines the program and distinguishes it from other research opportunities. It’s a great way to spend the summer.”

Tamara Broderick (Princeton University): “I would absolutely recommend [RIPS-Beijing] to other undergraduate students. Not only do you get to spend two full months in an exciting foreign country … but you get to work on an interesting project with like-minded individuals from the U.S. and abroad.”

Jeffrey Barnes (Macalester College): “Working alongside Chinese colleagues allowed a lot of immersion and cultural exchange. I especially benefited because I knew nothing of Chinese culture or language. It was a great way to learn.”

Graduate Summer School: **Probabilistic Models of Cognition: The Mathematics of Mind**
July 9 - 27, 2007

Organizing Committee: Josh Tenenbaum (Massachusetts Institute of Technology, Brain and Cog Sc, CS, and AI) and Alan Yuille (UCLA, Statistics)

This was a very successful summer school with over 200 participants, including a stellar list of speakers and an exceptionally talented group of junior people. Participants came from mathematics, statistics, computer science, cognitive science, psychology and neuroscience. The goal was to develop a common mathematical framework for all aspects of cognition, and review how it explains empirical phenomena in the major areas of cognitive science - including vision, memory, reasoning, learning, planning, and language. The summer school was motivated by recent advances which offer the promise of modeling human cognition mathematically. These advances have occurred largely because the mathematical and computational tools developed for designing artificial systems are beginning to make an impact on theoretical and empirical work in Cognitive Science. In turn, Cognitive Science offers an enormous range of complex problems which challenge and test these theories.

The main theoretical theme of the summer school was to model cognitive abilities as sophisticated forms of probabilistic inference. The approach is "sophisticated" in at least three respects. First, the knowledge and beliefs of cognitive agents are modeled using sophisticated probability distributions defined over structured relational systems, such as graphs and generative grammars. Second, the learning and reasoning processes of cognitive agents are modeled using advanced mathematical techniques from statistical estimation, statistical physics, and stochastic differential equations. Third, the decision making processes of agents are modeled using techniques from decision theory and game theory.

The summer school was designed especially for graduate students and postdocs, as well as more senior researchers interested in focusing their efforts on these mathematical challenges and crucial applications. The program was organized as follows:

Week 1: Tutorials: Introduction to the conceptual foundations and basic mathematical and computational techniques. Topics include Bayesian probability theory, parameter estimation, graphical models (directed and undirected), inference, learning (parameters & structure), dynamical models, basic Bayesian decision theory, MCMC other unsupervised learning topics (e.g. EM, PCA/FA), model selection, and information maximization. These methods were illustrated on simple cognitive examples. Computer software packages were demonstrated so that students can implement these theories and apply them to model simple cognitive tasks.

Week 2: Core applications to cognitive science. This includes advanced methods such as probabilistic grammars and relational models, which have recently been successfully applied to language and vision and hierarchical reinforcement learning (which relates to how cognitive agents make decisions over time). Core applications included how these mathematical techniques can be used to predict and explain cognitive phenomena, modeling reasoning over time, which relates to decision making experiments, and modeling information based exploration which accounts for cognitive reasoning experiments and aspects of visual search. All these core applications emphasized themes and tools that are common to all aspects of cognitive science.

Week 3: Advanced topics. There has recently been considerable success in developing unsupervised methods for learning probabilistic models for language and vision which has major implications for cognitive development. Talks took place on unsupervised learning of grammars for language and vision in tandem with research on modeling learnability and cognitive development. Advanced topics included modeling mutilmodal sensory interactions (e.g. between vision and audition) and sensorimotor integration, neuroeconomics which studies how decisions are made in brain and how this relates to decision theory and game theory. This was supplemented with studies of advanced decision making.

In view of the novelty of this program and the high level of interest, the lectures were all videotaped and made available on the web.

Affiliate Workshop: **Mathematics of Language**
July 28 – 30, 2007

Organizing Committee: Marcus Kracht (UCLA), Gerald Penn (University of Toronto and ISI), Ed Stabler (UCLA)

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Mathematics is becoming increasingly important in linguistics, as the level of sophistication rises in all areas. The workshop provided a forum for new ideas in the field and promoted the study of language from a mathematical point of view. There was no preference of the kinds of mathematics involved, though the conference clearly has a less computational slant than most others. The workshop emphasized the following areas:

- complexity and generative capacity of languages
- formal analysis of linguistic theories and frameworks

- model-theoretic and proof-theoretic methods in linguistics
- mathematical foundations of statistical and stochastic approaches to language analysis

The main speaker was Partha Niyogi (University of Chicago), who gave an overview of his work on the relationship between language change and learning strategies. The conference also had 12 contributed papers and one lecture by Kevin Knight (University of Southern California).

MoL also had two parasessions. One was devoted to the 50th anniversary of the publication of "Syntactic Structures" by Noam Chomsky. Speakers in this session were Geoffrey Pullum (University of Edinburgh) and Marcus Tomalin (University of Cambridge). The other parasession was in honour of Ed Keenan (UCLA), one of the leading figures in mathematical linguistics, who turned 70 this year. The speakers were Larry Moss (Indiana University) and Dag Westerstahl (Gotenburg University).

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.

SSPV2006

Dimitris Achlioptas, University of California, Santa Cruz (UC Santa Cruz)

Byron Cook, Microsoft Research

Moshe Vardi, Rice University

CMT2006

Marv Adams, Texas A&M

John Castor, Lawrence Livermore

Anthony Davis, Los Alamos

Frank Graziani, Lawrence Livermore

Ivan Hubeny, University of Arizona

David Keyes, Columbia

Tom Manteuffel, University of Colorado

Jim McGraw, Lawrence Livermore

Tony Mezzacappa, Oak Ridge National Lab

SC2006

Don Blasius, UCLA

Dan Boneh, Stanford University

Shafi Goldwasser, Massachusetts Institute of Technology

Eyal Kushilevitz, Technion - Israel Institute of Technology

Arjen Lenstra, École Polytechnique Fédérale de Lausanne (EPFL)

Rafail Ostrovsky, University of California, Los Angeles (UCLA)

Joseph Silverman, Brown University

SCTUT

Rafail Ostrovsky, University of California, Los Angeles (UCLA)

SCWS1

Don Blasius, UCLA

Kristin Lauter, Microsoft Research

Arjen Lenstra, École Polytechnique Fédérale de Lausanne (EPFL)

Alice Silverberg, University of California, Irvine

Joseph Silverman, Brown University

SCWS2

Rafail Ostrovsky, University of California, Los Angeles (UCLA)

Eyal Kushilevitz, Technion - Israel Institute of Technology

Yuval Ishai, Technion - Israel Institute of Technology

Dan Boneh, Stanford University

Jonathan Katz, University of Maryland

SCWS3

Dan Boneh, Stanford University

Ronald Cramer, CWI, Amsterdam & Math Inst, Leiden University

Boaz Barak, Princeton University

Ran Canetti, IBM Thomas J. Watson Research Center

Yuval Ishai, Technion - Israel Institute of Technology

Shafi Goldwasser, Massachusetts Institute of Technology

Eyal Kushilevitz, Technion - Israel Institute of Technology

Rafail Ostrovsky, University of California, Los Angeles (UCLA)

Amit Sahai, University of California, Los Angeles (UCLA)

SCWS4

Cetin Koc, Oregon State University

Christof Paar, Ruhr-Universität Bochum

David Naccache, École Normale Supérieure

Nigel Smart, University of Bristol

Eran Tromer, Weizmann Institute of Science

Arjen Lenstra, École Polytechnique Fédérale de Lausanne (EPFL)

SCLA

Rafail Ostrovsky, UCLA

PCARC2006

Phillip Colella, Lawrence Berkeley Laboratory

Joseph Monaghan, Monash University

Willy Benz, Universität Bern

Chi-Wang Shu, Brown University

Harold Yorke, Jet Propulsion Laboratory

Stanley Osher, Institute for Pure and Applied Mathematics

Richard Klein, UC Berkeley

James McWilliams, University of California, Los Angeles (UCLA)

Mark Morris, University of California, Los Angeles (UCLA)

SN2007

Mark Hansen, University of California, Los Angeles (UCLA)

Richard Baraniuk, Rice University

Robert Nowak, University of Wisconsin-Madison

CHS2007

George Rengert, Temple University

George Tita, University of California, Irvine (UCI)

Kate Bowers, University College London

P.Jeffrey Brantingham, University of California, Los Angeles (UCLA)

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

Lincoln Chayes, University of California, Los Angeles (UCLA)

HU2007

Kayo Ide, University of California, Los Angeles (UCLA)

Rupert Klein, Freie Universität Berlin

Michael Montgomery, Naval Postgraduate School

Andrew Majda, New York University

Joseph Tribbia, National Center for Atmospheric Research

Bjorn Stevens, University of California, Los Angeles (UCLA)

SAGE2007

David Joyner, U.S. Naval Academy

William Stein, University of Washington

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

Nathan Ryan, University of California, Los Angeles (UCLA)

Kristin Lauter, Microsoft Research

TQC2007

Zhenghan Wang, Microsoft Research

Chetan Nayak, Microsoft Station Q

Michael Freedman, Microsoft Research

RS2007

Steffen Rohde, University of Washington

Stanley Osher, Institute for Pure and Applied Mathematics

Leon Takhtajan, SUNY Stony Brook

Peter Jones, Yale University

Nicholas Read, Yale University

Igor Frenkel, Yale University

Bernard Sapoval, École Polytechnique

Richard Kenyon, University of British Columbia

RSML

Peter Jones, Yale University

RSTUT

Richard Kenyon, University of British Columbia

Bernard Sapoval, École Polytechnique

Igor Frenkel, Yale University

Peter Jones, Yale University

Leon Takhtajan, SUNY Stony Brook

Stanley Osher, Institute for Pure and Applied Mathematics

Nick Read, Yale University

Steffen Rohde, University of Washington

RSWS1

Steffen Rohde, University of Washington

Denis Bernard, École Normale Supérieure

Krzysztof Burdzy, University of Washington

Leon Takhtajan, SUNY Stony Brook

Peter Jones, Yale University

Nicholas Read, Yale University

Igor Frenkel, Yale University

Gregory Lawler, University of Chicago

John Cardy, University of Oxford

RSWS2

Hans Herrmann, Eidgenössische TH Zürich-Hönggerberg

Katepalli Sreenivasan, Abdus Salam International Centre for Theoretical Physics

Eli Ben-Naim, Los Alamos National Laboratory

Richard Kenyon, University of British Columbia

Bernard Sapoval, École Polytechnique

RSWS3

Marc Mezard, Université d'Orsay

Noam Berger, University of California, Los Angeles (UCLA)

Alessandro Vespignani, Indiana University

Elchanan Mossel, University of California, Berkeley (UC Berkeley)

Jennifer Chayes, Microsoft Research

Walter Willinger, AT&T Technologies, Engineering Research Center

RSWS4

Frederic Dias, École Normale Supérieure de Cachan

Guillermo Sapiro, University of Minnesota, Twin Cities

Peter Jones, Yale University

Jean-Luc Starck, Commissariat à l'Énergie Atomique (CEA)

Keith Worsley, McGill University

Stanley Osher, Institute for Pure and Applied Mathematics

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

VN2007

Anna Gilbert, University of Michigan

Jared Tanner, University of Utah

RSLA

Peter Jones, Yale University

MGARC2007

Peter Jones, Yale University

MARC2007

Russel Caflisch, UCLA

Cecilia Clementi, Rice University

Matthias Scheffler, Fritz-Haber-Institut

Christian Ratsch, IPAM

RIPS2007

Max Peterson, Accelrys

Mark Durst, Amgen

Egbert Tse, Arete

Parag Mallick, Cedars-Sinai Hospital

Martin Lo, Jet Propulsion Laboratory

Matt Sottile, Los Alamos

Charles Tong, Lawrence Livermore

John Anderson, Pixar Animation

Darren Shou, Symantec

Gerry Egan, Symantec

Mike Raugh, Harvey Mudd College

RIPSBJ2007

Cheng Niu, Microsoft Asia

Peng Yu, Microsoft Asia

Wei Chen, Microsoft Asia

Xu Yang, Microsoft Asia

Zhouchen Lin, Microsoft Asia

Xin Ma, Microsoft Asia

Yanming Cao, Microsoft Asia

Harry Shum, Microsoft Asia

GSS2007

Alan Yuille, UCLA

Josh Tenenbaum, Massachusetts Institute of Technology

ML2007

Markus Kracht, UCLA

Gerald Penn, University of Toronto

Ed Stabler, UCLA

NGA2007

Paul Salamonowicz, NGA

Edward Bosch, NGA

Robert Rand, NGA

SEML

Peter Jones, Yale University

SE2007

Yann LeCun, New York University

Vladimir Rokhlin, Yale University

Karin Verspoor, Los Alamos National Laboratory

Yuval Kluger, New York University

Ronald Coifman, Yale University

SETUT

Ronald Coifman, Yale University

Yuval Kluger, New York University

Karin Verspoor, Los Alamos National Laboratory

Vladimir Rokhlin, Yale University

Yann LeCun, New York University

SEWS1

Karin Verspoor, Los Alamos National Laboratory

Carey Priebe, Johns Hopkins University

Ronald Coifman, Yale University

Jennifer Chu-Carroll, IBM Watson Research Center

SEWS2

Piotr Indyk, Massachusetts Institute of Technology

Andrew Zisserman, University of Oxford

Sam Roweis, University of Toronto

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

Yann LeCun, New York University

Vladimir Rokhlin, Yale University

SEWS3

Johan Bollen, Los Alamos National Laboratory

Andrew McCallum, University of Massachusetts Amherst

Karin Verspoor, Los Alamos National Laboratory

Ronald Coifman, Yale University

Peter Jones, Yale University

SEWS4

Itsik Pe'er, Columbia University

Yuval Kluger, New York University

Gustavo Stolovitzky, IBM Watson Research Center

Xiaole Liu, Dana-Farber Cancer Institute

Olga Troyanskaya, Princeton University

PCARC2007

Mark Morrison, UCLA

Harold Yorke, JPL

Christian Klingenberg, Uni Wuerzburg

CMRC2007

Tom Chou, UCLA

VS2008

Dwight Meglan, SimQuest LLC

Court Cutting, New York University

Silvia Salinas-Blemker, University of Virginia

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

IMM2008

Guillermo Sapiro, University of Minnesota, Twin Cities

Jacqueline Milne, National Institutes of Health (NIH)

Sriram Subramaniam, National Institutes of Health (NIH)

Alberto Bartesaghi, National Institutes of Health (NIH)

EG2008

Avi Wigderson, Institute for Advanced Study

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

Alexander Lubotzky, Hebrew University

Audrey Terras, University of California, San Diego

GC2008

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

Yuri Boykov, University of Western Ontario

Vladimir Kolmogorov, University College London

Daniel Cremers, University of Bonn

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

Hiroshi Ishikawa, Nagoya City University

OT2008

Yann Brenier, Université de Nice Sophia Antipolis

Jean-Michel Morel, École Normale Supérieure de Cachan

Peter Markowich, Universität Wien

Wilfrid Gangbo, Georgia Institute of Technology

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

OTWS1

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

Yann Brenier, Université de Nice Sophia Antipolis

Luigi Ambrosio, Scuola Normale Superiore

Jose Carillo, Autonomous University of Barcelona

Wilfrid Gangbo, Georgia Institute of Technology

OTWS2

Karl Glasner, University of Arizona

Yann Brenier, Université de Nice Sophia Antipolis

Richard Tsai, University of Texas at Austin

Allen Tannenbaum, Georgia Institute of Technology

OTWS3

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

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

Dan Rothman, Massachusetts Institute of Technology

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

OTWS4

Anne Marie Robertson, University of Pittsburgh

Bertrand Maury, Université d'Orsay

Suncica Canic, University of Houston

Denis Grebenkov, École Polytechnique

Christian Ratsch, Institute for Pure and Applied Mathematics

MRA2008

Anna Gilbert, University of Michigan

Craig Partridge, Bolt Beranek and Newman (BBN) Laboratories, Inc.

Matthew Roughan, University of Adelaide

Walter Willinger, AT&T Technologies, Engineering Research Center

Paul Barford, University of Wisconsin-Madison

Mauro Maggioni, Duke University

John Doyle, Caltech

KT2009

Shi Jin, Uinversity of Wisconsin Madison

Irene Gamba, University of Texas at Austin

Eric Carlen, Georgia Institute of Technology

Pierre Degond, University of Toulouse

Frank Graziani, Lawrence Livermore

Karl Kempf, Intel

David Levermore, University of Maryland

Peter Markowich, University of Vienna

Christian Ringhofer, Arizona State University

Marshall Slemrod, University of Wisconsin-Madison

GENERAL

David Donoho, Stanford University

Deborah Estrin, UCLA

Matthew Fisher, UCSB

Irene Gamba, University of Texas at Austin

Ronald Graham, UCSD

Peter Jones, Yale University

Kenneth Ribet, UC Berkeley

Terence Tao, UCLA

Simon Tavare, USC

Gang Tian, Princeton University

Grace Wahba, University of Wisconsin-Madison

Andrew Yao, Tsinghua University

Rodrigo Banuelos, Purdue University

Stuart Feldman, IBM

Mac Hyman, Los Alamos

Linda Keen, CUNY

Cleve Moler, Mathworks Inc

Arlie Petters, Duke University

Leonard Rome, UCLA

Linda Rothschild, UCSD

David Levermore, University of Maryland

Arvind Gupta, MITACS

John Stockie, MITACS

Persi Diaconis, Stanford University

Doug Nychka, NCAR

Annick Pouquet, NCAR

Allon Percus, Los Alamos

Steve Hubbell, University of Georgia

Warren Mori, UCLA

JS Chen, UCLA

Wing-Kam Liu, Northwestern University

Stanley Erickson, Institute of Justice

John Cho, UCLA

Charles Kemp, MIT

Michael Gorin, UCLA

Esmond Ng, Department of Energy

Joseph O'Brien, Hewlett-Packard

Ellis Cumberbatch, Claremont Graduate School

Hong Zhou, UT Houston

Hongjing Lu, University of Hong Kong

Keith Worsley, McGill University

Jonathan Taylor, McGill University

Paul Thompson, UCLA

Michael Miller, Johns Hopkins University

Lieven Vanderberghe, UCLA

Jason Cong, UCLA

Dwight Read, UCLA

Zoe Borovsky, UCLA

Art Voter, Los Alamos

Kristin Fichthorn, Pennsylvania State U

Russel Caflisch, UCLA

Matthias Scheffler, Fritz-Haber-Institut

Denis Grebenkov, École Polytechnique

Bedros Afeyan, Polymath Inc

Yuval Rabani, Technion - Israel Institute of Technology

Martin Strauss, University of Michigan

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

Summary of Industry and Government Involvement with IPAM:

- RIPS Beijing, an innovative program for undergraduates held in China at Microsoft Asia was successfully launched with 10 US and 10 Chinese participants. The program received a $123K, 3-year grant from NSF's International Research Experiences for Students (IRES) program.
- Three new sponsors for RIPS LA were added: Accelrys, Amgen, and the Spielberg Family Center for Applied Proteomics
- IPAM followed up on its very successful "Computational Methods in Transport" affiliates workshop with Lawrence Livermore National Lab in Granlibakken in 2004 with a meeting emphasizing verification and validation in September 2006.
- IPAM has received a contract to run a series of workshops with the National Geospatial Agency; the first of these will be October 30-November 1, 2007.
- IPAM ran an affiliates workshop with Microsoft Research on "Satisfiability Solvers and Program Verification" in Seattle in August 2006.
- A number of practitioners from police departments attended and actively participated in an IPAM workshop on "Crime Hot Spots: Behavioral, Computational and Mathematical

Models," held January 29-February 2, 2007. The National Institute of Justice, the research arm of the US Department of Justice, was also represented.

- Felix Herrmann received over $1.5 million in industry and government grants to follow up on work that he did at IPAM.
- The DARPA Analog-to-Information Program awarded grants to several participants of IPAM's "Multiscale Geometry and Analysis in High Dimensions" program to pursue further work on compressive sensing.
- A new technique to double the precision of stellar photometry of bright stars observed with the Spitzer Space Telescope's Infrared Array Camera was developed by Ken Mighell, inspired by ideas and people he encountered at IPAM's "Mathematical Challenges in Astronomical Imaging" workshop in 2004.

Comments from past participants from industry and government labs:

David Alderson (Naval Postgraduate School): "It has been some time since I visited IPAM in support of the most recent NSF review (congrats on the renewed funding!), and I am writing to update you on my most recent career developments. As of September, I have completed my postdoctoral fellowship at Caltech and started as a tenure-track assistant professor in the Operations Research Department at the Naval Postgraduate School in Monterey, CA. My work remains focused on telecommunications network modeling and analysis, with increasing emphasis on the protection of national infrastructure networks. NPS is an ideal place to be doing this type of work, and I look forward to coming back to IPAM during the May 7-11 Workshop to tell you about it. I can proudly say without qualification that my success along this path is the direct result of my participation in the 2002 Large-Scale Communication Networks program at IPAM. It was there that I began my collaboration with John Doyle and Walter Willinger, and the early ideas explored there provided proof of concept for my postdoctoral work at Caltech. Since our participation in that program, John, Walter, and I have published together more than a dozen papers on related subjects appearing everywhere from the ACM and IEEE journals to PNAS. I am indebted to IPAM for the opportunity it gave me in making these connections."

Moysey Brio (University of Arizona): "At the photonics conference at IPAM I have met several people who were my former physics students and their boss that were right in town, Tucson, at Raytheon doing laser design based on photonic crystals. Exactly what I was doing with my Optical Sciences collaborators. Since then I have placed my two recent Applied Math PhDs with them and numerous undergrad with applied math/math/CS/ECE/OpSci majors/minors. Thanks for great applied conferences that bring together math/physics and engineering researchers."

Juan Garay (Lucent Technologies Bell Laboratories): "Several discussions took place and potential collaborations arose with other IPAM visitors, in particular with Leo Reyzin on achieving optimal perfectly secure message transmission making use of some new developments in the area of error correcting codes. My stay at IPAM has boosted my research, by providing in-depth coverage of new areas and techniques through its workshops, and expanding my network of scientific collaborators."

Felix Herrmann (University of British Columbia): "I would like to draw your attention to some of the work I have that came out of my stay at IPAM during the Multiscale Geometry and

Analysis in High Dimensions Program. First of all there are a number of papers that are directly related to my stay at IPAM and then there is the research program that came out of my exposure to this topic resulting in
- major funding by the petroleum industry
- matching by the NSERC in the form of a Collaborative Research and Development Grant The overall funding of this project is $700 k by NSERC and $875 k
by industry. The project now involves three additional faculty members from CS and Math covering the fields of nonlinear L1 optimization and harmonic analysis."

Gary Hewar (Naval Air Warfare Center, China Lake): "IPAM Provides an opportunity to hear speakers in a setting where they generally try to provide informative talks about their applications, and share their research insight evolution and latest results. I would say IPAM provides a valuable meeting site to both renew contacts and also meet researchers that otherwise might not be available in such an accessible and comfortable setting."

Tad Hogg (Hewlett Packard): "Mathematical models of robust self-assembly of molecular-scale machines, with M. D'Orsogna (UCLA math dept), continuing with the HP workshop on Expanders and Nano-Scale Self-Assembly discussing models and chemical synthesis including both mathematicians and chemists; models of swarm-based distributed controls of microscopic robots, with K. Lerman and A. Galystan (at USC/ISI); IPAM microfluidics workshop led to visits at HP exploring possible collaboration on robots moving in viscous fluids, by M. Graham (U. of Wisconsin) and J. Glazier (Indiana). IPAM workshops bring together people from different disciplines who don't normally encounter each other in conferences that focus on their separate fields. I've found these workshops helpful in learning about how these various fields provide useful background and different approaches to mathematical problems in the industrial development of new technologies. The workshops also provide opportunities to meet like-minded researchers at other institutions to explore possible new collaborations benefiting from the different disciplines. In my case, the recent workshops on swarms and microfluidics helped me identify phenonmena and modeling approaches for future molecular-scale devices."

Philipp Kuegler (Linz): "Due to the IPAM workshop with industries I also got interested in simulation and control of aircrafts. Currently I am focusing on on-line flight parameter identification with potential applications in control of unmanned air vehicles."

Leo Marcus (Aerospace Corp.): "It has shown me that there is some interest among the systems biology community in an approach utilizing methods of computer security engineering."

Daniel Marthaler (Northrop Grumman Corp.): "IPAM introduced me to members of government research labratories (e.g. Los Alamos). From there, I learned about promising research being done at aerospace industries up and down the California coast. This allowed me to get introduced into the industry and directly led me to my curent position; doing advanced R&D for Northrop Grumman Space Technology."

Ken Mighell (National Optical Astronomical Observatory): "At AI2004 I formed a very successful collaboration with Dr. Julian Christou. Since that meeting we have written several papers (given above). Christou is currently a Co-I on a pending NASA proposal "Adaptive

Drizzle: Applications of Robust Kernel Regression in Astronomical Imaging." After AI2004, Julian Christou (another AI2004 speaker), invited me to give a talk at the NSF-funded Center for Adaptive Optics-sponsored "Workshop on Adaptive Optics PSF Reconstruction" which was held in Victoria, BC on May 10-12, 2004. My participation in AI2004 has lead to some interesting new research areas for me and I feel that AI2004 was the most productive meetings I attended in 2004. The development of a new technique to double the precision of stellar photomety of bright stars observed with Channel 1 of the Spitzer Space Telescope's Infrared Array Camera was inspired by the ideas and people I met at AI2004. I am now collaborating with the IRAC Instrument Team in an effort to improve the calibrations for Channels 1 and 2 of IRAC for the upcoming Spitzer Warm Mission which will start around April 2009."

Giuseppina Nigro (Naval Research Laboratory): "Thanks to the 'Grand Challenge Problems in Computational Astrophysics' program I have had the possibility to improve my computational skill and my knowledge in Astrophysics. I have had also the possibility to meet many interesting scientists so that I could start collaborations. Right now I have a post doc positions in one of the most important research laboratories in the United States (Naval Research Laboratory, Washington DC)."

Michael Parks (Sandia National Laboratories): "Found the workshops "Multiscale Modeling in Condensed Matter and Materials Sciences" and "Multiscale Analysis and Computation" extremely useful for my work in the analysis of atomistic/continuum coupling algorithms. My participation in these workshops and interactions with the attendees deepened my understanding of this subfield, and helped lead me to identify the particular research problems on which I'm now working."

Carolyn Reynolds (Naval Research Laboratory): "Broadened my interest in, and appreciation for, how applied mathematics may relate to my field of study (atmospheric sciences)."

Jeff Scargle (NASA Ames Research Center): "The working atmosphere was extraordinarily stimulating, and much of my research in the last few years has been directly influenced by my attendance at several IPAM workshops."

Karin Verspoor (Los Alamos National Laboratory): "I became aware of work coming out of the mathematics community that I otherwise would not have been exposed to; this led me to explore some new directions in my work on pattern induction for information extraction. "

Kevin Vixie (Los Alamos National Laboratory): "It is really hard to overestimate the importance of my time at IPAM. It really would take me to go over all the ways in which the access to the opportunities has improved my research and career path. The influence of people like Allon Percus, Peter Jones, Mark Green, Stan Osher, Tony Chan, and recently others (like Christian Ratsch and John Garnett) is significant though not always easy to quantify or summarize.
1) Work with Selim Esedoglu, U Michigan
2) new: work with Carrie Salafia, NYU
3) new: work with Francois Meyer
4) recent: collaborations with Allon Percus on the development of a LANL/UCLA connection as well as the LANL CDDMA summer school

5) Work with Wotao Yin: we are now collaborating quite intensely.
6) Significant funding from NGA for my team (~1M$)
What I have written in this form just scratches the surface of the positive impact IPAM has had for me."

Arthur Voter (Los Alamos National Laboratory): "I have had three different postdoctoral applications from students who met me, or saw me speak, at IPAM. One of them, who is exceptionally strong, received a Director's funded postdoctoral fellowship from Los Alamos, and will start his postdoc with me in June, 2007. I must say also that I think the IPAM conference center offers an excellent environment for discussing science and making scientific contacts. I have always enjoyed my time there. I think the discussions I have had with other scientists at IPAM have probably influenced my research directions in ways that are not reflected in the simple lists of papers and collaborations above. IPAM is a truly valuable resource for the scientific community."

Eric Voth (Endocardial Solutions, Inc.): "It was a good workshop, and useful for me to meet many luminaries in applied mathematics and present my company's research to them."

Michael Wakin (re: DARPA): "I wanted to let you know a little bit more about the DARPA Analog-to-Information program, since it is another good IPAM success story (a large portion of the research is going toward building analog-to-digital converters that employ the principles of Compressed Sensing), and it has attracted the attention of an agency other than NSF. A short description is here: http://www.darpa.mil/mto/programs/atoi/index.html
Most of the teams pair an academic group with an industrial one. (There does not seem to be much public info about these teams, but Justin Romberg and I are working with Emmanuel Candes on one such team.) A more purely-academic team is led by Rich Baraniuk: http://www.dsp.ece.rice.edu/a2i/ This is just for the 2 teams; many other IPAM-familiar names are also involved."

Jianhua Xing (Lawrence Livermore National Laboratory): "It is really a great place to meet potential collaborators. After our meeting at IPAM, I have established collaboration with Professor Wei Cai at UNCC. He invited me to give a talk at the International Conference On Spectral and High Order Methods (ICOSAHOM) 2007. We are working on a NSF proposal. My meeting with Professor Hong Qian at University of Washington, Seattle also results in long time relationship. We frequently exchange ideas on problems with common interests, and are currently discussing collaborations on biological stochastic processes."

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 nor for custodial care. The value of these three items is approximately $800K. Senior long-term participants from other universities are usually funded on a replacement-buyout basis, in which they are released for the cost of replacing their teaching with a junior person.

Table N-1: Other Funding		
Federal Grants	**Year**	**Amount**
NSF- IRES RIPS China 07	2007	$41,000.00
NSA/USDOD H98230-07-01 RIPS07	2007	50,300.00
Sub-total		91,300.00
University Funding Support		
Dean Physical Sciences Support	2006-2007	60,000.00
Dean Physical Sciences Matching 1/2 IT Wages	2006-2007	43,354.00
Vice Chancellor 's Support	2006-2007	60,000.00
Sub-total		163,354.00
Industrial Affiliates Support		
Amgen	2006-2007	10,000.00
Cedars-Sinai	2006-2007	10,000.00
Pixar -Disney	2006-2007	10,000.00
Fidelity Gift	2006-2007	25,000.00
Hewlett Packard	2005-2006	10,000.00
Microsoft	2006-2007	12,500.00
Symantec	2006-2007	10,000.00
Sub-total		87,500.00
Others		
Registration Fees-Programs	2007	12,435.00
UCLA-Institute of Environment	2007	1,000.00
UCLA-Statistics from NSF for Graduate Summer Workshop	2007	99,198.00
UCLA-Psychology	2007	250.00
Sub-total		112,883.00
TOTAL		**$455,037.00**

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 will serve until the position is filled. The members of each as of July 2007 are listed here.

Science Advisory Board
David Donoho (Statistics, Stanford)
Deborah Estrin (Computer Science, UCLA)
Matthew Fisher (Institute for Theoretical Physics, UCSB)
Irene Gamba (Mathematics, University of Texas)
Ronald Graham (CSE, UCSD)
Mark Green (IPAM)
Peter W. Jones, Chair (Mathematics, Yale)

Stanley Osher (IPAM)
Christian Ratsch (IPAM)
Kenneth Ribet (Mathematics, Berkeley)
Terence Tao (Mathematics, UCLA)
Simon Tavaré (Molecular and Computational Biology and Mathematics, USC)
Gang Tian (Mathematics, MIT)
Grace Wahba (Statistics, Wisconsin)
Andrew Yao (Computer Science, Princeton)

Board of Trustees
Rodrigo Bañuelos (Mathematics, Purdue University)
Stuart Feldman (Vice-President for Internet Technology, IBM)
Mark Green (Director, IPAM)
James (Mac) Hyman, Chair (Los Alamos National Laboratory)
Linda Keen (Mathematics, Lehman College CUNY)
Cleve Moler (Chief Scientist, MathWorks Incorporated)
Stanley Osher (Director of Special Projects, IPAM)
Arlie Petters (Mathematics, Duke University)
Christian Ratsch (Associate Director, IPAM)
Leonard Rome (Associate Dean of Research, School of Medicine, UCLA)
Linda Rothschild (Mathematics, UCSD)
Harry Shum (Managing Director, Microsoft Research Asia)

Human Resources Committee
Robert Borrelli, Harvey Mudd College
William Massey, Princeton University
Joyce McLaughlin, Renesselaer Polytechnic Institute
Linda Petzold, UC Santa Barbara
Richard Tapia, Rice University

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

P. CONTINUING IMPACT OF PAST IPAM PROGRAMS

(IPAM chose to add this section that was not requested by NSF.)

IPAM's past programs continue to have impact, as reported this year by past participants:

Reka Albert (Pennsylvania State University) “Some of the talks on the functional principles of biological systems made a lasting impression on me because they are partly overlapping and complementary to what I have been thinking about. I will definitely follow up on these ideas.”

Michael Berry (University of Tennessee): “Exposure to research by other leading applied mathematicians and computer scientists is very important. I enjoyed the IPAM program I was invited to and the facilities (and UCLA campus) were excellent! I recommend IPAM programs to colleagues and graduate students.”

Sang-Hoon Cho (University of Wisconsin): “I attended the IPAM workshop, "Sequence Analysis Toward System Biology," 9-13 in Jan., 2006, which furnished me a new research direction in statistical genetics.”

Jim Colliander (University of Toronto): “Mike Christ, Terry Tao and I were considering ill-posedness questions for defocusing wave equations. The IPAM meeting I attended provided a chance encounter with Kenji Nakanishi that led to a suggestion that one could exploit modified wave operators for one of these problems to separate the defocusing nonlinear from the linear dynamics. This suggestion started our fruitful collaboration.”

Dale Durran (Washington University): “My participation led me to thoroughly investigate the application of WENO methods in atmospheric science. We wound up formulating the FCT-WENO hybrid described in the JCP paper. This is now being tested in state of the art atmospheric science models like the Weather Research and Forecasting Model (WRF) at the National Center for Atmospheric Research. My participation also help focus me on opportunities for collaboration with colleagues at UCLA.”

Bruno Eckhardt (Universitat Marburg): “I did learn about very practical applications of independent agents, and continued collaborations with a several participants of that workshop. These discussions deepened my interest in the issue of hydrodynamic interactions between swimming microorganisms, and it seems we are on the right track.
Finally, I would like to say that the workshop was extremely well organized, had the appropriate combination of formal presentations and free time for discussion and did include a few very stimulating presentations of subjects I had not yet heard of.”

Heinz Engl (University of Linz): “IPAM opened a whole new research area for me, and more opportunities for RICAM. I now employ people whom I met first at or via IPAM (e.g. Dr. Resmerita, Dr.Sini).”

Daniel Ennis (Stanford University): “I now have an on-going collaboration with a research group outside the U.S. They are currently using my data for one of their projects, and I plan to visit their lab to develop some computational modeling skills. It was important to meet some of the luminaries in the field. I think their support was important to my having successfully applied for and having been awarded an NIH K99/R00 grant. Letters of support from people I met at IPAM were part of the application.”

Jeffrey Essner (Iowa State University): “My involvement with IPAM has greatly enriched my new career path with mathematical modeling.”

Liesbet Geris (K.U. Leuven): “The workshop I attended at IPAM was a very inspiring and enlighting one that has given me (and my promoter who also attended) many new ideas on where to take our research next. Also the atmosphere at the workshop was very inviting (with plenty of room for a lot of questions and discussions with all participants). I'm now trying now to apply such an open and constructive vision in my own work.”

Brian Goldiez (University of Central Florida): “IPAM has influenced my view into using chaos theory to assess human agent (software or robotic) behavior and my colleague (Dr. T. L. Clarke) and I have received funding from the Army Research Laboratory to explore the efficacy of chaos models for predicting performance and providing assistance to humans who interact with robots. IPAM has also influenced work here at the Institute for Simulation and Training, U. Central Florida to further investigate biologically inspired models into modeling group behavior of humans.”

Alex Gottlieb (University of Vienna): “I have collaborated with Lisa Wesoloski, who was a core participant in the Nanoscience Program of Fall 2002. Lisa was a graduate student in Physical Chemistry who worked in a Scanning Tunneling Microscopy laboratory; I was a mathematics post-doc interested in quantum physics. Together we wrote an expository paper which has been published in Nanotechnology. This paper was downloaded 250 times within two weeks of its online publication!”

Jason Hafner (Rice University): “A paper was inspired by comments from and later discussion with Rolan Netz on my presentation. He pointed out that an effect he had recently theoretically calculated could affect my data. I determined that it didn't, but another part of my data could give the first direct experimental evidence for the effect. I met some important people in my field that I had not met before. I found new applications for my recently developed technique.”

Robin Hayes (New York University): “I appreciated the opportunity to interact with scientists from many different fields. The high-quality symposia and tutorials encouraged me to continue in the field of multiscale modeling.”

Xiaoming Huo (Georgia Institute of Technology): “Hongyuan Zha was my officemate at IPAM. Since then, we have become coauthors, as well as submitting joint proposals. Several recent research projects were initiated while attending presentations in IPAM. The program quality of IPAM is extremely high!”

Monica Hurdal (Florida State University): “Through the meetings and visits to IPAM, I have continued to stay involved din research involving the human brain and using mathematics to further research in this area. The meetings at IPAM that I have attended have been multi-disciplinary which has been an asset to my career and research. Such meetings allow me to interact with potential sources of data collaboration which are difficult to obtain.”

Jean-Michelet Jean-Michel (College of New Jersey): “Having been there for the Semester Program in Symplectic Geometry and Physics has greatly influenced my career. My field is Dynamical Systems. In addition to being exposed to the latest results in Dynamical Systems, I learned a little bit about Symplectic Geometry and how it applies to my research. IPAM is a sort of a crossroads. If one hangs out there long enough, one gets to see everybody who is anybody in the field of Mathematics come through the place. I even got reunited with a long lost school friend there. Interacting with my very accomplished colleagues attending the IPAM Semester Program in Symplectic Geometry and Physics did a lot to boost my confidence in my own abilities.”

Lin Ji (Scripps Research Institute): “The IPAM experience broadened my view of research activities in computational biology. It also established some connections with other mathematicians and physicists. It gave me a global picture of my position in the field and allowed me to see the uniqueness of my research direction relative to the others.”

Lars Jonsson (University of Toronto): “The joint conference between experimentalists, mathematicians and physicists on nonlinear optics was and is a great motivator for the choice of my current research interest. The selection of people did introduce many new contacts in different parts of the great field of nonlinear optics.”

Frank Kelly (Stanford University): “I benefited from taking part in the Spring 2002 Program on Large Scale Communication Networks at the Institute for Pure and Applied Mathematics, UCLA; I am grateful both to IPAM, and to John Doyle and Walter Willinger for their work in support of this Program. The Program alerted me to important work of which I might not have otherwise been aware.”

Barbara Keyfitz (Fields Institute): “This leadership conference served useful networking and education functions. (“Education” in the sense of providing information and guidance about how to succeed in management and leadership positions.).”

Isaac Klapper (Montana State University Bozeman): “A most important aspect of my stay at IPAM was the opportunity to hear and learn about a lot of interesting current work in, especially, physical approaches to biological problems. I work at a relatively small and very isolated institution, and the chance to see a lot of frontline research was really invaluable.”

Arthur Lander (UC Irvine): “I made contacts with people in my field that I had not met before. I had valuable discussions with people outside my field which helped me clarify my thinking about some important research themes.”

Edward Larsen (University of Michigan): “I had useful conversations with several German astrophysicists, who knew much more about non-LTE (local thermodynamic equilibrium) than I did, and who helped me significantly with my attempts to learn about it. (For several years, I have been attempting to develop a mathematical theory in which one can systematically derive, from the non-LTE equations, the standard LTE equations -- and hopefully useful more accurate approximations.) The IPAM meeting that I attended was very helpful in this long-term project.”

Eric Lauga (MIT): “The IPAM is a fantastic place for researchers to interact with the members of their community, and I have had many great scientific conversations there which have influenced my work tremendously. I have participated in 2 meetings, both of which were for a small group of selected people, and I enjoyed both of them very much.”

Yann LeCun (New York University): “The work described in several publications would not have been possible without the numerous discussions with Leon Bottou, John Lafferty, Bruno Olshausen, Martial Hebert, and many others which took place at the 2005 IPAM Graduate Summer School on Intelligent Extraction of Information from Graphs and High Dimensional Data. It enabled me to have a considerably tighter interaction with the applied math community. Much of my group's work on sparse feature extraction was greatly influenced by these interactions.”

Insuk Lee (University of Texas at Austin): “I had a chance to meet many active researchers in proteomics in my early stage of career in quantitative biology. I made me convinced that quantitative approaches in biology is a new paradigme, and found many key ideas in quantitative approaches in scientific problems from invaluable formal as well as informal conversation with other scientiests with physical or mathematical science background, which I was quite lack of before.”

Jae Hyouk Lee (Washington University): “My paper "Higher Dimensional Knot spaces for Manifolds with Vector Cross Product" with Prof. Nachung Conan Leung which will be published in Advances in Mathematics was studied while I was involved with IPAM program. I have been working on fundamental questions on symplectic geometry corresponding mathematical physics, and these interests were grown while I was researching at IPAM.”

Lei Li (University of Southern California): “Since my involvement at IPAM, I established several fruitful collaborations in computational biology and functional genomics. Some collaborative projects are as follows.
1. Yeast aging project with Dr. V. Longo
2. Diploid sequencing project, with Dr. Waterman
3. Optical mapping, Dr. Schwartz and Dr. Waterman
4. 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.”

Xiaole Liu (Harvard University): “The feedback from my talk helped the above mentioned three papers. I got to know many experts in the field, and learned a lot from their research. Knowing these experts also helped me with my recent promotion evaluation. In addition, I identified a very good student from the meeting, whom I am trying to recruit as a postdoc next year.”

Mauro Maggioni (Duke University): “The workshops at IPAM have been for me always an excellent ground for meeting with experts in several different fields and discover connections and new ideas for applying mathematics to different fields. This has greatly impacted my interests (for example leading to work interst and work in medical imaging, analysis of document corpora, statistical modeling, quantitative neuroscience).”

Dionisios Margetis (University of Maryland): “My involvement with IPAM has helped my career tremendously. 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.”

Richard Massey (Caltech): “It opened my eyes to the potential multidisciplinary uses of techniques in astronomy. I have since become involved in projects applying techniques from extragalactic astronomy to sunspot analysis, classification of brain lesion morphology in CT scans and other pattern recognition.”

Maria McGee (Wake Forest College): “Finally things have cleared enough to give you feedback on last spring’s program as well as an update on its positive influence on my career. First, I want to reiterate my enthusiastic support for the practical programs and philosophy of IPAM. I came back determined to expand my research strategy to include parallel math and physics approaches. On my return, at a special meeting with the Medical Center’s deans of research, I presented my impressions of IPAM and the program and how it has changed my perspective on the future of biomedical research. They were very interested and supportive but pointed out the difficulties implicit in the changes I suggested at a global, institutional level. I realized that they would take time.
Although I was prepared to change institutions if my efforts were not supported here, after a few months of planning, evaluating, and deciding, I was offered a particularly interesting opportunity. This new academic position will allow me to expand my knowledge base in math and physics applied to problems in medicine as well as to coordinate theoretical modeling efforts in a new center dedicated to wound healing within the Surgical Sciences Department at Wake Forest University Medical School. I will start in December, while maintaining a cross appointment with the Medicine department.
As part of my new contract, I received approval to spend up to 3 months a year away from the institution to learn from, and interact with, mathematicians and physicists. Your programs seem to me one of the best venues to facilitate our planned interdisciplinary collaborations. I hope that your invitation to participate in the Random Shapes Program next spring still stands. Many of the problems that we will have to tackle relate to surfaces, transport, imaging, and biological networks. I should be able to participate during April and May and will be prepared to present our problems and to learn more about up-to-date approaches to their solutions.”

Roeland Merks (ghent University):
“1. We were seeking collaboration with vascular biologists working with VE-cadherin (a cell-adhesion protein specific to endothelial cells, a type of blood vessel cell) to test a prediction of our computational model regarding the role of VE-cadherin during blood vessel sprouting. We

are now collaborating with Erica Perryn, a student of Charlie Little from KUMC, who we have contacted at IPAM.
"2. Within the same context, I have had plenty of time to interact with my former postdoc supervisor James Glazier and his new student Abbas Shirinifard. He has contributed new ideas on modeling vasculogenesis and a mathematical analysis of our computational model to our PLoS Comp. Biol. paper (citation 1 in the list above).
"3. At IPAM we met Liesbet Geris and Hans Van Oosterwyck from Leuven University in Belgium; we are now planning a symposium on biological modeling in Belgium, which will hopefully grow out into a network of Belgian modelers.
"4. I have discussed details regarding on pubs. 2 and 3 in the list above with James Glazier and Nikodem Poplawski, and some of the new ideas appeared in these papers.
The participation has provided me with an excellent opportunity to disseminate my work on vasculogenesis modeling, and has helped us significantly improve a pending manuscript with input of some of the workshop participants."

Jean-Michel Morel (ENS Cachan): "It has given me new insights on the role of PDE's in image processing, on numerical schemes, and on transport theory."

Adrian Neagu (University of Missouri Columbia): "Working in a group involved in tissue engineering I became interested in understanding blood vessel formation. Building a bulky, viable, vascularized tissue construct is one of the most tempting open problems of the field. Workshop III: Angiogenesis, NeoVascularization and Morphogenesis, (May 8 - 12, 2006) seemed to be a great opportunity to learn from Nature about mechanisms of vascularization. It turned out to be more than we expected. Besides being trained by a highly professional team of lecturers, we had excellent opportunities to talk to the other attendees. One of these discussions started along our way to lunch, and ended up in writing down a set of reaction-diffusion equations on the back of a napkin. It was just a spark, now it is a paper; then we barely knew each other, now we are friends. This gift, among others, makes the IPAM workshop an unforgettable experience. The IPAM meeting contributed to broadening our research field in at least two aspects. First, we established connections with one of the lecturers, Prof. George Davis, who recently moved to Columbia, MO. Our group benefits a lot from his expertise in three-dimensional structure formation by endothelial cells. Second, we extended our computational tools originally developed to meet tissue engineering needs in order to describe tumor angiogenesis. Finally, less quantifiable, but equally important, the interactive lectures, which covered various aspects of angiogenesis (biology, modeling, in vitro studies), inspired us and shaped our view of tissue vascularization."

Ifeanyi Ogueli (Galenica Senese): "Due to my stay at IPAM, I was able to establish a collaboration with Prof Joseph Loo and I have just initiated another with Prof Paul Bajaj both of UCLA.
1. With Prof Joseph Loo: Loo's lab has been involved in the De novo sequencing of the protein we believe inhibits the activity of snake venom.
2. With Prof. Paul Bajaj: In Prof Bajaj's lab, we will assay the protease specificity of the protease inhibitor from the aqueous protein extract of our plant, and hopefully crystalize the protein.
Attending the Proteomics program at IPAM (2004) and subsequently the Proteomics re-union conference a year and half later, has broadened my knowledge and skill in the area of

proteomics. I am now able to apply with ease the techniques I have learned in various research fields. A most recent example is in clinical research (see my 2006 publication in Hematology). The program has also exposed me to different research cultures as the participants of the program were drawn from different research, scientific and cultural backgrounds. The collaborations I established have helped and are still helping in finding answers to questions in our study that we would have left unsolved. It has made me a better and more confident scientist."

Tony Pantev (University of Pennsylvania): "The research environment at IPAM was extremely stimulating and I started several new research projects during my stay at the Institute. In addition, during the workshops I learned of some very interesting open problems in non-commutative geometry and symplectic topology. Two of those problems became thesis projects for my former Ph.D. students Sukhendu Merotra and Oren Ben-Bassat. Another great benefit of the IPAM program for me was the opportunity to interact with physicists and mathematicians (e.g. with George Zaslavsky) who work concrete questions in fluid dynamics and surface tension. Usually I don't have any point of contact with this type of applied math and if it wasn't for the IPAM program, I would have remained ignorant of all these fascinating questions. Because of the great interactions I had at IPAM, I sought out our local experts in the field and am currently working on a joint project with Prof. Charles Kane from Penn's soft condensed matter group."

Shayn Peirce-Cottler (University of Virginia): "Many of the conversations I had with other attendees greatly enriched aspects of my own research directions (e.g. grants I have since submitted and new projects that are now underway in my laboratory)."

David Pettifor (Oxford University): "Brought to fruition the dream of an analytic interatomic potential for transition metals and their alloys that goes far beyond the EAM or Finnis -Sinclair potentials by including the electronic terms that drive relative structural stability and heats of formation."

Monte Pettitt (University of Houston): "It reenforced my convictions about the importance and worth of multidisciplinary research at the boundaries with mathematics."

Philip Pincus (UC Santa Barbara): "Based or a talk by W. Urbach (ENS Paris) and discussion with him at IPAM, we have begun a study group on diffusion of membrane bound objects in the context of deviations from the Saffman-Delbruck model. A relevant mini -workshop is being organized at the Aspen Center for Physics during the Summer, 2007."

Yuval Rabani (Technion): "My stay facilitated my continuting collaboration with Professor Rafail Ostrovsky of UCLA. I also had numerous useful discussions with other IPAM participants, such as Professor Peter Jones, and Professor Emmanuel Candes. I got interested in various mathematical questions that relate to problems in computer vision. My IPAM visit also helped me to focus my research on data analysis, clustering, and pattern matching, in directions that might bear greater influence on other areas."

Naoki Saito (UC Davis): “Participating in the IPAM program 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" that I organized as a chair. Also through the interactions with Luminita Vese at IPAM, I hired Linh Lieu whom Luminita supervised as my postdoc.”

Don Sakaguchi (Iowa State University): “Strengthened my already exisiting collaboration with mathematicians here at Iowa State University (I am a cell and developmental biologist). Yes, most definitely [it had an impact on my career]. In terms of my research, we are now thinking much more about developmental processes and trying to model these events. Thinking in terms of using modeling to help us plan our next wet/bench experiments.”

Guillermo Sapiro (University of Minnesota): “I love meetings were we get together the unusual suspects and meet new people and new works!”

Stephen Simpson (Oxford University): “I have found the meetings at IPAM to be both stimulating and extremely enjoyable. They have crystallised some of my less well formulated ideas and opened up new opportunities. I maintain contact with several participants met through the two meetings.”

Jean-Luc Starck (Commisariat a l’Energie Atomique, Saclay): “IPAM was a fantastic opportunity to meet many bright researchers from different domains that I would not have met in other regular conferences more related to my domain. Thanks to IPAM, I made very good collaborations and I have learned a lot on some very hot topics in statistics such the compress sensing. It turns out that this new approach for data compression could be a key issue for the satellite Herchel that ESA will send in space next year.”

Rainer Steinwandt (Florida Atlantic University): “The possibility of interdisciplinary discussions was extraordinary fruitful.”

Gabriel Stoltz (Ecole Nationale de Ponts et Chausees): “I had the opportunity to discover new scientific fields in the molecular simulation of matter, and know now more active people in the field. I started a collaboration with Felix Otto (Bonn, Germany) six months after my stay at IPAM. I am also in touch with Arthur Voter at LANL, where I will be spending a week at the end of may, and who I well help in the teaching for a summer school.”

Wladimir Urbach (Ecole Normale Superieure): “The experimental approach to Membrane Viscosity is due to the discussion during my stay with Tom Chou who theoretically extracted the viscosity of bilayer from the value the viscosity of the lamellar solution.”

Adri van Duin (Caltech): “I attended a IPAM workshop in November 2005 (development of interatomic potentials, organizers Ral Drautz, David Pettifor and Christian Ratsch). I found this workshop extremely useful, providing a low-key environment for scientists working in the same field to exchange ideas, point out problems and discuss future directions. Such occasions to properly discuss science are unfortunately rare, and as such I am very grateful to IPAM for organizing these workshops.”

Dmitri Vvedensky (Imperial College): “It has made me more aware of the mathematical issues that lie at the foundation of my work on stochastic PDEs.”

Jack Xin (University of Texas at Austin): “the new direction from IPAM is the recent work on blind source separation; also a modeled based study of hearing aids algorithms.”

Peng Yang (Northwestern University): “My research focused on the design of bio-inspired swarm systems. I attended an IPAM swarming workshop with researcher from various fields, and through that I understand better the research activities on swarming within the biology society, their finding, methodologies, etc. Their models proved useful for my engineering design.”

Yong Yang (Beijing Institute of Technology): “The visit to IPAM helps me to learn about the frontier of condensed matter physics on the following aspects:
1) The materials at nanoscale will novel properties comparing to macroscopic situation, which leads to new challenge in physics.
2) The revolution in computational methods is an urgent job for theoretical physics, mathematics and chemistry.”

Alexander Yong (University of Minnesota): “Since attending I am engaged in two projects concerning mathematical biology. I am working with Claudia Neuhauser and Nicolas Lanchier in coalescent theory (population genetics) and with Duane Nykamp in the study of rat spike trains. My time at IPAM allowed me to the right environment to develop my agenda in these two directions. Moreover, during my stay, I proved one of my most substantial contributions to my pure math portfolio, which has led to further tightly related developments in two publications. In comparison to [other institutes] where I have also had time-substantial stays, I consider my stay at IPAM the most academically rewarding that I have had.”

Alan Yuille (UCLA): “The IPAM workshop (January 2005) has lead to a working relationship with Prof. J.B. Tenenbaum at MIT. We are co-organizing a summer school at IPAM in July 1007 to teach these techniques for developing mathematical models of the mind. The IPAM workshop led to a research collaboration with Prof.'s P. Cheng and K. Holyoak (Dept. Psychology, UCLA) on causal reasoning. (See publications by Lu et al).
A discussion at the IPAM workshop with Aaron Colville, stimulated my mathematical analysis of the augmented Rescorla-Wagner equation (see publications by Yuille). The IPAM workshop led to a special edition of Trends in Cognitive Sciences (TICS) in July 2006 (see publications by Chater et al, and Yuille & Kersten). This is an influencial journal in the cognitive science commumity with impact factor greater than 6. In addition, several students at the IPAM workshop applied for faculty positions at UCLA. These included Matt Jones, Christopher Rozzell, Charles Kemp, and Jonathan Nelson. The workshop, and the forthcoming summer school, has helped develop a community of researchers who model cognitive phenomena using mathematical techniques based on Bayesian inference. It offers the possibility of designing a mathematical framework for cognitive science. It has influenced my personal research in several directions: (i) it has enabled me to extend my research from visual perception to causal reasoning by my collaborations with Cheng and Holyoak (see publications by Lu et al), (ii) it has lead to

novel models for vision by exploiting the analogies between vision, natural language processing and reasoning (see publications by Zhu et al), (iii) my interactions at the IPAM workshop stimulated my mathematical analysis of the augmented Rescorla-Wagner equation (see publications by Yuille). Finally, I have written an IGERT pre-proposal which essentially uses the material from the IPAM workshop and summer school to develop a graduate training program at UCLA."