Institute for Pure and Applied Mathematics, UCLA
Award/Institution #0439872-013151000
***Updated* Annual Progress Report**
November 15, 2006

Table of Contents

Institute for Pure and Applied Mathematics, UCLA
Award/Institution #0439872-013151000
***Updated* Annual Progress Report**
November 15, 2006

EXECUTIVE SUMMARY

The Institute for Pure and Applied Mathematics (IPAM) had a successful and productive year. Here are some of the highlights for the reporting period of May 1, 2005 through July 31, 2006.

1. IPAM renewed by NSF for 2005-2010 with a new annual budget of $3.4 million, up 36% from $2.5 million in the last cycle.
2. Stanley Osher elected to the National Academy of Sciences.
3. IPAM Summer School "Intelligent Extraction of Information from Graphs and High-Dimensional Data" held with over 200 participants. Funded by a $200K grant from NSF's Approaches to Combat Terrorism program. Received additional funding of $200K from Los Alamos National Lab, a 1-1 match of the ACT grant. John Phillips, Chief Technical Officer of the intelligence community, spoke at the program to a luncheon with 55 scientists, plus representatives of 6 local Congressional offices.
4. RIPS expanded to 8 projects with 32 students in 2005 and 9 projects with 36 students in 2006. New sponsors for 2005 were Hewlett-Packard, Microsoft Research (Redmond) and TimeLogic, joining continuing sponsors Arete, Jet Propulsion Lab, Lawrence Livermore National Lab, Los Alamos National Lab and Pixar Animation. New sponsors for 2006 are NASA Goddard and Symantec. In 2006, 225 students applied for 36 positions.
5. IPAM establishes contacts with National Geospatial Intelligence Agency (NGA), which has indicated interest in doing a summer school with IPAM. Representatives from NGA attended essentially every lecture of the ACT Summer School.
6. National Security Agency site-visits RIPS for the first time; $100K of RIPS funding from NSA renewed.
7. IPAM's programs have continued to grow in size and quality. Multiscale Geometry and Analysis in High Dimensions, Computational Astrophysics and Bridging Time and Length Scales in Materials Science have all been well-attended and have attracted top speakers.
8. 11th Conference of African-American Researchers in Mathematics (CAARMS) was held at IPAM.
9. A Plasma Screen was purchased to provide for overflow from IPAM's main lecture room. It was used during Computational Astrophysics Workshop I on Astrophysical Fluid Dynamics, which had around 150 participants.
10. IPAM held its first ever Hands-on Workshop on Density Functional Theory as part of the current Bridging Time and Length Scales in Materials Science program. One of the open areas was converted into a bank of computers for participants to implement DFT programs as they learned.
11. IPAM partnered with the Anita Borg Institute to run a Women's Leadership Workshop at the Radcliffe Institute.

12. For the first time, held a post-RIPS workshop for both those with related types of programs and those interested in setting up a similar program at their universities.
13. IPAM sponsored with the American Statistical Association a 1 week undergraduate program in Statistics in both 2005 and 2006.
14. IPAM has restructured its staff and hired or replaced 7 new staff members.
15. Mac Hyman recruited as Chair-Elect and four new members added to the trustees (100% acceptance rate).

A. PARTICIPANT LIST

A list of all participants in IPAM programs is provided in electronic form (Excel). The list includes an update of the participants of programs that occurred between May 1 and August 1, 2005, and includes final participant lists for programs through July 31, 2006 including RIPS2006, our summer program which ended after the close of the fiscal year. **This updated version replaces the version submitted with our annual report dated June 23, 2006.**

B. FINANCIAL SUPPORT LIST

A list of participant support information is provided in electronic form (Excel). The list includes an update of financial support awarded to participants of programs that occurred between May 1 and August 1, 2005, includes final financial support information for programs through July 31, 2006. **This updated version replaces the version submitted with our annual report dated June 23, 2006.**

C. INCOME AND EXPENDITURE REPORT

IPAM received a no-cost extension to June 30, 2006 in order to spend $1,839,056 from its original 5-year funding. These funds have now been spent completely. We were able to spend somewhat more in the participant category and somewhat less on administration and staff than was originally budgeted.

Expense Category	Budget from Inception to 6/30/2006	Actual Expenses as of 06/30/2006	Balance as of 06/30/2006
Administrative Costs	$208,040.00	$75,295.47	$132,744.53
Senior Personnel/Staff	$3,147,873.58	$3,015,459.30	$132,414.28
Benefits	$492,447.58	$442,527.96	$49,919.62
Equipment	$412,000.00	$413,107.25	($1,107.25)
Participant Support Cost	$6,460,257.35	$6,748,697.40	($288,440.05)
Supplies/Expense	$266,523.47	$280,834.68	($14,311.21)
Total Direct Cost	$10,987,141.98	$10,975,922.06	$11,219.92
Total Indirect Cost	$1,767,238.02	$1,778,457.94	($11,219.92)
Total	$12,754,380.00	$12,754,380.00	($0.00)

For IPAM's new grant (year 1), the figures are as follows:

Expense Category	Budget From Inception to 7/31/2006	Actual Expenses as of 07/31/2006	Balance as of 07/31/2006
Senior Personnel/Staff	$770,566.00	$250,507.89	$520,058.11
Benefits	$160,138.00	$29,972.23	$130,165.77
Equipment	$43,650.00	$6,220.30	$37,429.70
Travel	$20,000.00	$1,100.67	$18,899.33
Participant Support Cost	$1,720,653.00	$787,586.99	$933,066.01
Supplies/Expense	$108,000.00	$60,718.36	$47,281.64
Total Direct Cost	$2,823,007.00	$1,136,106.44	**$1,686,900.56**
Total Indirect Cost*	$576,993.00	$135,868.04	$441,124.96
Total	$3,400,000.00	$1,271,974.48	$2,128,025.52

*Indirect cost calculation excludes the participant costs, equipment and sub-contract amount beyond $25K.

From these two sources of funding, IPAM spent $3,111,030 overall out of its $3,400,000 budget.

We did not know until almost the start of the grant period whether we would be allowed to have a no-cost extension from the first 5 years, so it seemed prudent to base plans for 2005-2006 without including these additional funds.

Because we used the carry-forward from the previous five-year grant towards our 2005-2006 programs, the budget for the first year of the current grant was only partially spent and resulted in a carry-forward in the amount of $2,128,026. We plan to use the carry-forward amount over the remaining 4 years of the grant as follows:

Carry Forward Spending Plan

Expense Category	Estimated Cost	Number of Events	Total Cost
Additional Support for Long Programs	$56,000.00	8	$448,000.00
Summer School	$100,000.00	4	$400,000.00
Affiliate Workshops	$10,000.00	8	$80,000.00
Equipment Replacement	$20,650.00	2	$41,300.00
Senior Personnel/Staff+Benefits	$162,500.00	4	$650,000.00
Supplies and Materials	$12,000.00	4	$48,000.00
Travel	$4,750.00	4	$19,000.00
Reserve for Inflation	$8,250.00	4	$33,000.00
Direct Cost			**$1,719,300.00**
Indirect Cost			$408,750.00
TOTAL			$2,128,050.00

The carry-forward funds will be used to:

A) Fund additional participants of long programs, summer school programs, and affiliate workshops where there is growth pattern on participants' applications brought about by continued success of previous programs.
B) Replace old computer equipment.
C) Augment costs of supplies and materials that are needed for the programs.
D) Cover the costs of additional staffing. The tremendous success of the previous programs has been bringing more participants that entail more labor-intensive tasks. IPAM has expanded and restructured its manpower to sustain and support the growing needs of its programmatic structure. Year-1 surplus will help to support the anticipated costs of the expanding operation and increasing number of participants.

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

This section includes the minutes from the 2005 and 2006 Directors' Meetings of Institutes for Mathematics and its Applications.

NSF Mathematics Institutes Directors Meeting, June 17-18, 2005

Chair	David McLaughlin (BMSA, NYU)
Directors	Douglas Arnold (IMA)
	James Berger (SAMSI)
	Brian Conrey (AIM)
	David Eisenbud (MSRI)
	Avner Friedman (MBI)
	Mark Green (IPAM)
	Arnd Scheel (IMA, Dep. Dir.)
NSF	William Rundell
	Dean Evasius
	Deborah Lockhart
	Chris Stark
	Henry Warchall

The meeting ran from 8:30 AM to 5:30 PM on Friday and continued on Saturday from 8:30 AM to noon with participation by NSF.

1. Coordination of institutes' activities

The most recent list of upcoming institute programs was discussed. A number of examples with positive outcomes coming from institute coordination were noted and several programs with potential fruitful future collaborations were identified. No points of concern were identified. Coverage of programs and the balance between the institutes leadership role and responsiveness to the community were discussed.

Action items

- The institutes will request that all program preproposals and proposals explicitly relate to and distinguish their programs from recent, ongoing, and planned activities at other mathematics institutes.
- When two programs at different institutes have commonality, the institutes will involve organizers in both programs in order to guarantee a complementarity and encourage synergy so as to strengthen both programs.
- The institutes will make the relation of their major activities to activities at other institutes explicit, by linking on web pages and, when appropriate, adding a short paragraph on common aspects and differences.
- AIM with its ARCC workshops will support the development of longer programs at other institutes. AIM will refer particularly successful organizers to other institutes as potential organizers of longer programs.

1. Development of a joint institute web space

IMA and MSRI have developed a structure for a joint website which contains information on all of the institutes' programs. The main page will contain pictures and links to nuggets, uniform description of institutes, a prominent link to a list of events and programs, and extended search boxes. The database will contain parent and child events. Details of the data structure were discussed and a two-level structure was agreed upon. Events will carry a short description, a list of keywords, and a link to the homepage of the event at the individual institute. The listing will be searchable, such that the listing of events can be restricted to individual NSF institutes or to all NSF institutes. There will be a list of hidden keywords associated with each event, allowing for combined searches on topics and time range. The default appearance will be the list of all NSF institutes activities. In a first step, the website will only refer to NSF institutes programs, but in a next step, it will host programs of other institutes. Events can be entered via a web interface or, in the form of an appropriately formatted XML file.

The directors envision a six-month target date for the release of a first public version. MSRI will take a lead in designing the web site and the multi-institute search engine. IMA will design the database and the events search engine. The institutes will generate nuggets, at least one nugget from each institute per year. Target dates for the individual institutes are annually, MBI July 1, AIM September 1, SAMSI November 1, IPAM January 1, IMA March 1, MSRI May 1, and IAS June 1.

The common institutes' website will provide a source of information for program organizers. It will also contain information on institute programs outside of the US. Douglas Arnold will encourage such a broadening at the meeting of international institutes' directors, IMSI, in 2006.

3. Broadening Participation

The directors discussed how best to increase the participation of women and underrepresented minorities in the mathematical sciences. The institutes have begun the process of sharing opportunities to present information about their programs to women and minorities. AIM has developed an extensive database for women and needs support from NSF for staffing to actively maintain the database. Some of the data has to be verified and its use needs to be approved by the individuals. AMS, MAA, MSRI, NAM, and NCTM have developed a small database of minority mathematicians which they will extend. The institutes will explore the possibility of using this information.

Concerns about the legality of collection and sharing of the data are a major impediment. AIM will seek legal advice by the NSF on the rules regarding how to build the database and share data.

4. Participant data collection

The proposed data collection fields were discussed in detail. The assignment of individual identifiers to participants and institutions are the major hurdles. There are major difficulties with using MR identifiers for individuals, because of lack of coverage, difficulties in obtaining them, and uncertainty as to their permanence. It was tentatively decided to use the email address as the unique identifier for individuals. Their variability appears to be less important in the context of annual reporting periods.

Extensive research has been made on institutional lists. Among lists from IMA, MR, or UNESCO, a modified MR list appears to be the most workable. IMA has agreed to revise this list for institutes reporting purposes. Institutes will jointly assign institution categories in this list. Once revised, the institutes anticipate using this list for a 5-10 year time frame.

MSRI will coordinate editing of the data collection fields based on the following suggestions which were discussed with the NSF representatives on June 18.

- Item 9. The department field will be replaced by primary field of interest, to be selected from Mathematical and Statistical Sciences, Computer Science, Physical Sciences, Life Sciences, Social Sciences, Engineering, Education, and Other.
- Item 10 will be replaced by reporting for those from academic institutions the categories undergraduate, graduate student, postdoc, faculty, other.
- Item 13 institution types will be assigned academic, industry, government lab/agency, or other.
- Item 16 should include the country of citizenship.

Item 19 and the postdoc spreadsheet will be discussed with the NSF.

5. Next meeting of Institute Directors

The next meeting will take place at MSRI May 5-6, 2006.

NSF Mathematics Institute Directors Meeting, May 5-6, 2006

Present:

Douglas 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 afriedma@mbi.ohio-state.edu
Mark Green IPAM mlg@ipam.ucla.edu
David McLaughlin (Facilitator) David.McLaughlin@nyu.edu
Dean Evasius NSF devasius@nsf.gov
Joanna Kania-Bartoszynska NSF jkaniaba@nsf.gov
Hans Kaper NSF hkaper@nsf.gov
Deborah Lockhart NSF dlockhar@nsf.gov
William Rundell NSF wrundell@nsf.gov
Hugo Rossi MSRI rossi@msri.org
Larry Patague MSRI larryp@msri.org
Anne Pfister MSRI annepf@msri.org

Action items are marked by **.

1. Website: www.mathinstitutes.org

**The directors approved the format presented by IMA, with some minor revisions that IMA will produce. Events are archived starting Jan. 1, 2005 and the event "teaser" displays 5 lines (400 characters).
**MSRI is to revise the "search" function to combine the items found on the different institutes' sites (or possibly offer a choice). It was agreed that the site would refer only to the seven NSF-supported US Mathematical Sciences Institutes for the first year. The question of whether to allow other institutes to publish their materials on the site will be considered again after this time.

**Nuggets:
It was agreed at the 2005 meeting that each institute would provide a "nugget" once a year, in the following order.

MBI (Oct 15)
IPAM (Dec 1)
AIM (Feb 1)
SAMSI (Apr 1)
IMA (Jun 30)

MSRI (Jul 15)
IAS (Sept 1)

The first five should have Nuggets up on June 1, the day the site goes public.

(I have added the due dates so that the five starting nuggets will stay up a while before the next one comes in -- DE)

Precise instructions for submitting the nuggets, and a description of the format in which they should be submitted, is given on the joint web site, (click on the link "for institute administrators" at the bottom of the home page). The nuggets will rotate on the homepage.

**SAMSI should submit its nugget to Doug ASAP to make this possible -- well before the end of May, so that it can be put up in time.
**The site is to go live on May 30, 2006.
**Institutes will provide a link from its site's home page by June 7.

**2. The Institutes will form a Technical Committee (and set-up an e-mailing list), consisting of a representative from each Institute and a representative from NSF, initially Dean Evasius.
The first tasks for the Technical Committee are:
a. Scrub the joint web site
b. Create an automated method for uploading events to the website.
c. Add to the website a method for subscribing to each institute's electronic newsletter.

**3. The Institutes will form a Diversity Committee. The initial membership is: Hugo Rossi, Chris Jones, Helen Moore. (This list needs to be updated: each Institute should appoint a representative.) The committee should choose its own chair. Chris Jones is the current chair.
**The Diversity Committee will make sure information about all the institutes is available whenever one institute has a conference targeting under-represented groups. Also, the institutes will plan social activities, as appropriate, at national meetings to encourage more participation. Example: Math Institutes Reception at SACNAS meeting.

4. Blackwell-Tapia Prize and Conference: The Institutes may propose to host the B-T conferences in rotation; **Jim Berger is writing the Proposal (for SAMSI in 2008), on behalf of the Institute Directors, offering to establish the hosting of the conference at the Institutes on a rotating basis; this will be circulated among all the institute directors for approval before being sent for consideration to the National Blackwell-Tapia committee. Avner Friedman proposed that MBI host B-T in 2010.

5. Discussion about sharing information on future programs noted, with appreciation, the list that Barbara Keyfitz has produced and circulated. A number of specific instances were recounted in which institutes revised their plans to better mesh with the programs at other institutes. It was agreed that the system was working well. The directors expressed satisfaction with the current relatively informal process, and agreed to continue with consultation and response on this basis.

6. Reporting to the NSF:

The following text emerged from a discussion with the NSF program officers, and was approved by all those present. **The NSF program officers will fashion the two points into memoranda to be inserted in the Institutes Contracts, so that the reporting process will become standardized and fixed in this form:

Annual reports from the Institutes will come to the NSF in two parts:
I. (90 days before renewal): 1 page report, referring to the fall report. First half about science, updates, approximate number of participants. Second half a general financial update. Rough expenditure. Any material changes flagged. Submitted via fastlane. Attach previous October's "interim" report as a single pdf document.

II. Full report in fall: science and financial. Includes 3 standard Spreadsheets plus scientific reports on the previous year's programs, including summer programs. The spreadsheets are emailed, not submitted by fastlane. The rest is submitted by fastlane as an "interim" report. The spreadsheets cover a twelve-month reporting period starting between July 1 and September 1, as appropriate for each institute.

**6. Next meeting: It will take place at IPAM, starting at noon on May 11, 2007 (for the Institute Directors) and at the dinner that evening (for the Institute Directors and the NSF representatives). It will end after lunch on May 12. (See http://www.ipam.ucla.edu/visitor_info/directions.aspx)

Some possible agenda items:
A. Should the Institutes produce a joint institute report, for *some* audience---congressional staffers, NSF, mathematicians, others (?) ---on the state of mathematics?
B. Extension of the web site. How about KITP? What about internationalization of the website: whether, what, how?

F. PARTICIPANT SUMMARY

IPAM actively seeks women and members of underrepresented ethnic groups to participate in its programs as speakers and participants.

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	102	22	97	0	1	4	93
Workshops	1510	330	1388	2	63	48	1231
Summer Programs	408	97	378	2	8	16	325
Reunion Conferences	134	21	127	0	2	2	122
Total	2154	470	1990	4	74	70	1771
Percent of No. Reporting		23.6%		0.2%	4.2%	4.0%	

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

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	45	98
Workshops	736	1301
Summer Programs	210	338
Reunion Conferences	58	124
Total	1049	1861
Percent of No. Reporting	56.4%	

92% of the participants (1983 out of 2154) reported their program category as faculty, postdoc, graduate student, undergraduate student, or other. (The remaining 171 participants either did not report their academic position or 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 can be involved at IPAM in four ways: As core participants in our Long Programs, as supported participants at IPAM workshops, as supported participants at our Graduate Summer School and as Faculty Mentors for RIPS.

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	20	6	20	0	1	1	19
Workshops	226	58	221	0	7	9	209
Summer Programs	43	7	43	0	1	1	39
Reunion Conferences	35	3	36	0	1	1	33
Total	324	74	320	0	10	12	300

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	6	19
Workshops	85	208
Summer Programs	18	38
Reunion Conferences	11	34
Total	120	299

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

Li Lei (USC):
"Now I am the PI of a yeast aging project. My knowledge and expertise in the area were developed when I was a postdoc at IPAM."

Raissa D'Souza, UC Davis:
"Wonderful opportunity to meet a broad range of people while I was a postdoc. This helped tremendously when it came time for my faculty job search. Thanks IPAM!"

Andres Jaramillo-Botero, Caltech:
"I began sustained collaborations with Prof. William A. Goddard III (Caltech) in molecular simulations and potential collaborations with Dr. Rima Gandlin at the Carnegie Mellon University in applied mathematics for multiscale simulations. It became the turning point for deciding to relocate in the US to pursue a full-time career in nanoscale research. I will be joining Caltech as Scientist (first principles multiscale simulations) starting June 1, 2006."

Jasmine Zhou, USC:
"My current research program started at IPAM, back in 2000."

Chrysoula Tsogka, Stanford University:
"My involvement with IPAM reinforced my knowledge on inverse problems and their applications. I met a lot of the leading scientists in this area and I had the opportunity to learn the state-of-the-art methods in the field. Being at IPAM also gave me the chance to present my work and therefore get to be known which is very important for a young researcher like me."

Arnold Kim, Stanford University:
"My involvement with IPAM has helped to fortify current career and research direction. By providing a dynamic environment to interact with colleagues, I gained a valuable experience that helped me in my career in becoming an assistant professor."

Thomas Juenger, University of Texas:

"My involvement in IPAM introduced me to several statisticians that have helped push my research in interesting new directions."

Katie Kerr, University of Washington:
"It was a very positive influence on my career due to the contacts I made in that semester and the ideas that were shared."

Alexandru Tamasan, University of Central Florida:
"The program at IPAM during the fall 2003 had a substantial impact on my work. Two collaborations and two papers have been completed. I believe that my participation and work at IPAM increased the visibility of my research and consequently advanced my academic career."

Danny Barash, New York University:
"Getting to meet prominent scientists in the field during IPAM 2002 was highly important for me, as I now teach numerical analysis and scientific computing. I got the opportunity to lecture and obtain valuable feedback to my work. I think that it is very important to keep supporting and organizing IPAM activities."

Saunak Sen, UC San Francisco:
"It has made me more aware of the different strategies employed for the genetic analysis of complex traits. I was also able to interact with top-quality researchers in a manner not possible at a regular conference."

Joeng-Rock Yoon, Clemson University:
"My visit of IPAM in 2003 as a postdoc was very helpful in my career. To meet many people with different background and to discuss many interesting research problems were especially beneficial to establish a long term research plan. The experience at IPAM certainly is a big plus in my research career and I believe it helped me get my current faculty position at Clemson University."

H. GRADUATE STUDENT PROGRAM SUMMARY

There are three principal mechanisms by which graduate students can be involved at IPAM: By being core participants in an IPAM Long Program, by attending an IPAM workshop, and by participating in an IPAM Graduate Summer School. Graduate students often find a compelling thesis topic at an IPAM program, and also frequently make contacts that lead to their first job.

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	29	5	27	0	0	0	26
Workshops	456	117	443	0	29	13	420
Summer Programs	117	27	111	0	1	8	104
Reunion Conferences	18	8	17	0	1	0	17
Total	620	157	598	0	31	21	567

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	3	28
Workshops	138	421
Summer Programs	40	102
Reunion Conferences	2	17
Total	183	568

In Summer 2005, IPAM held a 3-week Graduate Summer School on "Intelligent Extraction of Information from Graphs and High Dimensional Data (IEI)."

- The program was sponsored by a $200K grant from the Approaches to Combat Terrorism program, matched by $200K in additional funding from Los Alamos National Lab.
- The themes of the three weeks were: High Dimensional Data, Relational Data and Kernel Methods; Image Analysis and Machine Learning; Streaming Data and Networks.
- There were over 200 participants in this program.
- A new summer school format was introduced—the first 3 lectures of the day were tutorials, the other 2 talks were research talks. This worked exceptionally well. It met the needs of junior participants by giving them time in the afternoons to digest the day's tutorials. It kept the speakers interested via the research talks, and prompted many speakers to stay around for the full week during which they were speaking, magnifying opportunities for students to interact with them.
- The quality of the 49 speakers and of the presentations was exceptionally high. All of the talks were videotaped and are available on the web.
- The program gave an opportunity for a new generation to learn a broad spectrum of techniques relevant to national security. Both NSA and NGA provided input on topics of interest.
- There were 123 supported participants, almost all of whom were graduate students and postdocs.

- John Phillips, Chief Technical Officer of the intelligence community, addressed a special luncheon group consisting of speakers, campus researchers, and aides from six local Congressional offices.

Paul Salamonowicz, National Geospatial Intelligence Agency:
"First, everyone from NGA found the program interesting and relevant. The quality of the presentations was exceptional and there are several general topics that we will be pursuing as a direct result of what we learned this past July. In addition to the technical content of the program, we made many valuable contacts across the community, including parts of the mathematics community with which we would not normally associate. This alone will be extremely valuable."

Tanya Roosta (Berkeley):
"It introduced me to the area of statistical learning theory, and as a result I have been able to define my PhD topic."

Grace Wahba (Wisconsin):
Conference was a particularly rich experience and has influenced a significant part of my present research."

Benjamin Georgi (Max Planck):
"The GSS 2005 provided an excellent overview of the state of the art in machine learning. It was most useful for the decision in which direction to take my own PhD project."

Yosi Keller, Yale:
"I am a postdoc in Ronald Coifman's group in Yale and have been studying high dimensional data analysis over the past two years.
I would like to share my experience about the IPAM summer school on Intelligent Extraction of Information from Graphs and High Dimensional Data. This summer school was, and still is, not only the best availible source of knowledge about this topic, but actually the only one. The interesting aspect is that I never attended the conference personally (I was teaching the summer term in Yale at the time). But, I downloaded many of the talks and watched them on my TV via the computer. I actually sat down one night and saw the 4 hours of Lawrence Saul's tutorial. Later, I gave the talks to the new postdocs in our groups. Other than that and teaching them myself, we had no other way of passing them the material. They found the talks to be benefitial and much easier to understand then our group's preprints… To conclude, such summer schools are instrumental in advancing new research topics, both for students who attend them and even more for those who are far away, and have no other way of hearing lectures by likes of Lawrence Saul, Peter Jones and Ronald Coifman."

Mabel Ramirez-Velez, Colorado:
"As a graduate student, my participation at IPAM provided the opportunity to meet personally with experienced researchers in the area Intelligent Extraction of Information from Graphs and High Dimensionality Data. I was greatly benefited by the excellent quality of many of the workshops taught by outstanding researchers.

IPAM facilitated an excellent environment for communication and discussion of scientific ideas. Also, a great networking opportunity with student colleagues and internationally known scientists. My research was greatly benefited also, since many of the seminars helped me clarify and build a greater understanding about the techniques and methods I was using in my graduate research work beyond what I was learning from the literature and my own experience in the laboratory."

Gianluca Antonini, EPFL:
"Since the IPAM GSS, I am actively studying machine learning and artificial intelligence. Probabilistic graph models and dimensionality reduction techniques have become part of my background and I'm currently competing for three important industrial positions (UTC, IBM and Honda Research) where such methods are in daily use."

From Grace Wahba, University of Wisconsin:
"Congrats to Fan Lu who the "Best Student Paper Award", ASA Statistical Computing and Graphics Sections, JSM2006 for TR1119. Fan Lu also won the International Biometric Society's Eastern North American Region (ENAR) Distinguished Student Paper Award (2006) for his contributions in Lu, Keles, Wright and Wahba (PNAS 102(2005)12332-12337.) which was published shortly after the July meeting. The meeting undoubtedly helped him write up his winning proposal for the ENAR award."

From Previous Summer Schools:

David van Essen, Washington University, Mathematics of Brain Imaging:
"About a half dozen brain-mapping collaborations have emerged in connection with our new PALS human cortical atlas, the seeds of which were planted in connection with my IPAM presentation and publication. These include collaborations to study specific diseases and disorders as well as normal brain structure and function. [The program] helped contribute to a substantial shift in how my lab approaches surface-based analyses of human cerebral cortex."

John Csernansky, Washington University, Mathematics of Brain Imaging:
"As as a result of my participation at IPAM, our group has begun a collaboration with the MR neuroimaging group at Massachusetts General Hospital. IPAM made me aware of the advances achieved by other groups in quantitative analysis of surface of the human cerebral cortex, which has broadened the scope of our own work."

Steve Engel, UCLA, Mathematics of Brain Imaging:
"This program helped me think about data analysis in new ways."

Maria Helguera, Rochester Institute of Technology:
"The workshop I attended has helped me to start collaborating with researchers working on MRI. I recently submitted a proposal to the Center for Electronic Imaging Systems - University of Rochester. This work, if funded, will be a collaboration with a local company VirtualScopics on the simulation of MIR pulse sequences to assess machine performance… Up to recently my research has concentrated on ultrasound imaging."

Dargan Frierson, Princeton University, Modern Applied Mathematics for Atmospheric and Ocean Science:
"The MAMAOS summer school at IPAM in summer 2003 was an excellent experience for me, in terms of learning about a variety of new fields, meeting new colleagues, and also participating in my own multidisciplinary research projects. As a third year graduate student at the time, it was instrumental in determining the path of my subsequent thesis work and my research in general since then.

The format of the workshop included a teaching component (introductory lectures during the first half of each week) as well as a research component (research lectures as well as individual or group research projects for the students). The lectures, which included a broad range of fields from all parts of the spectrum between applied mathematics and atmospheric sciences, were greatly informative. The wide range of topics covered were especially interesting to me as a student just getting into research problems. The combination of introductory lectures smoothly leading into research lectures proved an excellent way to see how research is actually done, and helped me choose my subsequent direction in research. Lectures such as these are truly a unique experience that is not available in either a classroom setting or in typical research colloquia/conferences. The availability of professors and postdocs for discussion with the graduate students after the talks (again something that doesn't happen as much at conferences) was additionally quite useful. The interdisciplinary nature of the talks and attendees led to particularly fruitful discussion after the talks. The workshop definitely helped me feel more comfortable with participating in interdisciplinary research in general.

The students were additionally encouraged to participate in research projects during the course of the summer school. With help from my collaborators Andy Majda and Olivier Pauluis, my project integrated methods learned from the lectures with some questions I had been thinking about from my general exam project at Princeton. The new methods were successful, and we were able to publish our work the following year. This interdisciplinary paper was my first publication in graduate school, and has led to further collaboration with the co-authors which continues to today. In summary, the MAMAOS workshop was an excellent experience for me that continues to benefit my research career today."

Yi Deng, University of Illinois at Urbana-Champaign:
"My participation in 2003 IPAM summer school has greatly increased my interest in the application of stochastic dynamics and probability theory in atmospheric sciences. I have chosen my postdoctoral study on the Bayesian technique involved stochastic inversion problem."

****
Graduate Participants in IPAM Long Programs and Workshops say similar things…

Tracy Bergemann, University of Minnesota:
"I can safely say that my experience at IPAM completely laid the foundation for all of my later research and career success. I am currently a tenure-track assistant professor in the Division of Biostatistics at the University of Minnesota and actively work in the fields of statistical genetics and genomics. The size and breadth of knowledge that I gained while at IPAM provided the seed that now allows me to speak intelligently about the field I now work in. And this knowledge has not only assisted in my career development, but also my collaborative projects."

Nicola Bennert (UC Riverside):
*"I continue my collaboration with Dr. Bruno Jungwiert.
In fact, we are now both postdocs at the University of California, Riverside. We continue our work on numerical simulations on the narrow-line regions of active galaxies which we started at IPAM. My stay at IPAM helped me in getting the postdoc position I have now at the University of California, Riverside."*

Brian Gurbaxani (Center for Disease Control):
"As a graduate student with a fellowship in bioinformatics, the 2 IPAM programs I attended (Inverse Problems and Proteomics) confirmed that my direction should be in mathematical applications in biology, and many of the seminars I attended gave me lasting perspectives and key references for further research, which I am now pursuing."

Michael Wakin, Rice University:
"The IPAM MGA program played a huge role in shaping our research. Some of the very first talks in Compressed Sensing were given during the MGA program (by David Donoho, Emmanuel Candes, and Justin Romberg), and we had a number of very inspiring conversations with those people while at IPAM. Since then we have continued these conversations and collaborations, and we have ramped up a concerted group effort in Compressed Sensing research at Rice, involving several faculty and students in Rice ECE plus collaborations with Ron DeVore, Albert Cohen, Anna Gilbert, Martin Strauss, and Joel Tropp.

IPAM also gave me the opportunity to begin a collaboration with David Donoho studying the multiscale structure of nondifferentiable image manifolds. We did many of the initial computations while at IPAM and later refined these into a paper. This collaboration is still ongoing, and Dave is also a member of my PhD thesis committee, and I am planning to work with Emmanuel Candes as a postdoctoral researcher..

Thanks again for a great program!"

Stilian Stoev, Boston University:
"Honestly, the stay at IPAM was a great experience for me, both personally and scientifically. The atmosphere in the institute was very work conducive and the workshops during the program on Computer Networks I was involved in were an eye-opening experience for me as a young graduate student. I also benefited a lot from informally attending the workshops during two other programs and by meeting many of the truly great scientists. I truly hope that IPAM continues to be funded at least as well as it has been since it is a unique asset to the young researchers in the US."

Alex Gottlieb, Vienna:
"I have collaborated with Lisa Wesoloski, who was a core participant in the Nanoscience Program of Fall 2002. Lisa is a graduate student in Physical Chemistry who works with Scanning Tunneling Microscope; I am a mathematics post-doc who is interested in quantum physics. Lisa and I were both interested in theories of quantum tunneling. We wrote an expository paper that has just been published in Nanotechnology. Our paper was downloaded

250 times within thirteen days of its online publication! How your involvement with IPAM affected your career and research direction: I was most involved with the Mathematics of Nanosscale Science and Engineering workshops back in 2002, and since then I have certainly become more and more involved with the subject. I am definitely interested in quantum effects in nanotechnology, and I plan to continue study and collaboration in that field."

Andreas Hofinger (Linz):
"At IPAM I came in contact with "stochastic inverse problems". This opened a new area of research for me, and finally was the basis for my PhD thesis."

Ranaan Schul, UCLA:
"IPAM was a good place to be in the year I was looking for a postdoc. I met quite a few people, among them my current employers… As far as research direction, IPAM is the place where I got involved in collaborations with applied mathematicians."

Omar Lakkis, University of Sussex:
"I was at IPAM as an advanced Ph.D. student. My stay made me aware of the broad area of mathematics in which I currently do my research."

Dan Kushnir, Weizmann Institute:
"My visit to IPAM has contributed much to my research by exposing me to the cutting edge research done in my field. Moreover it gave me an opportunity to collaborate with other researchers who develop and need computational tools as the ones that I develop. I am still working on analyzing data sets from Jorg Schumacher and we intend to continue our collaboration and apply for grants."

David Ketcheson, University of Washington:
"The IPAM workshop on Computational Astrophysical Fluid Flow exposed me to a wide range of interesting problems. I am still deciding on a problem for my dissertation, but it will likely be one that I learned about at the workshop."

Alexandre Tkatchenko, Universidad Autonoma Metropolitana:
"I have been able to gain much broader view and look at my field of study (adsorption of atoms on surfaces) from another perspective. Also, I have established contacts with people whom I would not be able to meet otherwise. I think the involvement with IPAM have changed the way I see research at this moment and have helped me to broaden my knowledge."

Marta Garrido, University College London:
"I have attended the IPAM workshop entitled Probabilistic Models of Cognition. At that time I was in the first year of my PhD and my research project was still very much in a preliminary stage. Attending this workshop helped me to define better the line of research I wanted to follow. The opportunity to meet some of the speakers and to hear about their work was reassuring in confirming the relevance of the topics covered and increased my enthusiasm about the topics covered."

Tim Conrad, Free University, Berlin:

"I heard about many new techniques some of which I am using / will use in my PhD project."

I. UNDERGRADUATE STUDENT PROGRAM SUMMARY

Undergraduate students participate only in our summer RIPS program and Undergraduate Summer Program in Statistics, 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	111	45	97	1	6	5	77

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

Program Type	U.S. Citizens & Permanent Residents	No. Reporting Citizenship & Residency
Summer Programs	57	75

IPAM's primary program for undergraduates, Research in Industrial Projects for Students (RIPS), began in Summer 2001 with 12 students working on 4 projects. There were around 40 applications. In Summer 2005, there were 170 students applying for 32 positions on 8 projects. In Summer 2006, there were 225 students applying for 36 positions on 9 projects.

Main features of RIPS:

- Students work together in teams of 4 for nine weeks on real-world problems for which a sponsor from industry or a national lab wants the answer.
- 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.
- Admission to the program is highly competitive, with applicants coming from all over the world.
- Sponsors tend to be organizations that are reliant on sophisticated techology. Most return for multiple projects. Sponsors in 2006 were Arete Associates, Hewlett Packard, Jet Propulsion Lab, Lawrence Livermore National Lab, Los Alamos National Lab, NASA Goddard, Pixar Animation, Symantec and TimeLogic.

- Faculty mentors find this an exceptionally valuable teaching experience.
- In Summer 2005, a small meeting was held following RIPS Projects Day for universities with related programs and those who were interested in starting such a program; several institutions sent observers to the 2006 Projects Day as well.
- A program based on RIPS was started by Helena Noronha in Rio de Janeiro.
- Beginning in 2002, IPAM received additional funding for RIPS from the National Security Agency

Comments from RIPS 2006 Students:

Adrian Albert, International University Bremen
"RIPS really lets you feel some of the challenges of the business world before you graduate".

Marcelo Alvisio, MIT
"RIPS is a great program. The program is in itself an educational process where research, team work, documentation and presentations are all integrated. The organization is flawless".
"I would certainly recommend RIPS to other students. The educational experience is invaluable, the organization of the program is perfect, and the atmosphere, housing and facilities only enhance this great experience".

Nicolas Annoni, Carleton College
"RIPS has extraordinary educational value because students learn to do challenging research as part of a team within a larger community of mathematicians. My RIPS experience has more than confirmed my plan to pursue graduate study in biostatistics".

Markus Bachmayr,
"I consider it a very valuable experience to work together in an international team on challenging projects; you learn a lot both about the field and about presenting the results".

Sarah Bolt
"This was definitely a valuable experience for me – knowing that graduate studies can lead to exciting things in industry, not just academia".

Dharshi Devendran, UCLA
"RIPS is an excellent introduction to research since you must formulate a specific problem for yourself, find relevant papers and apply the knowledge you have in order to solve the problem".

Margarita Echavarria, Cornell University
"RIPS is such an incredible experience. It allowed me to have a task of applied math without having to make a drastic life choice. Furthermore, it has helped me grow immensely, not only professionally and intellectually, but also socially. It has been a once in a lifetime opportunity".

Jonathan Essen, Principia College

"RIPS is the only summer research program I know of that has students working and thinking in teams from day 1. I had never realized just how much more a group of people can be when tackling a new problem".

David Galkowski, Harvard University
"It gives the students experience with leading their own research effort and teaches them what and what not to do in a technical group project. The skills will be very useful in the future for all of us".

Lu Gram, Oxford
"RIPS teaches students the intangible aspect of mathematical research – what it feels like, what the difficulties are, what the social dynamics are. RIPS showed me that math research is quite rewarding and enjoyable. I had previously thought it mostly consisted of providing theorems in a lonely basement, but now I discovered that it is fully compatible with fun and games".

Ellie Grano, North Carolina State University
"We have learned a great deal beyond academics, namely how to work in groups, what research is, and various technical programs like Matlab and Latex. Before RIPS, when people learned what my major was they would ask 'what do you do with a math degree?' Now I have a list of answers for them".

Kenneth Ho, California Institute of Technology
"RIPS provides students with high-quality projects and an intensive introduction to team-based research. The latter is particularly useful as preparation for future work".

Amol Kumar, UCLA
"This is the first time I learned how effective a group of people with varying backgrounds could be".

Gitendra Malla, Gettysburg College
"The projects for RIPS were very focused problems and meticulously designed for undergrads and recent grads. They were not easy to solve but did push the students' limits. There was a healthy competition among a very diverse group of students and yet the work environment was so relaxed. RIPS has helped me get a perspective on the career opportunities that I can pursue in the future and also allowed me to see my interests in artificial intelligence and robotics".

Cory Nathe, Augsburg College
"The challenging but interesting research project I worked on here at RIPS gave me a lot of insight into what I am capable of when I put my mind to something and work hard". "The combination of the location at UCLA, the cultural diversity of the students and the research projects makes this a wonderful way to spend two months of a summer".

Alex Petrakiev, USC
"It has significantly impacted my future goals. I have always thought of going immediately to graduate school right after finishing my undergraduate degree. After this internship, I realized

that I can postpone my PhD for a year or two and start working for a company like Symantec. Then I could probably even come with better ideas when working on my PhD".

Yulan Qing, Colorado College
"It was an eye-opening experience to work and study with people from so many countries. The conversations and time we shared together are priceless".

Efrem Rensi, San Jose State University
"I was impressed by the enthusiasm of the participants. I was used to being the only person crazy enough to hang around late at night working on things but at RIPS a lot of others were like that too. I got to do real work in the field of computer vision and I could go on about that more, but the most important aspect of RIPS was the environment created by the IPAM staff. They provided me with the opportunity to really show what I am capable of."

Anne Skaron, UCLA
"RIPS helps you learn to apply all this random stuff you know to real problems. It's really cool to see that the math you learned in class a couple years ago actually can be used for something".

Jeri Xu, Yale University
"I gained lots of presentation skills from RIPS. The critiques from others were especially helpful, and now I know how to make slides concise and clear, and I am more confident about speaking in public."

Past RIPS Student, Faculty Mentor, and Industry Sponsor Comments:

Bruno Galerne, RIPS Student 2005
"After the RIPS program I really decided to become a researcher in applied mathematics. This year I studied image processing at the Ecole Normale Supérieure de Cachan and I dare say my experience of the RIPS project helped me a lot. It was also nice to be aware that a lot of UCLA people that I met (L. Vese, S. Osher, T. Chan,...) are actually really famous on their field."

Mihai Bailesteanu, RIPS Student 2005:
"Working at IPAM for two months definitely influenced my career direction. It helped me make up my mind on what to do after graduating from college, and I must admit that my decision to go to grad school (in US) was strongly influenced by the experience at IPAM."

Michelle Bailey, RIPS Student 2005:
"Before IPAM I didn't think I was that interested in research. After my experience however, I am now strongly considering returning to school to pursue a graduate mathematics degree."

Kevin Vixie, Los Alamos, RIPS Industry Mentor 2005
"Two RIPS students we sponsored (from different summers) subsequently ended up in LANL internships."

Matteo Pellegrini, RIPS Faculty Mentor 2005

"The summer RIPS program in 2005, for which I was a faculty mentor, introduced me to the field of mass spectrometry. This has significantly increased my awareness of an important branch of genomics."

Jacob Macke, RIPS Student 2004
"The experience in doing research, working in teams, holding presentations and writing reports is invaluable, as is the knowledge gained by attending talks at IPAM. It has also greatly strengthened my resolve to pursue a career in academia, and I will embark on graduate studies in computational neuroscience next year. I have plenty of offers to choose from—Berkeley, Cold Spring Harbor Laboratory, Max Planck Goettingen,…--I am convinced that without RIPS at IPAM, I would not have been able to achieve this."

Jeff Aristoff, RIPS Student 2004:
"I believe my involvement with IPAM helped me to obtain a NSF Graduate Research Fellowship in the area of applied mathematics."

Lisa McFerrin, RIPS Student 2004:
"My IPAM experience was a huge motivator to my current situation. I was placed in the BioDiscovery group during my work at IPAM and was introduced to the field of Bioinformatics. I loved the ideas that we were working with and the implementation process which coincided exactly with my expertise and interest. Since IPAM 2004 I aided a professor with sequencing Pseudomonas Syringae strains for his research and have graduated from Virginia Tech with 2 Cum Laude degrees in Mathematics and Computer Science as a Commonwealth Scholar…I am now a PhD student at North Carolina State University studying Bioinformatics."

Peterkin Quagraine, RIPS Student 2004:
"I presented the RIPS research at a symposium in April 2005 - the 19th Annual Symposium in Mathematical, Statistical and Computer Sciences at Eastern Kentucky University (Richmond, KY), and I won first prize in the undergraduate category."

Martin Lo, RIPS Industry Mentor 2004
"I am just delighted with the RIPS program…This really is a super program. It is really needed for the math community, especially the younger generation…It is what every math student, pure or applied, should learn before getting their BS."

Dan Shaevitz, RIPS Student 2002
"I have been working at Arete Associates as a Research Analyst for 7 months. I first learned of Arete at the RIPS program at IPAM."

Jason Geertz, RIPS Student 2002
"After attending the IPAM program RIPS 2002, I decided to attend graduate school and continue with research. I believe my experience there taught me a lot about managing and doing scientific research. I also believe that my experience at IPAM led directly to me receiving the NSF Graduate Research Fellowship."

Jennifer Garcia, RIPS Student 2001

"I now work for the UCLA Medical Imaging Informatics group doing some programming and mathematical modeling. Most of my tasks use the skills that I have learned and was introduced to during the time I was participating in the IPAM program…If it were not for IPAM and a small list of caring professors, I would never have learned of my passion for research."

Peter Eltgroth and Peter Brown, RIPS Industry Sponsors 2002-2004
"During both the summers of 2002 and 2004, I was impressed by the quality of the students, not just in terms of their credentials coming into the program, but at what they produced, as undergraduates, over the course of two months…The final report for this project is a remarkable piece of work that benefits us here at LLNL."

The **Undergraduate Summer Program in Statistics (USPS)** was launched in Summer 2005. IPAM sponsored jointly with the American Statistical Association, this one-week program was repeated in 2006. Unfortunately, no ethnicity or citizenship data was collected for undergraduate students who participated in the 2005 summer program in statistics**.**

.
Diane Lambert, Bell Labs, Speaker at USPS 2005:
"It was a great experience for me. The students were clearly engaged by the wireless project and made a lot more progress with the data than I would have thought possible. It was clear that many of them were intrigued by the power of data analysis and statistical thinking…You deserve kudos for diversity. I've never been to any kind of statistics program that had as high a fraction of women and minorities."

Doug Nychka, National Center for Atmospheric Research, Organizer and Speaker at USPS 2005:
"I was enthusiastic about the format of the data analysis summer program that was sponsored by IPAM. It seemed to me highly successful. The combination of real problems and data sets and the ability of the students to interact with the data and display results was very powerful…The emphasis on team problem solving reminded me of the kind of valuable dynamic that is present in the RIPS program."

J. PROGRAM DESCRIPTION

Long Program: Grand Challenge Problems in Computational Astrophysics, March 7-June 10, 2005

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)
Harold Yorke (California Institute of Technology, Astrophysics)

The 20th century saw the culmination of efforts to solve the major theoretical problems of astrophysics using analytical techniques. Indeed, most of the basic underpinnings of our current understanding of stellar and galactic dynamics, gas dynamics, stellar evolution, and planetary dynamics, were laid out by the heroic efforts of several generations of theorists from Eddington, Chandrasekhar, Schwarzchild and Milne to the likes of Parker, Mestel, Zel'dovich, Ostriker, Goldreich, Rees, Shu and Blandford. However, the complexity of most astrophysical phenomena dictates that accessible analytical techniques are increasingly becoming relegated to limiting cases. In a realistic and complete description of most cosmic phenomena, one must typically face highly non-linear interactions between objects or particles, as well as non-linear couplings between different kinds of interactions, including gravitational, electromagnetic, radiative, and gas dynamical interactions. Consequently, numerical approaches to understanding astrophysical phenomena have become indispensable, and promise to dominate the methodology of theorists well into the 21st century and presumably beyond.

The sophistication and the diversity of computational methods have grown alongside the power of computers, but there has emerged the perception amongst some theorists that we have reached certain roadblocks in this evolutionary process. While technical advances continue to be made, including massive parallelization and the development of dedicated special-purpose computers, such as GRAPE, investigators have encountered various algorithmic limitations. With the possible exception of some novel methodologies currently being explored, future progress in computational theory appears to be awaiting only the inexorable increase in raw computing power. The most advanced coding techniques, including adaptive mesh refinement (AMR), N-body tree codes, and smoothed particle hydrodynamics (SPH) and its offshoots, have been very successful, but their accuracy in the 3-dimensional realm is often problematical, especially over long time spans. The devil is often in the unresolved, small-scale details of such physical processes as turbulent cascades, turbulent energy dissipation, magnetic field line reconnection, narrow shock fronts and dynamical instabilities, among others.

The availability of a cascade of new data from new instruments of quite varied modalities made this an especially exciting time to hold this program. The tutorials from this program, available at http://www.ipam.ucla.edu/schedule.aspx?pc=pcatut , provide an excellent introduction to both the principal numerical techniques used in astrophysics and to the scientific questions that currently challenge existing techniques.

The program was enriched by several special events. There was a series of 8 lectures on adaptive mesh refinement by members of Phil Colella's group at Lawrence Berkeley National Lab, a special session devoted to Coronal Heating led by Marco Velli (Florence), a Supernovae Focus Day, and a special session on the challenges of combining magnetohydrodynamics with smooth particle hydrodynamics.

Alexei Poludnenko (University of Chicago):

"The IPAM semester program has been one of the most (if not the most) productive and enjoyable long-term programs that I have participated in. It was a completely unique opportunity to get the overview of the field of computational astrophysics as a whole. Most importantly, it was a chance to interact in one place and within a short period of time with

people who are involved in developing and applying numerical methods in a wide range of problems and thus to acquaint myself with approaches and techniques used in other areas of the field. I believe that such exchange of methods, tools, approaches between various areas of the field as well as other disciplines, e.g., applied mathematics, software engineering, etc. is instrumental to the overall success and development of computational astrophysics. I would also like to mention the excellent level of the facilities provided by the IPAM."

Benjamin Zuckerman (UCLA):

"In Matthew Bate's first talk in the current IPAM series he mentioned a paper by Low and Lynden-Bell where they show that the minimum mass fragment expected in a star-forming molecular cloud undergoing Jeans mass type fragmentation is about 7 times the mass of Jupiter. L & L-B argue that this result is quite robust and insensitive to reasonable changes in the relevant physical and chemical parameters. Matt mentioned this result in conjunction with the theoretical problems he is investigating.

However, for me, the interesting aspect was an observational one. In our imaging searches for extrasolar planets we are sensitive to detection of planets down to a few Jupiter masses. Thus, we can check whether or notthe Jeans fragmentation picture is consistent with the observations of actual low-mass objects. The question of how planets and brown dwarfs form is of great interest to a lot of astronomers.

As a result of hearing Matt's talk and then checking out the L & L-B paper, I wrote some paragraphs about this Jeans fragmentation picture for our paper on planet 2M1207b now in press at Astronomy & Astrophysics… I intend for future papers to go into more depth on these issues. In any event, my learning of the L & L-B result has enabled us to sharpen up our focus on how our observational results relate to theories of planet formation."

Juergen Steinacker (Max Planck Institute for Astronomy):

"The visit to the conferences organized at IPAM have been very constructive to gain a broad overview over the computational challenges in numerical astrophysics. It enabled me to focus and redirect my research in order to meet the current difficulties in the numerical modeling. Important ideas about new projects and papers arose from the communications during the conferences. The perfect environment established by IPAM during the conference helped very much in making the visit a success.

I consider an invitation for a stay at IPAM to be a very positive item in my CV, and expect evaluators to share this view. I would suggest to any researcher who has a chance to come to IPAM events to apply in order to improve his research and his career."

Sverre Aarseth (Cambridge University):
"A project carried out by myself has turned out to be extremely interesting and fruitful. The new code which was developed is currently being used for some large calculations.

During my stay I gave some informal lectures on numerical techniques. Personally I benefited greatly from the two month period. In particular, the working environment was ideal. Finally, I would like to say that the IPAM N-body workshop gave me the idea to organize my own event. Thus the Cambridge N-body School will take place during 30 July - 11 August this year. We have 10 speakers and at least 20 participants, the latter supported by a grant from the Royal Astronomical Society. I refer to our website http://www.cambody.org for further details."

Walter Dehnen, University of Leicester:
"It was a very fruitful meeting, because it enabled us to think and talk about technical issues, which are important but usually, i.e. in science driven meetings, do not receive the necessary attention. Meeting (and talking to) some of the people I've never met before (e.g. Monaghan, Springel) was a very valuable and important experience. I am very much interested in some of the technical issues and going to do some research (in collaboration with Leimkuhler & Stadel) on N-body integration methods."

Long Program Workshop: Relativistic Astrophysics, May 2-6, 2005
Organizing Committee: Richard Matzner, Chair (University of Texas at Austin)
Curt Cutler (University of Potsdam)
Michael Holst (University of California at San Diego)
Richard Klein (University of California at Berkeley/Lawrence Livermore National Laboratory)
Joseph Monaghan (Monash University, Australia)
Ewald Mueller (Max Planck Institute for Astrophysics)
Tsvi Piran (Hebrew University)
Stuart Shapiro (University of Illinois at Urbana-Champaign)

Richard Matzner, University of Texas: "The workshop had several major scientific areas of focus: modeling of binary astrophysical systems in General Relativity as sources of gravitational radiation; supernova explosion modeling, especially core collapse (type II) supernovae, which presumably result in black hole remnants; presentations on MHD; on black holes in higher dimensions; the computational science aspects of astrophysical computation, including mesh refinement and discretization schemes; and formal treatments, analytical formulations of the problem, and the relation to implementation methods.

Presenters included a range of experts in various aspects of these problems, and a special session also allowed some of the junior participants to present their work. The program worked out extremely well in practice, and its breadth of topics seemed to be of interest to and to be perfectly adapted to the skills of the participants.

Generally, the impression is that this was an extremely worthwhile workshop. The talks were very uniformly of extremely high quality, the participation in discussions and questioning, was very close, and the responses on the quality of the workshop from the participants were very positive.

Because the topics included questions of formulation and of implementation, there was substantial "cross fertilization" in the discussion sessions. I believe new collaborations will arise from these discussions. I do know that a number of ongoing collaborations were pursued by participants at the workshop.

The organization and the execution of the workshop went extremely smoothly. The advice of the organizing committee quickly led to a full schedule of speakers. The IPAM staff was very efficient in handling the registration and on the travel arrangements. The facilities were perfect, and the large common area supported multiple multi-personal interactions. (The fact that there were a number of ongoing participants for the ongoing IPAM program, rather than just participants in this workshop made these interactions even more interesting and far-ranging.) Accommodation at the recommended hotel was very adequate, and IPAM is located in a pleasant (and interesting) section of the UCLA campus.

The workshop format was timely because the astrophysical topics (compact binary interactions in General Relativity, core collapse supernova explosions) have been slowly developing for a number of years. Presentations at this workshop highlighted the fact that new progress is accelerating, so there is optimism that these problems will be brought closer to completion in a reasonably short amount of time. Both the new results, and the development of new implementation techniques, were seen to have a broad applicability across computational astrophysics."

Long Program Workshop: Transfer Phenomena, May 16-20, 2005

Organizing Committee: Rolf-Peter Kudritzki, Chair (University of Hawaii)
Adam Burrows (University of Arizona)
Jim Morel (Los Alamos National Laboratory)
Mark Morris (UCLA)
Chi-Wang Shu (Brown University)
William Watson (University of Illinois at Urbana-Champaign)
Harold Yorke (California Institute of Technology)

Transport of radiation and particles is an essential element of the description of almost any astrophysical phenomenon. While radiative transport is a mature area of inquiry, new astrophysical paradigms are giving rise to new approaches and methodologies that challenge even the most modern computational capabilities. Among the topics that were discussed were the relativistic Boltzmann equation, photon-matter interactions, line transfer in moving media, polarized radiation, masers, continuum radiation transport ,neutrino and neutron transport and cosmic rays.

This meeting provided an opportunity for an exchange of ideas between academic researchers and researchers at national laboratories and research centers (Lawrence Berkeley, Oak Ridge, Los Alamos, Lawrence Livermore and the National Center for Atmospheric Research.)

Adalbert Pauldrach, University of Munich:

"This has been an excellent meeting! The discussions with the world wide leading persons in the field of radiative transfer problems influenced my research direction severely."

William Watson, University of Illinois Urbana-Champaign:
"My horizons were broadened by hearing and interacting with researchers using unfamiliar methods of radiative transfer and using methods similar to my own, but in different areas of astrophysics."

Long Program Culminating Workshop at Lake Arrowhead, June 5-10, 2005
Organizer: Mark Morris (UCLA)

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.

Maria Babiuc, University of Pittsburgh:
"I developed strategies for obtaining physically realistic boundary data by means of well-posed version of the initial-boundary value problem for gravitational theory in harmonic coordinates. I have made important steps toward the new computational method, based upon a combination of Cauchy and light cone evolution, called Cauchy-characteristic matching (CCM) method by using a Cauchy code to provide boundary data for a characteristic code which propagates the solution to infinity and extract the waveform. I am exploring also various options for constructing a hyperbolic evolution algorithm, based upon the harmonic formulation."

Chi-Wang Shu, Brown University:
"We had started joint research with Professor Longlong Feng of China and Professor Li-Zhi Fang of University of Arizona on cosmology simulations, but the IPAM program facilitated the progress of this collaboration. This is a multi-disciplinary research aimed at adapting and using state of the art high order numerical methods for convection dominated problems to cosmology. It has been progressing well, with one paper published in Physical Review Letters (a leading journal in physics), one submitted for publication, and two under preparation."

Eric Ford, UC Berkeley:
"It was very useful to sit down with Ben Leimkuhler and discuss modern variants on symplectic and time-reversible integration algorithms for planetary systems. I have many notes from these discussions that I hope to draw upon in future work."

John Vernaleo, University of Maryland:
"Our decision to publicly release our modified version of the zeus-mp v1 code http://www.astro.umd.edu/~vernaleo/zeusmp.html was partly influenced by conversations while at the IPAM meeting."

Nelly Mouawad, University of Cologne:
"Of course it helped me a lot to work with numerical simulations. It helped to choose this direction in my research. At a long range, it would have influenced considerably my career."

Hui-Chen Chen, National Chinese University:
"The program is a very good opportunity to me, a PhD student, to know more about various simulation methods. People showed the methods results of their work, talked about the advantages and disadvantages. So we could think more before we start a project. So after this program, I know working only on nbody simulation might be not good enough. It is better to include hydrodynamic part. It is difficult. But that's what I will try to learn in the near future."

John Wise, Stanford University:

"The exposure to the many methods in computational astrophysics influenced me to approach research while considering these methods. The workshops enhanced my pursuit of learning more about early structure formation through computational work."

Richard Matzner, University of Texas:
"I have developed a broader range of computational methods including variational approaches, and finite element and finite volume approaches."

East Coast Women's Leadership Workshop, May 9-10, 2005
Organizing Committee: Barbara Grosz, Co-Chair (Harvard University), Telle Whitney, Co-Chair (Anita Borg Institute), Fran Allen (IBM), Fran Berman (San Diego Supercomputing Center), Jennifer Chayes (Microsoft Research), Robin Jeffries (Sun Microsystems), Maria Klawe (Princeton University), Jill Mesirov (Whitehead Institute)

This was a leadership event for women holding high-level positions in technology. Sponsored jointly with the Anita Borg Institute and the Radcliffe Institute, it was a follow-up to a similar workshop held at IPAM. This workshop was held at the Radcliffe Institute in Cambridge, MA, with a view toward attracting participants from the Eastern half of the country.

Reunion Conference: Symplectic Geometry and Physics, May 22-26, 2005
Organizing Committee: Denis Auroux (MIT), Conan Leung (University of Minnesota)

This reunion conference gave the long program participants a chance to reconnect and to begin new collaborations. A highlight was a report by Melissa Liu about her work with Kefeng Liu proving the Marino-Vafa Conjecture and work of Sergiy Koshkin on the Gopakumar-Vafa Conjecture.

Denis Auroux, MIT:
"I have an ongoing collaboration with Katzarkov and Orlov on homological mirror symmetry for various types of varieties. This has already led to 2 major papers and should lead to several more in the future."

Reunion Conference: Inverse Problems, June 5-10, 2005
Organizer: Heinz Engl (Johannes Kepler, Linz)

It was clear at this reunion conference that members of the group had made considerable progress in projects that they had begun at IPAM. There was a particular interesting and success in problems involving life sciences, such as elastography and ion channels.

Heinz Engl (Radon Institute, Linz):
"The most important effect for me was the move into inverse problems in life sciences, both with P.Schuster (inverse problems in systems biology) and with R.Eisenberg (identification and design of ion channels). Both involve also other participants in the IPAM special semester (P.Kügler, M.Burger); this will be the topic of a Special Semester at the Radon Institute in Linz in 2007."

CAARMS11 Conference for African American Researchers in the Mathematical Sciences, June 21-24, 2005
Organizing Committee: Mark Green (IPAM), William Massey (Princeton)

In the early 1990s, William Massey of Bell Laboratories (then AT&T, now Lucent Technologies) had an idea for an organization devoted mainly to addressing critical issues involving African-American researchers and graduate students in the mathematical sciences. It was envisioned that this organization would highlight current research by African-American researchers and graduate students in mathematics, strengthen the mathematical sciences by encouraging increased participation of African-Americans and members of other underrepresented groups, facilitate working relations among them, and provide assistance to them in cultivating their careers. This organization became known as the Conference for African-American Researchers in the Mathematical Sciences (CAARMS).

The program showcased the work of African-American mathematicians, with a focus, in keeping with the IPAM venue, on applications. William Massey gave a beautiful tutorial on the calculus of variations, and there were talks from academic researchers and also from Lawrence Livermore National Lab and the Molecular Sciences Institute. Graduate students and postdocs had an opportunity to present to the group, there was a poster session and a panel of seasoned experts (Idris Assani, William Massey and Scott Williams) offering career advice. Mark Green gave a presentation about opportunities at IPAM.

Isaac Woungang, Ryerson University:

"From many valuable presentations and discussions that I had with participants of the CAARMS11, I have learned novel ideas that were put into the form of a collaborative research partnership with colleagues at the department of computer science at Carleton University, Ottawa, Canada. A proposal I made focused on developing adaptive algorithms for traffic engineering problems in Wireless Ad-hoc networks based on learning automata. My involvement with IPAM has changed my vision on how to tackle real world problems using mathematical models and tools. I have learned a lot from various resources provided through IPAM and its members."

Charles Hagwood, NIST:
"I have had several inquires from African American graduate students about summer employment at NIST. This came from conversations with graduate students IPAM afforded me at last summer's CAARMS11…IPAM's workshop topic selections have provided guidance for future research paths to take."

Undergraduate Summer Program in Statistics 2005: June 19-24, 2005
Organizing committee: Mark Hansen (UCLA)
Doug Nychka (National Center for Atmospheric Research)
Deborah Nolan (UC Berkeley)
Duncan Temple Lang (UC Davis)

The broad theme was Visualization; the overall goal was to provide students with a better understanding of the role of statistics in scientific discovery, and thereby to raise the number of

strong students attracted into graduate study in Statistics. There were 5 sub-themes: statistical modeling of automobile traffic, genotyping and cluster analysis of single nucleotide polymorphisms, geo-location using 802.11 signal strength, prediction of extreme weather events, and computer vision. 25 undergraduates from around the US participated. Ten PhD statisticians from government, industry and academia led sessions and helped students with computational and visual analyses. Principal speakers were Christopher Genovese (Carnegie Mellon), David Madigan (Rutgers), and Jane-Ling Wang (UC Davis). A series of panels presented students with career opportunities for those with a graduate degree in statistics.

RIPS 2005 Research in Industrial Projects for Students, June 26-August 26, 2005

This program has been reported on in the section on undergraduate programs.

Graduate Summer School: Intelligent Extraction of Information from Graphs and High-Dimensional Data, July 11-29, 2005

Organizing Committee: Kevin Vixie, Chair (Los Alamos National Laboratory)
Edmond Chow (D.E. Shaw Research & Development)
Tina Eliassi-Rad (Lawrence Livermore National Laboratory)
Yann LeCun (New York University)
Carey Priebe (Johns Hopkins University)

In recent years, there has been a rapidly increasing demand for targeted analysis of large data streams and large networks. One of the main goals has been identification of key features: face recognition in video streams and voice recognition in audio streams are two examples. Another goal has been inference of relationships: pattern discovery in large databases and determination of key links in social networks. At the same time, a number of scientific disciplines have come together to develop a theory for the analysis of high-dimensional data, as well as for the analysis of dynamic processes on massive graphs. The new techniques and new mathematics coming out of this line of research are ideally suited to a wide range of applications.

Applications and connections to real challenges were drawn from: data fusion, automated feature extraction, face and shape recognition, spectral and hyperspectral image analysis, relational data mining, link analysis and discovery, graph mining, social and transactional networks, robust network design (making networks hard to break), optimal epidemic intervention (making networks easy to break), and hidden state inference (where are targets based on indirect measurements?).

The summer school was created for graduate students and postdocs, as well as more senior researchers interested in focusing their efforts on these mathematical challenges and crucial applications, especially in the area of national security. The program was organized as follows.

Week 1: High-dimensional data, relational data and kernel methods. The ubiquitous nature of high-dimensional data, combined with the difficulties presented by them, argues for the importance of finding models for their analysis. At the same time, large collections of relational data present the challenge of detecting and inferring factual information from sparse evidence.

This week highlighted research in dimensionality reduction, as well as methods of graph mining and relational data mining.

Week 2: Image analysis and machine learning. The importance of image data for the validation of scientific theories in the form of large-scale computations underscores the need for principled metrics on data in those image spaces. This week explored topics involving image detection as well as learning from image, voice and text data. Such problem are integral to building efficient algorithms for automatic detection of targets (such as faces), classification of patterns (face recognition) and prediction of important events (extreme event prediction).

Week 3: Streaming data and networks. There is a rapidly growing need for effective methods in addressing problems on large distributed networks. Problems associated with dynamics on and of networks are largely unexplored. This week provided a further focus on graph mining as well as on analysis of streaming data, and will involve such topics as network tomography, moving neighborhood networks, dynamic network analysis and social networks.

The summer school was funded by a $200K grant from NSF's Approaches to Combat Terrorism program, with an additional $200K in funding from Los Alamos National Lab. There were over 200 attendees.

Mauro Maggioni ,Yale University:
"It has greatly broadened my research interests, in several directions, both at the level of discovering unexpected links with other fields and at the level of starting research in different branches of applied mathematics. In particular it has pushed me to work on areas such as imaging, certain problems at the interface between mathematics and computer science (e.g. nearest neighbor algorithms) and machine learning and statistics."

Jared Tanner, UC Davis:
"My research direction has changed dramatically, from more traditional computational harmonic analysis to data processing from the perspective of high dimensional geometry. Specifically my recent research program has involved sparse approximation, in collaboration with David L. Donoho."

Aaron Luttman, University of Montana:
"My involvement at IPAM last summer directly affected my doctoral research. I was aware of level set methods for video segmentation, but after participating in IPAM, meeting, and talking with the people who developed the methods, I was able to find a method that worked very well for the problem I was addressing. One of the primary aspects of my dissertation is a segmentation algorithm based on that to which I was introduced at IPAM."

Shakti Davis, University of Wisconsin:
"My research group in signal processing has formed a collaboration with Grace Wabha at UW-Madison as a result of the IPAM Graduate Summer School program. The IPAM Graduate Summer School introduced me to a number of applied mathematic topics that I hadn't heard of before. One talk in particular inspired me to learn more about tensor analysis and I am excited to try applying it in new applications."

William Allard, Duke University:
"The workshop I attended was as stimulating and informative as any I have been to."

Daniel Bilar, Colby College:
"The new tools and methods I gained made me branch out into complex system and multi-dimensional analysis aspects as they affect information and network security issues."

James Abello, Rutgers University:
"Two papers were crystallized during my stay at IPAM. It gave me exposure to a variety of current research topics on a short period of time. It has been a good entry point to the literature on areas outside my main expertise domain."

Kevin Vixie, LANL:
"The latest thing is that we are now funded by NGA to do research for them as a direct result of my involvement with (and short course I taught at) the 2005 Graduate Summer School."

Long Program: Bridging Time and Length Scales in Materials Science and Bio-Physics, September 12-December 16, 2005

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)
Annabella Selloni (Princeton University)

Physical, chemical, and biological processes for many problems in computational physics, biology, and materials sciences span length and time scales of many orders of magnitude. For example, on the microscopic level, the typical bond distance between atoms is of the order of Ångstroms (the lattice constant), and atoms vibrate with a frequency of approx. 10^{13} 1/s. On the other hand, phenomena and applications of practical interest occur on a timescale of seconds, with system sizes that can be micrometer or larger. A grand challenge in computational physics, biology, and materials sciences is to link these vastly different time and length scales.

Traditionally, scientists and research groups have typically focused on methods that are particularly applicable in only a small regime. For example, due to the increase in computational power together with the advance of novel physical methodology and computer algorithms, there is a very active and rapidly growing community for electronic-structure calculations. These quantum-mechanical calculations are particularly well suited to describe the energetics and dynamics of few (maybe up to 1000) atoms. At the other end of the spectrum, applied mathematics has made large progress in numerical solutions to partial differential equations that are typically used to describe much larger (continuum) scales. By construction these methods do not resolve individual atoms any longer.

This program brought together scientists and mathematicians with expertise in modeling, analysis and computation that is valid on all different time and length scales, from the atomistic to the continuum. A main goal was to facilitate modeling that combines these different modeling techniques. Assembled as participants were scientists from seemingly different areas such as physics, chemistry, materials sciences, mathematics, and biology.

In addition to the workshops that were planed in advance of the program, we had a number of additional activities that took part during the program, and that were organized on a more spontaneous, short-term basis. Among them were:

- **Weekly seminar series in materials science, biophysics, and applied math**. These seminar series took place during the weeks without a major workshop. They were mainly intended for the more junior people who participated in the program, and the long-term participants who did not speak at any of the main workshops. We also had a number of guest speakers. We believe that almost all of the participants had a chance to present their work in these seminars. Also, we were able to involve a number of people from local institutions (Caltech, UCLA, USC) to participate in the seminar program, in particular in the biophysics series. We are also happy and proud that the organization of these seminars was mainly done by some of the junior participants. In particular, we would like to mention Payel Das and Silvina Matysiak (biophysics), Robin Hayes (material sciences), and Dionisios Margetis (applied math).
- **A mini-workshop on empirical potential**: During the first 2 workshops on biophysics and materials science, we identified the development of reliable potentials (for realistic atomistic simulations) to be a major challenge in this field. In particular, potentials that properly describe hydrogen bonds are extremely important for biological systems. These potentials still need a lot of work, and even DFT is not as reliable for this as one would hope. For materials science applications, good potentials exist for most metal systems, but not so much for system with covalent bonds. We were fortunate that David Pettifor was one of the long-term core participants of the program. David Pettifor is one of the leading scientists in the development of new, more reliable bond-order potentials. He volunteered to organize a 1 ½ day mini-workshop on potentials, that consisted of tutorials, and a small number of talks about recent progress in the field. We invited a few outside speakers for this workshop, with some participation from the group of Bill Goddard (Caltech), and from the group of Charlie Brooks (UCSD). This mini workshop was very successful, as we were able to identify the current bottlenecks in the field, and new directions how to proceed in the development of empirical potentials.

It is never easy to measure the success of a program, especially immediately after the program has ended. Nevertheless, we believe that there are a number of indications that suggest that this program was indeed a highly successful program, by a variety of different measures. We therefore list the major accomplishments here:

- Improved interactions between the different disciplines: This can not be measured by any numbers. Nevertheless, it was a general agreement during the concluding panel discussion at Lake Arrowhead that 10 years ago, it would have been impossible for this group of mathematicians, physicists, chemists, biologists, material scientists, and related disciplines, to sit together in one room, listen to each other, and even understand each others. We truly

believe and heard this from all participants that this workshop did help in reducing the barriers between the different disciplines.

- A number of new collaborations were started at IPAM, while others were continued and refreshed. Some of these new collaborations were highlighted in the "Hot Topic Session" at Lake Arrowhead. We list all them here:

    1. Collaboration between Otto Anatole von Lilienfeld-Toal and Denis Andrienko on "Coarse grained interaction potentials for polyaromatic hydrocarbons". This work has actually been accepted as a paper in the Journal of Chemical Physics (Jan. 2006).
    2. Collaboration between Dionisios Margetis, Russel Caflisch, and Axel Voigt on "Coarse graining of step edge kinetic models".
    3. Collaboration between Axel Voigt and Petr Plechac on "Coexisting fluid domains in biomembranes".
    4. Collaboration between Petr Plechac and Dimitri Vvedensky, which has actually lead to a joint proposal.
    5. Collaboration between the groups of Cecilia Clementi and Kurt Kremer, to apply new multiscale statistical physics approaches to the protein-folding problem, in particular to modeling water in a biological setting. Silvina Matysiak from Clementi's group has spent one month (April 2006) visiting Kremer's group at the Max-Plank Institute for Polymer Physics in Mainz (Germany) to work on this collaborative project.
    6. Collaboration between the groups of Cecilia Clementi and Yannis Kevrikides on the definition of collective coordinates for complex reactions, and the use of these coordinates to efficiently sample the dynamics of these processes. After Kevrikidis' visit to Rice University (January 2006), Payel Das from Clementi's group has visited Kevrikides' group in Princeton in March 2006 to continue to exchange ideas, methods and results within this project.
    7. Many discussions between Peter Kratzer, Christian Ratsch, Dimitri Vvedensky, and Peter Smereka on modeling (strain-driven) self organization of quantum dots. These discussions will almost certainly lead to new collaborations, and several joint publications.

- As a result of this program, many participants have been invited to give seminars at the institutions of other participants, with the goal to start and/or improve collaborations.

Long Program Tutorials, September 13-16, 2005
Organizers: Russel Caflisch (UCLA) and Christian Ratsch (UCLA)

During the first week of the program, we had a number of tutorials. The main focus of the tutorials was to introduce different modeling techniques to the core participants, and others, who came explicitly for the tutorials, or are working at or near UCLA. The tutorials were at a level that an interested graduate student could follow. A brief description of the 5 sets of tutorials is given here:

1. **Density-functional theory (DFT) by Richard Martin:** Richard Martin is a well-known physicist at the University of Illinois in Urbana-Champaign, and one of the pioneers of the some of the foundations of DFT. He has recently written a book on DFT, called: "Electronic Structure – Basic theory and practical applications". He gave a set of two lectures, each over 1 ½ hours, on two successive days. Most people felt that he did a very good job in explaining DFT, in describing the value of modern DFT, but also discussing the problems and limitations of DFT. The lectures were well received by the non-experts as well as the experts.
2. **Molecular Dynamics (MD) by Art Voter:** Art Voter is an expert in molecular dynamics techniques. He is a lab-fellow at the Los Alamos National Laboratory. In particular in the past decade, he has gained the reputation of being among the world leaders in accelerated MD techniques. He gave a set of 4 lectures, explaining basic MD, and then discussing the different accelerated MD (AMD) schemes, with all their advantages and limitations. These tutorials were particularly well received by the participants with an (applied) math background; several people spontaneously started writing small MD programs themselves, and a number of people expressed an interest in a more detailed MD hands-on workshop.
3. **Monte Carlo techniques by Kristen Fichthorn:** Kristen Fichthorn is a Merrell R. Fenske Chair Professor at Penn State University. She is known for her fundamental work in Monte Carlo methods, and more recently for her contributions to applying these methods to materials science. Her tutorial lectures were well received. In particular, the combination of basic theory, applications and examples, and a number of Matlab demos was very useful. These demos were made available on the IPAM webpages, so that the participants of the tutorials could download them, and try out more examples.
4. **Analytic methods by Bjorn Engquist:** Bjorn Engquist is one of the leading applied mathematicians of our time, and currently holds an appointment at the University of Texas in Austin. He gave an inspiring 2-day overview on analytical multiscale methods. In particular, he highlighted how all of the more physics-based methods (described above) can benefit from more rigorous, mathematical input and treatments.
5. **Numerical methods by Michael Holst:** Michael Holst is a professor at the University of San Diego. He gave a 2-day overview over recent development in numerical methods for multiscale applications. His presentation focused on theory and application of finite element methods with adaptive mesh refinement, guided by error analysis.

In addition to these method-oriented tutorials, we had a couple of subject-oriented tutorials. They were given by Russel Caflisch on "**hot topics for applied mathematicians**", and by Cecilia Clementi on "**hot topics in computational biophysics**". Both speakers are well known researchers in their respective areas. These talks helped in setting the stage for the workshops that followed later, and served to motivate and inspire the long-term participants.

Long Program Workshop: Multiscale Modeling in Soft Matter and Bio-Physics, September 26-30, 2005

Organizing Committee: Cecilia Clementi, Chair (Rice University)
Joel Ireta (Fritz-Haber-Institut der Max-Planck-Gesellschaft)

This workshop discussed current problems in computational bio-physics, in particular problems that can only be addressed within a multiscale approach. An important example is the

understanding and simulation of protein folding. MD or KMC simulations that include every atom give the most detailed information and are often used, but are limited to the picosecond scale. An important issue is the development of reliable effective potentials and force fields. Coarse-graining can be introduced by reducing the problem to fewer (larger) building blocks (such as peptide units), so that such simulations can be performed more efficiently and on larger time scale. Another approach is to employ continuum models, where the parameters are obtained from the microscopic approaches, and the time evolution of proteins can be tracked with state-of-the art methods for moving fronts and boundaries (such as the level set method). This is also relevant for problems like DNA stretching, where one needs to understand the extent to which continuum elasticity theory can be used to describe the mechanical response of nano-objects measured using e.g. atomic force microscopes. This workshop brought together researchers from different communities with expertise in different modeling techniques to understand how to address multiscale problems in computational bio-physics.

Alexander Grosberg, University of Minnesota:

"With Professor Y.Rabin, we wrote a proposal while he was here and it is now funded under US-Israeli Binational Science Foundation…Exciting talks are stimulating for the good work."

Mark Tuckerman, New York University:
"I have begun to explore new multiscale mathematical modeling approaches for elastic materials. With my postdoc, I have begun to develop the mathematical/theoretical underpinnings (multicomponent grand-canonical density functional theory) for compound design, which has sparked new collaborations with synthetic chemists at NYU working in the area of biomimetic design…I have submitted an NSF proposal with an applied mathematician, Keith Promislow at Michigan State on new multiscale mathematical models for modeling of proton-exchange membrane materials in fuel-cell applications. In addition, several possible collaborations have been leveraged via my postdoc Anatole von Lilienfeld. "

Paul Atzberger, Rennselaer Polytechnic Institute:
"I have found the IPAM Workshops of exceptional quality…IPAM offered a unique opportunity not only to learn about other mathematican's work, but also to gain perspective and contact with a diversity of scientists working in fields related to applied mathematics. This contact has had an important impact on shaping my perspective about the role applied mathematics may play in research areas of interest to the broad scientific community, especially in the biological sciences."

Otto von Lilienfeld, New York University:
"I can not judge yet in how far this will affect my career but am optimistic that the effect will be positive. My research directions have been diversified, new directions have been added, such as adsorption-processes and electronic molecular devices."

Jade Mackay, Victoria University of Wellington:
"The time I spent at IPAM influenced my career plan very strongly.
It influenced both the direction of my PhD research, and the research I plan to do once I graduate."

Long Program Workshop: Multiscale Modeling in Condensed Matter and Materials Science, October 17-20, 2005

Organizing Committee: Peter Kratzer (Fritz-Haber Institute, Germany)
Christian Ratsch (UCLA)
Dimitri Vvedensky (Imperial College, London, UK)

The first part of the workshop was a 4-day workshop on different applications in materials sciences that are pertinent to mutiscale modeling. For each subject, we had a number of speakers. In the next few paragraphs, we will summarize the topics that were covered, the speakers that participated, and will discuss some of the highlights of each session.

- **Fracture and Crack Propagation:** The speakers in this session were Sidney Yip, Priya Vashishta, Ashwin Ramasubramaniam (replacement for Michael Ortiz), and Efthimios (Tim) Kaxiras. Multiscale modeling of fracture and crack propagation is really one of the prime examples for multiscale modeling in materials sciences. The speakers invited have done some of the most relevant work in this area, and demonstrated that indeed, atomistic simulation (based on quantum mechanical methods such as density functional theory) can be combined with more coarse-grained methods, up to continuum methods that are based on partial differential equations (PDEs). Particularly impressive in this respect was the talk by Priya Vashishta.
- **Friction:** The speakers on this subject were Bo Person, and Uzi Landman. Bo Person gave a very insightful talk, discussing some basic aspects of friction. Uzi Landman gave a rather general talk about all the work that has been done in his group in the past years.
- **Thin Film Growth**: The speakers in this session were Anupam Madhukar, Peter Kratzer, Christian Ratsch, Peter Smereka, Chaouqi Misbah, and Dimitri Vvedensky. Modeling thin film growth is an area that has generated a lot of interest among the applied math community. It is of course of high technological interest, in particular in microelectronics and the semiconductor industry, and is a very active area in almost any physics or materials science department. One of the highlights in this session was the talk by Peter Kratzer. He presented a huge amount of DFT data that has been compined with KMC simulations, and continuum elasticity. Another highlight was the talk by Dimitri Vvedensky, who to described a renormalization –group approach to derive continuum equations, where all parameters in the equations can be directly related to microscopic parameters.
- **Elasticity:** The speakers for this subject were Peter Vorhees and Jerry Tersoff. They presented continuum approaches to better understand the formation of quantum dots. This session was very related to the thin film growth session the day before.
- **Transport:** The speakers in this session were Gerhard Klimmeck and Jean-Pierre Leburton. This session was a somewhat detached subject from the rest of the workshop. Nevertheless, it generated a lot of interest. In particular Klimmeck's opinions about grid-computing lead to a lot of discussion.
- **Catalysis:** The speakers were Karsten Reuter and Jim Evans. Catalysis is a technologically very important area, and both speakers covered approaches from DFT to continuum and reaction-type rate equations.

- **Nanostructures:** The speakers for this session were Jerry Bernholc, David Tomanek, Michael Biehl, and Robert Rudd. They are all well established scientists in their respective fields. This session covered the description of nanoparticles ("buckyballs"), nanowires, but also quantum dots.

At the end of the last day, we had a 1 ½ hour panel discussion, that was led by Dimitri Vvedensky. It was generally agreed upon that the workshop was of a very high quality. It covered all the methods and computational approaches that are currently considered important for multiscale modeling. The subjects were very representative for the important subjects in computational materials sciences. We identified the major open questions and challenges in the field as follows: modeling of catalysis; modeling of water; finding good potentials; finding transition states; optical and magnetic properties of materials.

Nathan Baker, Washington University

"This was an excellent conference and I made a number of very helpful contacts which may turn into full collaborations."

Mini-Workshop: Time Acceleration Methods in Atomistic Simulations, October 21-22, 2005

Organizing Committee: Peter Kratzer (Fritz-Haber Institute, Germany)
Christian Ratsch (UCLA)
Dimitri Vvedensky (Imperial College, London, UK)

This workshop was treated separate from the main workshop, as it was focusing more on new methods, rather than applications in materials sciences. Nevertheless, most of the methods described and discussed have (so far) mainly been applied to problems in materials sciences. This is the reason why we scheduled these 2 workshops back-to-back. It turned out to be a good idea, as most participants of the main workshop stayed for this mini-workshop, and many of the participants of the mini-workshop came early, to also participate in the main workshop. This workshop was organized by Kristen Fichthorn and Art Voter, who are both recognized leaders in the field of acceleration methods. They have also been main contributors to the overall IPAM program, as they were both tutorial speakers in the first week of the program.

The speakers in this mini-workshop were Graeme Henkelman, Peter Bolhuis, Normand Mousseau, Steve Stuart, Blas Uberuaga, Kristen Fichthorn, David Wales, Dionisios Vlachos, Jacques Amar, Francesco Montalenti, and Yannis Kevrekides. The topics covered were accelerated molecular dynamics (AMD), accelerated and parallel kinetic Monte Carlo (KMC), and methods to find transition states. AMD methods are very important for many applications that include rare events, as traditional AMD methods can not reach the time scales that are required. The most promising methods are hyperdynamics, parallel replica dynamics, and temperature accelerated dynamics. Advantages and limitations of these methods were discussed. We also heard a number of talks on different methods to sample transition path, and identify saddle points (and also stable points). There was tremendous interest in the different AMD and transition path methods, so that we scheduled spontaneously an additional panel discussion on Friday night, after the reception. This discussion was led by Graeme Henkelman, who nicely summarized all the talk of the day. We were all very impressed by the high interest level and

energy on a Friday night, after 5 days of talks. It was also impressive to see that even on the 6th day (Saturyday), the lecture hall was essentially full. It is fair to say that this 2-day mini-workshop was certainly one of the highlights of the entire program. To give you just one quote: Francesco Montalenti commented after the workshop that this was "the best workshop I have ever been to!".

Long Program Workshop: Density-Functional Theory Calculations for Modeling Materials and Bio-Molecular Properties and Functions—A Hands-On Computer Course, October 30-November 5, 2005

Organizing Committee: Peter Blaha (Technische Universität Wien)
Karsten Reuter (Fritz-Haber-Institut der Max-Planck-Gesellschaft)
Matthias Scheffler (Fritz-Haber-Institut der Max-Planck-Gesellschaft)
Karlheinz Schwarz (Technische Universität Wien)

This workshop was a new idea for an IPAM program: It involved morning lectures about the theoretical foundations of DFT, followed by afternoon practical sessions, where the participants where working on real problems that can be solved with DFT, with the help of a number of tutors. For this purpose, the IPAM computing staff set up a temporary computer lab in the IPAM building. Most of the tutors came from the Fritz-Haber-Institute (FHI) in Berlin, and we are very grateful for all the work that went into this workshop by many members of the FHI. We believe that this workshop was a big success. We recommend that such hands-on workshops should be seriously considered for future IPAM programs. This type of workshop really helps the participants to understand in more depths the numerical approaches that are currently used in the field discussed. The hands-on workshop helped beginners to get started, but it was also useful to people already familiar with DFT, who gained a deeper insight into the power and limitations of DFT calculations.
Topics covered were:

- APW and LAPW method
- the WIEN2k code
- Comparison of different methods and codes
- Algorithms for total-energy minimization and forces
- k-point summation and "electron temperature"
- Structure optimization, phase transitions, phonons
- Exchange-correlation functionals
- Charge densities, energy bands, density of states, and Fermi surfaces
- QM/MM calculations and applications to Biophysics
- Ab initio molecular dynamics, kinetic Monte Carlo, and thermodynamics
- core-level shifts
- Spin-orbit coupling, magnetism, strongly correlated electrons: charge-, spin- and orbital ordering
- Excited states: GW and TD-DFT calculations
- Exact exchange

Denis Andrienko, Max-Planck Institute:

"My previous background was in Soft Condensed Matter Theory and Simulation. The course on DFT which I attended during my stay at IPAM is extremely useful for a new project in material science which I have just started."

Yunkai Zhou, University of Minnesota:

"I have done some nice work, collaborating with Profs. James Chelikowsky and Yousef Saad. The nonlinear Chebyshev-filtered-subspace-iteration (CheFSI) method that we developed significantly speeds up the self-consistent-field calculations in DFT."

Long Program Workshop: Multiscale Analysis and Computation, November 14-16, 2005
Organizing Committee: Russel Caflisch, Chair (UCLA)
Weinan E (Princeton University)
Felix Otto (Rheinische Friedrich-Wilhelms-Universität Bonn)

This workshop was focused on mathematical methods for systems that involve multiple length/time scales and multiple physics. The complexity of structure and phenomena of these systems gives added importance to mathematical results. In addition, mathematics provides an additional approach towards devising computational strategies for handling multiple scales and multiple physics. Examples include continuum limit of atomistic models, hydrodynamic limit of interacting particle systems, heterogeneous multiscale methods, adaptive model refinement, and many other methods. This workshop brought together researchers from PDEs, analysis, mathematical physics, numerical analysis, and scientific computing to address the difficult challenges that are presented by these issues.

This 3-day workshop on math and analysis was followed immediately by a 2-day satellite workshop at Caltech. This workshop complemented the workshops on biophysics and materials sciences, to emphasize geophysical applications and the more rigorous mathematical aspects of the modeling techniques discussed in this program. The feedback and comments for this workshop were very positive, and we believe that it was very successful.

Satellite Workshop at Caltech: Multiscale Modeling and Computation—Basic Theory and the Geosciences, November 17-18, 2005
Organizing Committee: Tom Hou (Caltech)
Jerrold Marsden (Caltech)
Tapio Schneider (Caltech)
Nadia Lapusta (Harvard University)

This CIMMS/IPAM affiliates workshop had two general themes:

- General mathematical techniques for multiscale modeling and simulation
- Applications in the geosciences.

Dynamical processes in the geosciences span scales from the fractions of a second within which ruptures in the solid earth occur to the geological time scales of plate tectonics, and from the micron scales on which ice crystals form to the planetary scales of the global circulation of the

atmosphere. Because of the often tight coupling of processes across scales, simulating and understanding multiscale processes in the geosciences poses great challenges.

In addition to general presentations on multiscale methods, this workshop brought together experts in geophysics, atmosphere dynamics, and applied mathematics with the aim of fostering exchange among geoscientists and those working on methods of multiscale analysis and simulation.

Long Program Culminating Workshop at Lake Arrowhead, December 11-16, 2005
Organizers: Russel Caflisch (UCLA) and Christian Ratsch (UCLA)

The last activity of the program was the culminating workshop at the Lake Arrowhead conference center. The participants of this workshop were all the core participants (who did not have to leave early), and a number of outside speakers, who came specifically for this workshop. We also included the participants of the second reunion of the nano-program, and in fact had a joint program. The main focus of the culminating workshop were the following:

1. More discussion of the areas that have been identified in workshops 1 and 2 as important areas for the future. David Pettifor and his postdoc Ralf Drautz gave talks and a summary about the mini-workshops on potentials, and lead a discussion in this area. Blas Uberuaga from Los Alamos gave a long talk about accelerated MD methods and methods to find transition path. This latter talk was a continuation of the spontaneous panel discussion during workshop 2, and lead to more discussions and new ideas at the Lake Arrowhead workshop.
2. We had several talks by Dimitri Vvedensky, Bjorn Engquist, and Yannis Kevrikides about future trends in this field. These talks were setting the basis for some discussion, in particular the concluding panel discussion that took place on Thursday evening.
3. We had several "Hot Topic" sessions. These sessions consisted of talks that described research and in particular collaborations that started at IPAM, during the program. They will be listed below.
4. On the last evening, we had a concluding panel discussion. During this discussion, we summarized again some of the successes of the entire program (and also the things we did not like so much), listed the accomplishments in the field, and discussed the future of this field. We think that the discussion was quite lively, with lots of input from the junior participants.

Payel Das, Rice University:

"The multidisciplinary environment at IPAM helped me to have a broader viewpoint to address any research problem. It was a very nice opportunity to know scientific languages of people from diverse background. The very friendly atmosphere was also a plus point."

David Pettifor, Oxford University:

"The derivation of an analytic bond-order potential for transition metals whilst at IPAM last Fall suggests for the first time the possibility of developing an interatomic potential that can handle mixed covalent-metallic systems such as the transition metal carbides and nitrides."

Veronika Brazdova, Humboldt University, Berlin:

"My stay at IPAM has strengthened my decision to change my field of research, from DFT modeling of solid state oxides to QM(DFT)/MM modeling of biological systems. I learned a lot about the subject at IPAM and I rediscovered my interest in method development."

Dmitri Vvedensky, Imperial College:

"[I learned] how such a center should be run. Imperial College has recently set up a Mathematics Institute and my experiences at IPAM will be relayed to the Management Committee."

Christoph Haselwandter, Imperial College:

"Through my involvement with IPAM I was able to significantly broaden my view of problems encountered in my area of specialization, in particular with respect to mathematical and computational aspects. But maybe most importantly the diversity of the lectures and workshops at IPAM has provided me with enough general background knowledge to confidently tackle research problems in different fields of study."

Anton Arkhipov, University of Illinois at Urbana-Champaign:

"I am a graduate student in the Professor Klaus Schulten's group, and we are currently working on the coarse-grained models for simulations of macromolecular complexes. In the Fall 2005 I came to IPAM to participate in the workshop on multiscale simulations in biophysics. At the workshop, I learned about a number of coarse-graining techniques, and it is of course helped me greatly in my own work and gave an impulse for my deeper interest in this field."

Badrinarayan Athreya, University of Illinois at Urbana-Champaign:

"Gave me a strong push towards pursuing a career in academia. Exposed me to various cutting edge approaches to multiscale modeling of materials, and critical problems facing them. It was a wonderful opportunity to mix with and talk to some of the leading experts in the business."

Francesco Montalenti, University of Milan:

"The key advantage I had was to directly know some experts in my field that I had met only at large conferences where there was no real time to discuss. Also, during the IPAM workshop I have learned how important is the role of Si intermixing in the study of Ge quantum dots grown on Si(001), so that one of the new directions of my research is now to investigate this issue."

Olof Runborg, KTH:

"The program will certainly affect my future research direction. I have been planning to move into the area of bio and materials science related multiscale problems for some time and the

program gave me an excellent introduction to both the problems and the people in the area. I believe mathematicians have much to contribute there, but for a mathematically oriented person it is quite a big threshold to overcome before one can, with some confidence, work in the field. In terms of addressing that problem, a program like this is a real boost."

Reunion Conference: Proteomics, December 11-16, 2005
Organizing Committee: Dorothy Buck (Imperial College), Tim Chen (USC), Lars Jensen (EMBL), Roland Krause (Max Planck Institute for Infection Biology), David Wild (Keck Graduate Institute)

Some highlights were reports by David Wild on his work on algorithms for high-throughput protein interaction detection, Fengzhu Sun on techniques for integrating biological databases, Ifeanyi Ogueli on a proteomics approach to understanding snake venom, Dorothy Buck on modeling small scale networks, and Debo Dutta on scalable partitioning of chemical and proteomics spaces. A number of junior participants in the program were offered excellent positions as a result of their participation—Parag \Mallick at Cedars-Sinai Medical Center and Debo Dutta at USC.

Reunion Conference: Mathematics in Nanoscale Science and Engineering, December 11-16, 2005
Organizer: Russel Caflisch (UCLA)

Because of a confluence of interests, this group held its talks jointly with the Materials program.

Workshop: Sequence Analysis Toward System Biology, January 9-13, 2006
Organizing Committee: Jun Liu (Harvard University)
Chiara Sabatti (UCLA)

In the last decade, as the scale of available genome and protein sequence data increased dramatically, a number of mathematical and statistical models and algorithms have been developed to address some of the questions presented by the analysis of these biological sequences. For example, we now have available a much larger bag of tools for the identification of genes, exon boundaries, regulatory elements in DNA sequences and domains in amino acid sequences.

The present availability of complete genome sequences for a considerable number of species, together with measures of expression and a growing collection of protein structures open further challenges and opportunities. For example, evolution and speciation can be studied using entire genome sequences, rather than few genes. The extent of functional variation within the same specie can start to be explored in a more systematic fashion. Cross-genome comparisons appear to be an important tool in unraveling the more subtle aspects of gene regulation and splicing. Given the growing amount of information on protein abundance, it is possible to explore post transcriptional mechanism of gene regulation. The coordinated efforts invested in the gathering of protein structures may enable a successful investigation of the connection between sequence and structure.

When consideration is given to all these possibilities, it appears that the larger and more comprehensive datasets now available and the knowledge we have acquired so far begin to enable us to bridge the gap between the static nature of sequence information and the dynamic of biological systems. Coded in DNA is the information behind thousands of biological pathways, only a small fraction of which are actually activated in a cell at any given time. Gene identification is perhaps the first step in decoding DNA, but it provides us with only a very abstract picture of all the proteins that a cell could possibly synthesize. The identification of regulatory proteins binding sites start providing us with information on possible network connections between genes, but only a fraction of such connections are actually active and meaningful in any specific condition. DNA contains further, more subtle information that determine the cell dynamic behavior and that we can begin to explore. For example, there are elements in DNA sequence that determine alternative splicing, control the decay of mRNA transcripts, the cooperation or competition of different regulatory proteins in controlling the expression of genes; the presence of alternate pathways can be detected on a sequence level using intraspecies comparison.

The 5-day workshop focused on the exploration of how sequence analysis can take advantage of the recently acquired datasets and contribute to a mechanistic understanding of the cell system. As outlined, to tackle the opportunities presented by the contemporary abundance of data, it will be necessary to combine expertise in sequence evolution, gene finding, motif recognition, alignment.

Elaine Angelino (Harvard University):
"As a graduating senior entering a PhD program in systems biology, the IPAM workshop "Sequence Analysis Toward Systems Biology" gave me an opportunity to listen to and meet many people interested in my field of interest. I found this experience very valuable; it was my first conference experience, and I am very grateful to have been given the opportunity and funding to have made my participation possible."

Nancy Wang (UC Berkeley):
"My involvement with IPAM has fortified my determination to pursue a career in the area of computational biology. Specifically, participation in the Sequence Analysis workshop encouraged me to conjecture research directions in this field."

Insuk Lee, University of Texas Austin:

"IPAM allowed me to extend my view of fields and make good connection to researchers with different background. It also provided me perspectives that I have been missed for my project, for example, data normalization, network topology, internet mapping, and so on."

Workshop: Document Space, January 23-27, 2006
Organizing Committee: Carey Priebe, Chair (Johns Hopkins University, Center for Imaging Science/Applied Mathematics and Statistics)
Damianos Karakos (Johns Hopkins University, Center for Language and Speech Processing)
Mauro Maggioni (Yale University, Mathematics/Program in Applied Mathematics)
David Marchette (Naval Surface Warfare Center)

Processing and management of the ever-increasing amount of spoken and written information appears to be a huge challenge for statisticians, computer scientists, engineers and linguists; the situation is further aggravated by the explosive growth of the web, the largest known electronic document collection.

There is a pressing need for high-accuracy Information Retrieval (IR) systems, Speech Recognition systems, and "smart" Natural Language Processing (NLP) systems. For tackling many problems in these fields, most approaches rely on:

- Well-established statistical techniques, sometimes borrowed from the analysis of numerical data,
- Ad-hoc, fast techniques that appear to work "well", but which lack a solid understanding of how the language is structured, and
- High-complexity algorithms from Computational Linguistics that exploit the syntactic structure of language but which do not scale well with the amount of information that needs to be processed in emerging applications.

This workshop on Document Space brought together researchers in Mathematics, Statistics, Electrical Engineering, Computer Science and Linguistics; the hope is that a unified theory describing "document space" can be created that will become the vehicle for the development of algorithms for tackling efficiently (both in accuracy and computational complexity) the challenges mentioned above.

Text documents are sequences of words, usually with high syntactic structure, where the number of distinct words per document ranges from a few hundreds to a few thousands. Much effort has been devoted to finding (e.g., through statistical means) useful low-dimensional representations of these inherently high-dimensional documents, that would facilitate NLP tasks such as document categorization, question answering, machine translation, unstructured information management, etc. Moreover, many of these tasks can be formulated as problems of clustering, outlier detection, and statistical modeling. Many important questions arise:

- What is the best way to perform dimensionality reduction? The fact that documents can have diverse features in terms of vocabulary, genre, style, etc., makes the mapping into a common space very challenging. Is there a single best metric for measuring similarity between documents? Documents can be similar in many ways (in terms of content, style, etc); how do different vector representations facilitate different similarity judgments?
- How can the semantics of each word be incorporated into the analysis and representation? For example, there are many cases where related documents share very few common words (e.g., due to synonymy). On the other hand, documents with high vocabulary overlap are not necessarily on the same topic.
- It has been argued that sub-corpus dependent feature extraction (that is, document feature computation that depends on collective features of a subset of the corpus) yields far better retrieval results than when the features depend only on each document independently. Hence, efficient representation of documents into a common space

becomes a "hard" problem: in principle, one would have to consider all possible subsets of a corpus in order to find the one that yields the best feature selection.

- There is a natural duality between the symbolic and stochastic approaches in NLP, which have been exploited in order to organize document corpora. Symbolic information can be used to define coordinates and/or similarities between documents, and conversely the stochastic approach can lead to the definition of symbolic information. As above, this correspondence is relative to different subsets, of both documents and symbols, and organizing and fully exploiting it, with efficient algorithms, is challenging.

This was a workshop that provoked spirited discussion among some of the leaders in the field. It provides a wonderful lead-in to IPAM's upcoming long program "Mathematics of Knowledge and Search Engines" in Fall 2007.

Michael Berry (University of Tennessee):
"Launched new collaborations and kept me abreast of new developments in document clustering and classification. It was a very positive experience for both myself and my PhD student (Kevin Heinrich)."

John Conroy, Institute for Defense Analyses:

"Both Document Space and the high graphs weeks were terrific weeks to see top talks in the area and to have in depth discussions which lead naturally to collaboration. Good show IPAM!"

Interestingly, a blog was posted anonymously at http://forums.searchenginewatch.com/showthread.php?t=9711 that gives a very detailed overview of the workshop with a summary of each talk.

Workshop: Heart Modeling—Image Acquisition, Segmentation, Modeling and Analysis, February 6-10, 2006
Organizing Committee: Dimitris Metaxas, Chair (Rutgers University)
Leon Axel (New York University)
James Duncan (Yale University)
Jerry Prince (Johns Hopkins University)

The leading cause of death in the Western World is heart disease and consequently study of normal and pathological heart behavior has become the topic of rigorous research. In particular the study of the shape and motion of the heart is important because many heart diseases are thought to be strongly correlated to the shape and motion of the heart. Important examples of such heart diseases include ischemia and right ventricle (RV) hypertrophy.

The heart is actually two separate pumps: a right heart that pumps the blood through the lungs and a left heart that pumps the blood through the peripheral organs. In turn, each of these "hearts" is a two-chamber pump composed of an atrium and a ventricle. Special mechanisms in the heart provide cardiac rhythm and transmit action potentials throughout the heart muscle to cause the heart's rhythmic relaxation and contraction, known as diastole and systole respectively.

The understanding of the heart mechanics is crucial in clinical research for diagnosis and patient study. The imaging techniques, such as Magnetic Resonance Imaging (MRI), Ultrasound, CT, X-ray provide noninvasive methods to study internal organs in vivo. Typically 2-D slices are combined to generate a 3-D volumetric model. Furthermore the images taken over time make 4-D (3-D + time) analysis possible. Accurate and expedient interpretation of this data is difficult to achieve. These modalities provide a tremendous amount of data and when presented as 2D images typically require an expert anatomist to interpret. Moreover, comprehensive understanding of diastole and systole is difficult because the heart moves some structures become invisible and then visible again as they move through the image planes acquired by the scanner. Image interpretation is further confounded by motion artifacts from the subject. The cost incurred in manual interpretation of the data by a cardiology/radiology specialist is prohibitive for routine data analysis; however an automated analysis system holds the promise of reducing interpretation costs. It also paves the way for objective, quantitative analysis rather than a subjective, qualitative analysis. In addition an automated analysis system may be used to give evidence of a correlation between particular diseases and the regional changes in the shape and motion of the heart.

This workshop covered the most recent efforts by several research groups towards improved data acquisition, data analysis, 3D shape and material modeling, hemodynamics and electrophysiology, including:

- Imaging Modalities such as MRI, MRI-tagging and Ultrasound that are currently being used clinically and in research labs for data acquisition and the properties of these data.
- Low level segmentation methods to extract the epicardium and the endocardium for both the Left and the Right Ventricles, as well as the papillary muscle and the valves.
- Heart anatomy and physiology, various diseases and 3D modeling methods
- Estimation of the 3D heart anatomy from various modalities
- 3D analysis of the shape and motion during the cardiac cycle
- Estimation in vivo and in vitro of the heart's material properties
- Relationship between the wall motion and disease
- Hemodynamics and related challenges (description of the existing efforts)
- Electrophysiology and its relationship to the heart's fibers and deformation

There were two unusual features of this workshop: It brought together two communities—those imaging the heart and those modeling its motion—groups which rarely meet and yet whose efforts can help each other enormously. Secondly, speakers included mathematicians, computer scientists, bioengineers and physicians, a range of perspectives that rarely get an opportunity to dialogue.

Jerry Prince (Johns Hopkins University):

"Methods presented by D. Metaxas have influenced our ideas significantly. Results of Van Wedeen have spurred new ideas in cardiac imaging…I have attended two IPAM workshops, and they have both been influential."

Carissa Fonseca, UCLA:

"I found the Heart Modeling Workshop extremely useful. Existing ideas and work pathways were strengthened by the presentations and discussions, and many new ideas and possibly connections were formed. If this particular workshop were to be repeated (e.g., annually) I would definitely attend again. Thank you."

Marius Linguraru, Harvard University:

"The IPAM Symposium on Heart Modeling organized in February 2005 was an excellent opportunity to interactively learn about the latest contributions and development on heart analysis at an international level. The list of participants was impressive and covered well-established scientists in heart-related research, whether medical, imaging or mechanics. My personal understanding and view on heart modeling was enriched and diversified and the symposium offered opulent sources of ideas for my present and future interest in heart imaging."

Workshop: Swarming by Nature and by Design, February 27-March 3, 2006
Organizing Committee: Andrea Bertozzi (UCLA, Mathematics)
Daniel Grunbaum (University of Washington, Oceanography)
P. S. Krishnaprasad (University of Maryland, Electrical and Computer Engineering)
Ira Schwartz (Naval Research Laboratory, Nonlinear Dynamical Systems)

The cohesive movement of a biological population is a commonly observed natural phenomenon. With the advent of platforms of unmanned vehicles, this occurrence is attracting renewed interest from the engineering community. The purpose of this workshop is to foster advances in the modeling and analysis of biological swarms and to explore design ideas for efficient algorithms to control groups of autonomous agents. This interdisciplinary program draws from ideas in biology (experimental and theoretical), mathematics (including PDEs, dynamical systems, and numerical analysis), physics (statistical mechanics and non-equilibrium thermodynamics), computer science (distributed AI), and engineering (control theory).

Biological perspectives on formation and dissolution of groups are motivated by the fact that nearly all organisms are aggregated relative to environmental variables and to other members of their own species. Swarms, schools, flocks and herds successfully perform tasks that individual members cannot. Aggregated populations fulfill different objectives from those met by dispersed populations. The relationships between individual behaviors and resulting group characteristics are of ecological and evolutionary importance.

Biological studies of collective motion are developing rapidly, spurred by technological improvements in the observation of behavioral interactions among individuals within groups, by advances in behavioral theory and computer simulations, and by insights such as those gathered from studies of how kinship within a group affects group characteristics. In biomechanics, among other fields, collaboration between biologists and engineers has advanced biological understanding and inspired engineering concepts. The topic of biological aggregation, particularly active social aggregation behaviors such as swarming and schooling, is now ripe for this kind of cross-disciplinary collaboration.

In many areas of science and engineering, it is important to quantify the location of coherent structures, whether large scale -- internal waves in the ocean -- or microscopic, such as space-time chaos in CO platinum reactions. In two dimensional problems, the structures may be viewed by remote sensing and imaging. However, in many cases, direct measurement may be the only way to locate coherent structures. Direct measurements require multiple coordinated mobile sensors. The problem of coordination of collective sensing naturally leads to new mathematical explorations of pattern-forming systems. Sensors could be put on mobile vehicles, and in the future, micro- or nano-particles might be used for exploration and control-- an idea that was once proposed by Richard Feynman. As machines get smaller, it is evident that new possibilities for direct sensing may be found in fluid control, materials science, and bio-engineering, among other fields. By forming systems which are not only coupled but interact with their environment we will encounter problems that require new mathematical tools to make reasonable predictions. Such tools will require areas as diverse as nonlinear analysis of PDE-ODE systems, stochastic nonlinear equations, communication theory, game theory and voting theory. The areas the conference covered represent just a few of the new ideas for swarming dynamics. They included areas such as:

- Controlling unmanned autonomous vehicles
- Building swarming targeting and acquisition systems
- Embedding swarming sensors in advection-reaction systems
- Swarming Levy distribution search processes
- Search algorithms and their implementation on platforms
- Pattern formation in biological swarms
- Control of biological swarms, such as locusts

The attendees of this 5-day workshop were junior and senior scientists from the varied fields mentioned above, who may not generally attend the same scientific conferences or publish in the same scientific journals. The diverse backgrounds of the attendees and a multi-format workshop structure will help forge new scientific relationships and collaborations. This program built on a two-day program jointly held October 3 - 4, 2003, between IPAM and the Department of Mathematics at UCLA. The format incorporated both long format talks as well as a special time set aside for a poster session featuring work done by students and new post-docs working in this area.

This event was sufficiently unusual that a team from *Nature* came out to interview the participants about the significance of Stephen Simpson's work on locusts.

Long Program: Cells and Materials—At the Interface between Mathematics, Biology and Engineering, March 13-June 16, 2006

Organizing Committee: Tom Chou (UCLA, Biomathematics)
Trachette Jackson (University of Michigan, Dept of Mathematics)
Mark Lewis (U. of Utah, Mathematics)
John Lowengrub (University of California, Irvine, Mathematics)
Sharon Lubkin (North Carolina State University, Department of Mathematics)
Stanley Osher (Institute for Pure and Applied Mathematics, Mathematics)
Bill Tawil (Baxter Biosciences, BioSurgery)
Ben Wu (UCLA, Material Sciences and Engr: Biomed Engr)

"The most exciting science in the 21st century is likely to evolve among, not within, traditional disciplines" (Sung et al. 2003, Science 301:1485). Bioengineering programs have transformed from training of engineers to work in hospitals in the 60's and 70's, to training of principal investigators about scientific problems in medicine and biology. This transition has paralleled unprecedented advances in the medical sciences, basic sciences, and engineering, and created unique educational and research opportunities. Driven initially by intellectual pursuit of solutions to medical problems, the field of bioengineering has emerged internationally as an established discipline which integrates engineering and analytical tools with principles in the medical and life sciences.

In February 2002, IPAM organized a Short Program focusing on one subfield of bioengineering: Cells & Materials: at the Tissue Engineering Interface. The meeting provided a unique venue and brought together mathematicians and biologist who would otherwise not have the opportunity to immerse themselves into new problems and solution techniques. The meeting was well-attended and the reviews were excellent. Most importantly, the meeting catalyzed formal collaborations between some of the attendants. Many participants inquired about the possibility of future programs. Based on the success of the Tissue Engineering short program, the organizing committee proposed a 3 month long program to explore other subfields in bioengineering of major interest to bioengineers and mathematicians.

The Cells and Materials program was aimed at providing an environment for researchers to explore new applications of mathematics in a variety the bioengineering fields. Our hope is that modern mathematical techniques and ideas can be brought to bear on fundamental problems in bioengineering and biomaterials research, much as it has impacted materials science and engineering. Specifically, the program created an opportunity for participants to learn about various sub-disciplines of bioengineering; gain perspective by engaging in extended discussions with mathematicians, physical scientists, physicians, life scientists, and engineers; and develop new collaborations.

Long Program Tutorials, March 14-17, 2006
Organizers: Ben Wu (UCLA) and Tom Chou (UCLA)

The tutorials for this program were successful in combining accessible talks on biology and physics, on the one hand, and a survey of the principal modern techniques in modeling on the other. On the mathematical side, John Lowengrub gave a series of talks on Continuum Methods, Elliot Landaw on Reaction Networks and Identifiability from an ODE perspective, and James Glazier on Cell Level Modeling for Developmental Biology. On the biological side, Toshikazu Hamasaki gave a series on Cell Structure and on Biological Membranes and Patricia Zuk-Deslippe on Receptor-Ligand Interactions and on Cell Differentiation. David Needham presented an engineering perspective on Lipid Bilayer Membranes and Philip Pincus a series on the Physics of Membranes. These tutorials are available at http://www.ipam.ucla.edu/schedule.aspx?pc=cmtut .

Long Program Workshop: Membrane Protein Science and Engineering, March 27-31, 2006
Organizing Committee: Tom Chou, Chair (UCLA)
Francisco Bezanilla (UCLA)

Ka Yee Lee (University of Chicago)
Jacob Schmidt (UCLA)

Membrane proteins are a huge and widely diverse family: with functions including valves, pumps, sorters, sensors, energy transducers, and more, it is not surprising that a large fraction of the human genome has been found to comprise membrane proteins. However, due to the difficulty in crystallizing these proteins, structures are only known for a fraction of them. This is the current rate-limiting step in the overall understanding of this protein family, since the structure/function relationship is responsible for the unique performance of each protein. Far from being a purely biological problem, there is a growing realization within the community that the transport properties of some proteins can be described from a device perspective, using mean field theories, the development of which may allow the determination of the positions of specific key atoms and charges through an inverse problem formalism by measurement of "device" transport characteristics of these proteins. Aside from structural determination, further work concerns the behavior of a subset of membrane proteins whose structures and transport properties can change with electrostatic potential. These so-called "voltage gated" proteins function through an as yet unknown mechanism, although they are fundamental to the function of the heart and brain. Due to the importance, ubiquity, and functions of membrane proteins, they are targets of high pharmaceutical interest, and their ability to govern transmembrane transport addressable electrically opens new engineering vistas as well. This program brought together experimental and theoretical experts in membrane protein structure and function highlighting the state-of-the-art in the science and integrated these perspectives with those of mathematical modelers. Some of the mathematics involved were stochastic processes, Monte-Carlo and Molecular Dynamics simulations, membrane elasticity theory, and inverse problems.

Long Program Workshop: Microfluidic Flows in Nature and Microfluidic Technologies, April 18-22, 2006

Organizing Committee: Andrea Bertozzi (UCLA, Mathematics)
Michael Brenner (Harvard University, Applied Mathematics and Applied Physics)
Vittorio Cristini (University of California, Irvine, Biomedical Engineering and Mathematics)
John Frangos (La Jolla Bioengineering)
Howard Winet (UCLA, Orthopedic Surgery)

Convective fluid transport is critical for most physiological processes. At the microscopic level it ranges from flow around a swimming Spirillum bacterium to active transport of molecules across membranes by pumps. Many life threatening diseases progress due to reduction in microfluidic flows. Diabetes affects transmural exchange in kidney nephrons and capillaries. Stroke and reperfusion injury interrupt capillary bloodflow. Edema results when fluid cannot escape a tissue, as occurs in compartment syndromes. In bone microfluidic transport - bone interstitial fluid flow (BIFF) - has been identified as the stimulus that is detected by osteocyte and osteoblast mechano-receptors and modulates their physiology. There is evidence that BIFF is generated by poroelastic deformation of the bone matrix and may be influenced by bone capillary blood pressure. Since the mechanical impulse modulating endothelial cells is fluid shear stress it is reasonable to propose that the same mechanism operates in bone cells. An alternative - possibly collateral - mechanism may be streaming potentials. Enhancement of BIFF may be the key to improving fracture healing and preventing osteoporosis. Appropriate BIFF assist devices may, accordingly, be worn during healing, prolonged periods of disuse (bed rest) and microgravity exposure. Microfluidic flows are also critical for maintenance of tissue engineered scaffolds. If

the implant is erodable, convection will hasten decomposition. If it carries cytokines/growth factors convection will hasten their dissemination. If it is a bioreactor, i.e. carries functioning cells, convection will supply the nutrients to keep its seeded cells alive until host vasculature can penetrate the scaffold. Mathematical modeling of such flows in and around individual cells is relatively straightforward. Observations generating data which can be used to determine model coefficients are plentiful. In the intact organism, these data are less available. Accurate measurements from within the intact organ usually involve probes which disturb the flow being measured. Mathematical modeling and computation extrapolated from data from less invasive approaches can help decide which measures are "real" and which "artifacts". Mathematical approaches presented involved: microfluidics, partial differential equations, flow through random media, finite elements, and homogenization. A mix of experimentalist and modelers made for a very lively meeting.

George Homsy, UC Santa Barbara:

"It's always nice to go to a small workshop with high quality talks and some of the best people in the world."

Long Program Workshop: Angiogenesis, NeoVascularization and Morphogenesis, May 8-12, 2006

Organizing Committee: Luisa Iruela-Arispe (UCLA)
Trachette Jackson (University of Michigan)
Howard Levine (Iowa State University)
John Lowengrub (University of California, Irvine)
Bill Tawil (Baxter BioSurgery)

The development and life-cycles of all living beings are characterized by striking changes in morphology ranging from cell-differentiation to organ development. Morphogenesis occurs in response to gradients of morphogens whose concentrations determine the pathway cells will take during development. Angiogenesis and neovascularization are a specific example of morphogenesis and describe the recruitment and proliferation of vascular endothelial cells from the existing vascular system in order to develop a new vascular network that provides blood and nutrients to specific tissues. Angiogenesis occurs during the natural course of wound healing and tissue regeneration as well as in fetal development. A pathological form of angiogenesis occurs during tumor growth and the resulting neovasculature is much more leaky than is normally the case. Thus, during tissue regeneration it is desirable to promote angiogenesis while during tumor growth angiogenesis should be suppressed. Angiogenesis involves through a number of biochemical and biophysical pathways that have been extensively studied experimentally although there is still much more work to be done. Mathematical modeling, analysis and numerical simulations of angiogenesis are the subject of current research efforts. In this program, we brought together experts to discuss the state-of-the-art of this field.

The overall structure of the workshop, modulo some adaptations to fit speakers' schedules, was:

Day 1: Foundations of Angiogenesis (Tutorials)
Day 2: Angiogenesis and Development
Day 3: Angiogenesis and Wound Healing

Day 4: Angiogenesis and Tumor Growth
Day 5: Analogies with Neuronal Development

Mathematical approaches involved included equations of reaction-diffusion-chemotaxis, stochastic processes, percolation, and numerical simulations. The mix of experimentalists and modelers was very good, and there was considerable interaction between the groups.

Long Program Workshop: Systems Biology and Molecular Modeling, May 22-26, 2006
Organizing Committee: James Glazier (Indiana University, Biocomplexity Institute)
Dan Kamei (UCLA, Bioengineering)
Douglas Lauffenburger (Massachusetts Institute of Technology, Biological Engineering)
Ben Wu (UCLA, Bioengineering and Weintraub Center for Reconstructive Biotechnology)

Systems biology involves the quantitative and simultaneous integration of different and multiple biological components and their relationships with one another. For example, the components may be proteins, while their relationships may be described by signal transduction pathways. Unlike systems biology, molecular modeling focuses on a single complex between biomolecules and computes the interactions that exist in the complex. Although the two fields appear dissimilar, they are both quantitative in nature and involve many components and relationships. In the case of molecular modeling, the components are the atoms and their partial charges, and their relationships are the different interactions between them. Therefore, it's no surprise that some molecular modeling methods are now being applied to systems biology. Moreover, there has been recent success in combining these two fields to rationally design effective therapeutics. In this program, we brought together experts in these two fields of computational biology to discuss their frontier research. Mathematical approaches presented involved differential equations, finite difference methods, Bayesian approaches, molecular dynamics, stochastic systems, clustering, nonlinear dynamics, Monte Carlo simulations, and simulated annealing.

Long Program Culminating Workshop at Lake Arrowhead, June 11-16, 2006
Organizer: Tom Chou (UCLA)

The work reported on ranged from a new multiscale model for biofilm development developed by Bruce Ayati and Isaac Klapper, a new technique for numerical simulation for tissue morphogenesis developed by Xiaohai Wan and Sharon Lubkin, work by Ka Yee Lee on modeling the collapse process in lung surfactant, work by Qing Nie on a new class of numerical algorithms for reaction-diffusion equations, and modeling signaling pathways in yeast and robustness of morphogen systems in Drosophila embryos.

Chohong Min, UC Santa Barbara:

"My research is focused on designing numerical methods for sciences and engineering problems. Through my participation to the conference of "Cells and Materials", I could broaden my view in applications especially in biology. I deeply thank IPAM for allowing me to have this wonderful chance."

Nikodem Poplawski, Indiana University:

"The atmosphere during the workshops was great, not only talks were interesting and useful for my research, but also the time between the talks when there was a big opportunity to discuss various topics. The organizing people (all you guys) were great, very nice and helpful. The food was good, and the idea of IPAM dinners and receptions where the participants could socialize after talks. And the time between workshops was wonderful, more time for research but also very relaxing atmosphere.

Overall, I am pleased and thankful that I was able to be a part of this program. I started some promising collaborations with few people there (such as Sandy Anderson) so I think IPAM should be acknowledged if we write some good papers."

David Needham, Duke University:
"Here's what I distilled and some new opportunities that it has already developed:

- *1. Temperature Sensitive Liposomes (TSL) for Infectious Disease*
- *2. Hydrophobic liquid and solid phase emulsions for hydrophobic drug targeting*
- *3. Protein Concentration Technology for Growth Factors for Limb Regeneration*
- *4. Polymer Slow Release Systems for Growth Factors for Limb Regeneration*

The new and exciting developments already happened this morning when I returned to IPAM, and include some additional collaborators that would bring much needed THEORY to these experimental and preclinical projects. Three of my colleagues at the IPAM workshops, Bruce Ayati, Isaac Klapper, and Howard Levine have already expressed interest in collaborating, and would add a very important and much needed theory and modeling component to the work in 1 and 3-4."

Reunion Conference: Inverse Problems, June 11-16, 2006
Organizer: Heinz Engl (Johannes Kepler University)

Several quite interesting collaborations that came out of the IPAM program were reported on. Notable were collaborations of Heinz Engl, Peter Schuster and Philipp Kuegler on reverse engineering in cellular networks, which has been funded by the Viennese Science and Technology Fund, Heinz Engl and Robert Eisenberg and Martin Burger on Ion Channels, which has resulted in a patent application, work by Joyce McLaughlin's group on inverse problems in Elastography, and a collaboration of Victor Isakov and Martin Burger on inverse problems in oil production.

Martin Burger, Johannes Kepler:
"The enormous impact of IPAM discussions is beyond what can be measured by publications. I got a full Professor position in Muenster, Germany. Participation in IPAM programs weighed positively for my qualification. I was selected as key lecturer at Winter School in Norway, 2005 due to recommendation by Kenneth Karlsen, whom I met at IPAM."

Joyce McLaughlin, Renesselaer Polytechnic Institute:
"During and after the second reunion conference for the 2003 Inverse Problems special semester participants, I have been reminded about the tremendous opportunity provided by the special semester and the subsequent conferences. Indeed I should include the June, 2003 Applied Inverse Problems (AIP) conference in all of this as it too contributed to

this vast opportunity both for myself and other senior researchers but particularly for early career participants whose careers obtained a significant boost from all these activities. This meeting, which attracted a large number of high quality participants, had multiple sessions, over 130 participants and was a huge success as the second AIP meeting in what is expected to continue as a biannual event for many years to come. Please accept my thanks in making one of the initial meetings in this series such a success.

The Fall 2003 semester enabled me to introduce the new medical imaging problem, tissue shear stiffness imaging, through tutorials and enabled the postdocs and graduate students working with me to advance their work but equally significantly to learn about new techniques and new application areas. This was so effectively enabled because of the interactive environment at IPAM and the emphasis on frontiers in mathematical sciences as it is applied to exciting new scientific problems. The Inverse Problems in Biology Workshop that I organized and was made possible by IPAM's support, also initiated a number of new projects that connect with our work.

What I observed during the Fall 2003 special semester continued during the culminating and reunion workshops where I saw a sharpening of ideas and creative surge in the work of the young participants as they gave well organized presentations, received feedback on their work, interacted with both senior and junior researchers about their current challenges, research plans, and picked up sparks of ideas from conversations and presentations of others. It's great fun for me to both participate and observe, as it is happening, but also to see the ideas bear fruit with results presented at subsequent reunions.

So let me give thanks to you and the IPAM staff for making the success in the Inverse Problems events possible. These activities have had an enormous impact on this very rapidly expanding field."

Reunion Conference: Multiscale Geometry and Analysis in High Dimensions, June 11-16, 2006
Organizer: Peter Jones (Yale University)

An extraordinary number of active collaborations came out of this program. Because David Donoho's discoveries that began the field of compressed sensing, which had just been done, were presented at the tutorials, and the work of Candes and Tao on sparse representations was done at IPAM during the MGA program, many of the participants used these ideas in an enormous variety of applications—in astrophysics, in a chemical camera, in medical imaging, in geosciences, in image processing and analysis. This work was cited when Candes was given the Waterman Award. A number of additional collaborations emerged using other tools for high dimensional data analysis, notably Coifman's diffusion geometry. It was also striking how well the junior participants are doing, both scientifically and on the job market: jobs at Yale, Caltech, Stanford, UC Davis were among those that junior participants have received in the 18 months since the MGA program was held.

Peter Jones, Yale:
"This was the greatest program I have attended in the past 28 years. I think the program was astonishingly successful in building new communities and connecting previously existing ones. A new viewpoint on high dimensional data is now emerging."

Jonathan Kaplan, Stanford:
"At the MGA reunion, a number of new projects were started."

Luminita Vese, UCLA:
"My students Triet Le and Linh Lieu have obtained postdoctoral job offers at Yale and UC Davis thanks to the MGA program."

RIPS 2006: Research in Industrial Projects for Students, June 25-August 25, 2006

Although only about half of this program falls within the 2005-2006 NSF funding cycle, we have chosen to report on the entire RIPS2006 program in this annual report. The Finance Support List and Participant List reflect all participants of the program and all individual financial transactions associated with RIPS2006.

This program has been reported on in the section on undergraduate programs.

Second Annual Undergraduate Summer Program in Statistics: June 17-24, 2006
Organizers: Mark Hansen (UCLA), Vijay Nair (University of Michigan), Deborah Nolan (UC Berkeley), Doug Nychka (NCAR), Duncan Temple Lang (UC Davis), Bin Yu (UC Berkeley)

This program was organized by the Department of Statistics at UCLA with funding from IPAM. The theme was visualization and its role in the practice of statistics. Visualization and statistical graphics are at the core of exploratory data analysis, and in turn shape how we think about a particular application, the models we entertain and the kinds of theory we propose. Over the course of our seven day program, we highlighted a number of statistical applications, and with each we considered novel approaches to visualization that help guide our insight about the underlying statistical questions. Through computer lab sessions that draw on each day's application, students received a basic introduction to statistical computing, providing them with the skills to perform simple data manipulations, conduct exploratory analyses and create informative visualizations.

The seven day workshop was designed so that students get a sense of how statisticians approach large, complex problems. Several different topics will be presented over the course of the week, including bioinformatics and neuroscience , text and document analysis, environmental statistics, and earth and space science.

Statisticians from UC Berkeley, UCLA, Stanford, UC Davis, Rutgers University, Carnegie Mellon University, Bell Laboratories, and AT&T Labs participated.

It is anticipated that the program will continue, but will be held at a different institution each summer.

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. A list of program consultants is available as an appendix, in order by program. Upcoming programs for which planning has begun are also included.

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

In the period covered by this report, IPAM has made major strides in its relationship with the government and with industry.

- IPAM's Associate Director, Allon Percus, was "on loan" to us from Los Alamos National Lab through June 30, 2006.
- IPAM's new chair of the Board of Trustees, Mac Hyman, and Trustee Steve Ashby, are both from national labs. Trustees Stuart Feldman and Cleve Moler come from IBM and MathWorks respectively.
- Sponsors of 2005 and 2006 RIPS projects from government are Jet Propulsion Laboratory, Los Alamos, Lawrence Livermore and NASA Goddard. Sponsors from industry are Arete Associates, Hewlett-Packard, Microsoft Research, Pixar Animation, Symantec, and TimeLogic.
- IPAM is in conversation with Amgen, Accelrys Software, CalTRANS, and RAND Corporation about sponsoring RIPS projects in 2007 or 2008.
- IPAM is collaborating with Microsoft Research Asia on RIPS-Beijing in 2007.
- The National Security Agency supported RIPS with a $100K grant. In Summer 2005, the NSA site visited RIPS and gave a recruitment talk to the RIPS participants.
- IPAM received a $200K grant for its summer school "Intelligent Extraction of Information from Graphs and High Dimensional Data" from NSF's Approaches to Combat Terrorism program. Input about the program was received from both the NSA and the National Geospatial-Intelligence Agency.
- The graduate summer school received additional funding of $200K from Los Alamos, a 100% match of the ACT money. Planning for the summer school involved organizers from both Lawrence Livermore and Los Alamos.
- IPAM continues to attract participants from industry for a variety of programs. Many of our RIPS sponsors have been recruited through their participation in IPAM workshops (for example, Microsoft Research).
- There were at least 81 industry and 127 government/military participants of IPAM programs over this reporting period.

Comments from Industry and Government Participants:

Kevin Vixie of Los Alamos National Labs:
"It has also been during this time of frequent IPAM interactions that I have developed the deepest components of my research program. For me -- and I have always taken fairly nonstandard paths -- I had to have enough experience to personally choose the area into which I wanted to immerse most deeply. This is quite different than having an advisor hand you an area into which you dutifully (and hopefully with enthusiasm) delve very deeply. But for me, the choice of area to dig most deeply has come only now, 5 years after my Ph.D. degree. My ability to go to IPAM, think deeply about things with people I invited there or were already there and see how these deep areas interacted with applications I cared about was extremely important for this process. The importance can not be overestimated. So, to sum it up -- the impact has been enormous!"

Chris Farmer of Schlumberger:
"Involvement with the international inverse problems community via IPAM has enabled me to meet many of the key people in the field who I would otherwise have not encountered so easily."

David Meier of Jet Propulsion Laboratory:
"IPAM has regenerated past collaborations, enhanced current interactions, and fostered new ones as well. In addition to the regional and national participation of U.S. scientists, the international participation is particularly useful. I attended over 10 major meetings in 2005. While many meetings brought together observers and theorists in a particular scientific field, no other meeting equaled IPAM's ability to draw together early all the major players in the field of numerical astrophysics, where the participants could concentrate on the sharing of techniques and experience."

Li Deng of Microsoft Research:
"Results of the work at IPAM [during RIPS] are to become a common resource expected to be widely used by the speech processing research community."

Matthew Coleman of Lawrence Livermore:
"The IPAM conference has helped solidify my approaches to understanding the both the technical and biological variation buried within my experiments. The lessons learned at the conference have carried through multiple publications and the ability to fund several grants."

Jeffrey Scargle of NASA:
"The two workshops I attended were right on target for my current research, and I learned a lot, including many ideas and computer methods that I am using on a day-to-day basis."

Mel Kronick, Agilent:
"It helped Agilent understand many of the issues involved in creating products for those interested in RNA splicing."

Nitesh Shah, Raytheon:
"[IPAM's Summer School] pulled me into the manifold extraction / intelligent dimensionality reduction world."

John Lavery, Army Research Office:

"The presentations in the GUMBY workshop in November 2004 were instrumental in identifying additional research opportunities, specifically, in clarifying the role of distributed information and control in a search operation by a set of unmanned aerial vehicles."

John Pask, Lawrence Livermore National Laboratory:
"Provided clear perspective on the variety of related efforts and techniques that are being applied to the ab initio electronic-structure problem, highlighted a number of outstanding problems, and reinforced the clear need for continued work in this area."

Ramesh Neelamani, ExxonMobil:
"Kept me abreast of the latest innovations in signal processing and imaging."

Ken Mighell, NOAO:
"By attending "Mathematical Challenges in Astronomical Imaging" (AI2004) in January 2004, I was inspired to apply information theory to determine the Cramer-Rao Lower Bounds for the performance of astronomical stellar photometry and astrometry; this theoretical work is described in Mighell, K. J. 2005, MNRAS, 361, 861-878. Personally, I have found that AI2004 was an important meeting at the right time when I was developing new innovative image-analysis algorithms for the Applied Information Systems Research (AISR) program for NASA's Science Mission Directorate (formerly known as the Office of Space Science); participating in AI2004 has led to many research contacts which have in turn resulted in invited talks at several technical workshops and conferences."

Tad Hogg, Hewlett Packard:
"Broadened contacts with people in other fields, particularly the UCLA math dept. and USC multiagent systems groups, for possible future collaborations in problems related to molecular electronics systems."

Shaun Hendy, Industrial Research Limited:
"I think I have made some substantial progress on several existing problems I was working on as a result of the IPAM program. It was a very positive experience."

Z.Q. John Lu, NIST:
"I participated an IPAM workshop in October 2004 on Multiscale Geometry and Analysis in High Dimensions. I think it was a very positive experience since it gave me confidence and encouragement to explore and to approach data analysis in new directions which are not available in standard statistical training. The kinds of applications in my work include analysis of mass spectral and chemical data, and metrology issues in gene expression experiments, all of which involve high-dimensional data analysis in one form or other. Recently, I have taken another new direction from a NIST ATP intramurally funded project involving NIST's effort in building a Geometry Measuring Machine (GEMM) for precise optical aspheric surface calibration. There are challenging mathematical and statistical issues which arise in curvature estimation and surface reconstruction. I think that again geometrical data analysis plays an important role in a crucial industry problem."

Carolyn Reynolds, Naval Research Lab:

"My stay at IPAM (as well as SAMSI) facilitated collaboration with Lenny Smith on drift calculations for forecast errors. This work is ongoing. My stay at IPAM also facilitated collaboration with Nancy Nichols (control theory expert), who visited NRL this past winter working with Liang Xu, Craig Bishop, and myself on data assimilation issues.
How your involvement with IPAM affected your career and research direction: It has not really affected my career and research direction at this point, although my attitude toward collaboration with applied mathematicians has become even more positive then it was before."

N. EXTERNAL SUPPORT

Source		**Amount**	
Non-NSF Carry Forward Funds on 7/1/05		***$***	***299,377.74***
Other Funding -			
NSF ACT Grant 9/1/04-8/31/05		$	199,735.00
NSA Grant 3/4/05-3/3/06		$	100,000.00
NSA Grant 4/8/06-4/7/07		$	100,000.00
ONR Grant 9/1/04-3/31/07		$	10,038.95
LANL - RIPS $25K, MGA $50K, GSS $200K		$	275,000.00
RIPS Sponsors			
	Microsoft 12/05	$	10,000.00
	Pixar 4/06	$	10,000.00
	Symantec 4/06	$	10,000.00
	HP 10/05	$	10,000.00
	HP	$	10,000.00
	LANL 5/05	$	10,000.00
	LLNL 6/05	$	20,000.00
	LLNL	$	10,000.00
Registration Fees-Programs		$	6,475.00
Dean of Physical Sciences Support			
	General Support	$	60,000.00
	IT Support .5 FTE	$	32,977.48
Vice Chancellor Support		$	60,000.00
Sub-total: Other Funding		***$***	***934,226.43***
Total Revenues		**$**	**1,233,604.17**

In addition, IPAM receives a very substantial amount of in-kind financial support from UCLA and other elsewhere. For example, 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. Los Alamos contributed $67K to support for IPAM's Associate Director. 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.

As included above, IPAM's Graduate Summer School (GSS) in Summer 2005 was supported by a $199.7K grant from NSF's ACT program, and this was matched by $200K in funding from Los Alamos National Laboratory.

O. COMMITTEE MEMBERSHIP

IPAM's committees include the Board of Trustees, Science Advisory Board, and Human Resources Committee. The members of each as of June 2006 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, Univ of Texas)
Ronald Graham (CSE, UCSD)
Mark Green (IPAM)
Peter W. Jones-Chair (Mathematics, Yale)
Douglas Lauffenburger (Biomedical and Chemical Engineering, MIT)
Stanley Osher (IPAM)
Allon Percus (LANL/IPAM)
Kenneth Ribet (Mathematics, Berkeley)
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
Russel Caflisch, Mathematics, UCLA
Stuart Feldman, Vice-President for Internet Technology, IBM
Mark Green, Director of Institute for Pure and Applied Mathematics
James (Mac) Hyman --Chair, Los Alamos National Laboratory
Linda Keen, Mathematics, Lehman College CUNY
Maria Klawe, Dean of Engineering, Princeton University
Jerrold Marsden (Chair), Control Theory and Dynamical Systems, California Institute of Technology
Cleve Moler, Chief Scientist, MathWorks Incorporated
Stanley Osher, Director of Special Projects of Institute for Pure and Applied Mathematics
Allon Percus, Associate Director of Institute for Pure and Applied Mathematics
Arlie Petters, Mathematics, Duke University
Leonard Rome, Associate Dean of Research, School of Medicine, UCLA
Linda Rothschild, Mathematics, UCSD
Harry Shum, Managing Director, Microsoft Research Asia
Joseph Silverman, Mathematics, Brown University and NTRU

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

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:

Matthew Coleman, Lawrence Livermore National Laboratory:
"I now work with several biostatisticians to include Dave Nelson for addressing different biological questions related to microarrays, biodosimetry and genetic susceptibility. How your involvement with IPAM affected your career and research direction: The IPAM conference has helped solidify my approaches to understanding the both the technical and biological variation buried within my experiments. The lessons learned at the conference have carried through multiple publications and the ability to fund several grants."

Peter Dayan, Gatsby University:
"The meeting I attended helped cement a nascent view in my mind as to work in statistical cognitive science and neuroscience. This has many implications which are perhaps a little hard to pin down precisely. The field as a whole benefits from people realizing that they are saying similar things in different languages -- a huge, if rather intangible, benefit from the meeting.

For instance, hearing Brian Stanckiewicz talk about his work on how humans learn to navigate in a novel maze is helping me think about how to design an fMRI experiment based on tasks like those pioneered by Tolman, to study aspects of reinforcement learning and reward/punishment-based planning in controlled settings. Our maze will be formally rather different from Brian's, but this was important work to hear about."

Jing Huang, UCLA:
"My involvement with IPAM has been a most rewarding experience for my professional development as well as my lab's efforts in combining experimental and computational approaches in our research. The programs on the IPAM calendar throughout the years, even those that have to be unattended due to the need for my current focus, are a constant source of our inspiration and fascination."

Arnold Goodman, UC Irvine:
"A Data Mining Woprkshop in 2003 introduced me to my two co-editors for a new John Wiley Journal on "Statistical Analysis and Data Mining. Two Proteomics Workshops in 2004 prepared me to develop a new systems model of the cell and to introduce uncertainty into its behavior."

George Oster, UC Berkeley:
"My long-time collaboration with John Neu (Mathematics Dept., UC Berkekeley) arose from my participation in IPAM, as well as several works with CHarles Peskin (Courant Institute) on protein motors. I am in a biology department, and IPAM has facilitated my work with mathematicians in ways that would not have come about otherwise."

Alex Lubotzky, Hebrew University:
"The conference I organized at IPAM was a wonderful introduction for a great year long research program at the Institute for Advance Study at Princeton in the academic year 2005/6. The conference brought together people who usually don't go to the same conferences: mathematicians for several areas and computer scientists and this with the year at the IAS created a community of scientists who can now relate to each other."

Jianhua Xing, UC Berkeley:
"IPAM provides excellent and unique opportunities to bring researchers with different background to discuss some important problems (for me mathematical modeling of biological systems). Participating IPAM workshops helps me to find and see problems from different angles. It also provides opportunities to meet potential collaborators (for example I met several mathematicians expressing common interests). Similar multi-disciplinary experiences are not easy to have at other conventional conferences. I am looking forward for more IPAM workshops."

Konstantin Oskolkov, USC:
"Greatly affected in the positive sense. I understood that things I am doing in Schroedinger type equations with the periodic initial data are interesting to my colleagues - leading experts in Harmonic Analysis, and it was very important to me as a researcher.

Recently, I also addressed to applications of the results of analytic number theory to the study of some effects in quantum optics (Talbot's phenomenon). This was also influenced by my involvement with IPAM."

Carlangelo Liverani, RomeII:
"I became aware of several issues in transport theory that are closely related to my researches in dynamical systems. In turn this has rised my interest in the physical application of some aspects of dynamical systems that I am pursuing right now (e.g. the problem of anomalous heat conductivity)."

Stuart Russell, UC Berkeley:
"The interactions re-emphasized my focus on first-order probabilistic languages and indicated several directions for further work, particularly in vision (based on discussions with Alan Yuille). For the latter topic I have hired a postdoc, Erik Sudderth, from MIT. Interactions with Tom Griffiths at the workshop (among other factors) were important in Berkeley's decision to hire him as a faculty member in Cognitive Science.

Discussions at the workshop and presentations by Griffiths and Tenenbaum led me to modify my own presentation to include material from work I had done 20 years ago on knowledge-guided

learning and formal logical models of relevance. This in turn led to a proposal to DARPA's Transfer Learning program that was funded for $10.6M."

Eduardo Socolovsky, Norfolk State Univsersity:
"The "Mathematical Challenges in Scientific Data Mining" in January 2002, congregated some of the best practitioners of the field and allowed me to get a feel for the state of the art. This was very useful and influential since this was a new topic for me."

Kevin Iga, Pepperdine University:
"It gives me fuel to do research while at a non-research school, and opportunities to broaden mathematically."

Richark Baraniuk, Rice University:
"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."

Ryan McClarren, University of Michigan:
"It has allowed me to understand, adopt, and utilize the methods and techniques of other disciplines of applied mathematics than my own. Also, it has allowed me to connecting with researchers whose work I may have never encountered."

Jichun Li, University of Nevada:
"IPAM is always a great place to learn some new research topics, which inspired me working on interesting problems."

Kunio Hidano, Mie University:
"I think I was lucky to participate in a workshop at IPAM.
The workshop I attended was really stimulating. Since then, with the speaker and his collaborators I have shared the enthusiasm about nonlinear wave equations in domains exterior to obstacles."

Christopher Jones, University of North Carolina:
"The most significant was the collaboration with Andrew Stuart of Warwick. He is an expert in dynamics and stochastic computation. Based on his lecture at IPAM, we are collaborating on the use of Langevin sampling in Lagrangian data assimilation. It is a very promising new approach. The Data SAssimilation meeting gave me the oportunity to reach out to mathematicians who might be interested in DA problems. It was extremely beneficial to realise the extent of interest and available techniques and approaches that have been developed in related areas but not yet applied in DA."

Jari Kaipio, University of Kuopio:
"The most important new contacts were with profs. Bob Eisenberg (Chicago) and Christopher Farmer (Oxford). The first regarding biological applications of inverse problems and the latter

with the statistical methodology of inverse problems in general. Moreover, Prof. Heinz Engl, who was one of the organizers, invited prof. Farmer and myself to Linz for a workshop under the theme of the IPAM meeting. This is planned sometime later this year. The IPAM meeting has been one of the most important channels for bringing the statistical inverse problem framework into the awareness of both experienced scientists and graduate students in the field."

Virgil Pierce, Ohio State University:
"It clarified many ideas I had about where partition functions from string theory come from, and what information they should contain. The G2-Manifold conference was a great combination of mathematics and physics. Many good speakers from both fields."

Sergey Prants, Pacific Oceanological Institute:
"Among the other things, I would like to stress that ideas to use geometric and topological approaches in describing advection of passive particles (contaminants, in particular) in the ocean and in studying atomic transport in optical lattices have been developed by me at that IPAM meeting."

Martin Peters, Springer-Verlag:
"Being in publishing, visiting IPAM is excellent for discussing potential new publication projects, be they books or new journals with scientists. How your involvement with IPAM affected your career and research direction: IPAM programs are excellent for learning about upcoming new fields, I believe IPAM excels in this. This is essential for preparing the future of our maths and computational science publishing program. I'll try to visit IPAM events twice a year as a rule; were it not so far away, I'd come more often."

Mario Ruggero, Northwestern University:
"For an experimentalist, it is always good to appreciate the viewpoint of mathematicians and modelers."

Joyce Macabea, Molecular Sciences Institute:
"My participation at IPAM allowed me to meet new mathematicians and engineers that were not in my specific field of interest which helped to broaden my research plans. Also one of the people I made contact with at IPAM helped me to get employment. So the IPAM conference was a succesful event for networking."

Uzi Vishne, Bar-Ilan University:
"My visit at the IPAM allowed me to expose other researchers to a project connecting representation theory with manifolds and complexes. Some time after the conference at IPAM I was invited to participate in a year-long program in the Institute for Advanced Study in Princeton, where I continued working on close problems."

Sungwhan Kim, Tokyo University:
"I met a researcher at Inverse Problems Reunion Conference I last year who had studied a similar inverse problem to mine. So we had deep discussion about our research during staying at IPAM. IPAM gave me opportunity to see mathematical problems occurring in biology, engineering, geophysics, etc. They are quite interesting problems which I didn't know. In

particular, I'm interested in an inverse problem in geophysics and reading related literatures and papers to the problem."

Ingo Ruczinski, Johns Hopkins University:
"My main collaborator on the protein folding problem is Kevin Plaxco. Other collaborators and colleagues with whom I discuss my work include George Rose, Susan Marquesee, Tobin Sosnick, and Pernilla Wittung-Stafshede. I attended the IPAM worksop on Protein sequence, structure, and function in May 2004. Until then, my main research focus was on structure prediction (and my presentation was on my work on ROSETTA). I also greatly enjoyed the lectures on the protein folding problem itself: how does a protein arrive at its native conformation from the unfolded state, and how can we characterize the folding transition state? I was very fortunate to be able to discuss some of the unsolved issues with some real leaders in the field, including George Rose, Arthur Lesk, Ken Dill, and Kevin Plaxco. Since then, my research w/ regards to proteins has revolved around addressing quantitative issues related to the protein folding problem (see the list of publications). As an example, blatantly missing from 15 years of publications on phi-values for the folding transition state was method for valid statistical inference (mainly, on the standard error) of the phi estimate. We have just submitted a manuscript, and implemented those methods as a web server, see http://biostat.jhsph.edu/~iruczins/software/phi/ ."

Kai Schneider, University of Marseille:
"New collaborations with Bill Dorland (U. Maryland), Steve Cowley (UCLA) were initiated. The workshop motivated me strongly to continue in the field of plasma physics, in particular using adaptive numerical methods for MHD simulation."

Naoki Saito, UC Davis:
"I got to know some details of the Laplacian eigenfunctions, diffusion maps, spectral clustering techniques by participating this program. Also, as an organizer, I got to know many leading experts in the diverse fields including math, applied math, CS, EE, statistics, and even music. I truly appreciate that IPAM gave me such a wonderful opportunity and memorable experience!"

Robert Megginson, MSRI:
"I met people at the Blackwell-Tapia conference there who have been terrifically good to know for further interactions with the underrepresented minority mathematics community. I greatly appreciate IPAM's interest in this important area, and hope additional mathematics institutes follow."

Alan Yuille, UCLA:
"Probabilistic Models of Cognition: The Mathematics of Mind. Jan 24-28, 2005 has had several positive results:

(I) A special issue of Trends in Cognitive Sciences. Proposed publication date: July 2006.

(II) I am co-author on three papers in this special issue.

(III) There will probably be an edited book on the meeting after the special issue has been finished.

(IV) The workshop has led me to collaborations with Psychology faculty at UCLA, Keith Holyoak and Patricia Cheng, on topics which were outside my field of expertise until the workshop. I hope these collaborations will be longterm. So far, they have led to a paper accepted in a peer-reviewed conference."

Irina Popovici, US Naval Academy:
"Motivated me to pursue a new research direction in image analysis,focusing on geometric elements in images."

Carole Le Guyader, University of Rennes:
"It enabled me to focus on new subjects that are emerging in the field of image sciences (brain mapping, flat mapping) and to deal with concrete issues encountered by radiologists, biologists, etc...
To a larger extent, it also enabled to get a more accurate idea of how Image Sciences appear as a transverse discipline and to devote my research both to theoretical questions and applied problems."

Minh Do, University of Illinois Urbana-Champaign:
"Attending workshops at IPAM has been great opportunities for me, a signal processor, to interact with mathematicians and other researchers working in related problems."