



Institute for Mathematics and its Applications

Annual Report

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1 Overview of the IMA

The IMA is an exquisite realization of an a critically important kind of research: the direct involvement of “pure” mathematicians into problems of other sciences, in the great tradition of H. Poincaré, A. Kolmogorov, I. Gelfand, J. von Neumann, V. Kantorovich, J. Lighthill, J. Charney. – Vladimir Keilis-Borok, Russian Academy of Sciences and Regent’s Professor, UCLA

1.1 The mission of the IMA

The primary mission of the IMA is to foster research of a truly interdisciplinary nature, establishing links between mathematics of the highest caliber and important scientific and technological problems from other disciplines and industry. Allied with this mission, the IMA also aims to expand and strengthen the talent base engaged in mathematical research applied to or relevant to such problems.

1.2 IMA strategies

The IMA pursues a variety of strategies to advance its mission.

- The IMA positions itself as an information hub in the mathematical sciences. It identifies important research areas and problems in need of new mathematics and communicates them to high quality mathematicians. It informs and instructs users and potential users about new mathematical developments. It brings together mathematicians and scientists to discuss important issues to whose resolution both groups may contribute.

Next to my graduate school studies at Columbia University, my 3-month visit to IMA was the most enriching intellectual experience in my career... I believe that IMA is a crown jewel of America’s scientific establishment that uniquely brings together diverse groups of scientists and mathematicians. It frees mid-career scientists from their stifling bureaucratic schedules to cooperatively indulge in unfettered exploration of scientific ideas. Just like the long ago days of graduate school. – Gerard Schuster, Professor of Geophysics, University of Utah

- The IMA provides a program and an environment which is highly conducive to research, collaboration, and communication.

I found that the IMA provided me with an ideal environment to meet other workers in the my field and to pursue in depth collaborations with many scientists with common interests. I find it hard to imagine a better format than the prevailing one... – Robert Burrige, Earth Resources Laboratory, MIT

- The IMA works to build lasting new multidisciplinary research communities.

The primary benefit of this meeting for me (and from other IMA workshops in the past) is making excellent contacts. I find that many of the people who attend IMA symposia are either current leaders in the field or up-and-coming researchers who are already making a significant impact. In either case, I have had some excellent discussions and made some (hopefully) lasting connections. – John Stockie, Mathematics and Statistics, University of New Brunswick

- The IMA seeks out and meaningfully engages mathematicians and scientists from as wide as possible a variety of backgrounds, particularly considering groups which are traditionally underrepresented.

The project was very interesting; it gave me an insight of how working for an industry is like. I had never considered doing research for an industry, but this workshop broadened my knowledge about different possibilities. – Sara Del Valle, University of Iowa, Math Modeling Workshop participant

- The IMA educates mathematicians at the start of their career and after they have been well-established. Its programs not only help mathematicians to extend their expertise, but also to broaden their perspective on the utility and impact of mathematics in science and technology. It enables them to become essential participants in interdisciplinary collaborations.

The IMA has helped understand the role an applied mathematician can and should play in solving real world problems with people from other fields. – Yvonne Ou, IMA Postdoc, 2001–2003

- The IMA enriches the education of the next generation of mathematical scientists by introducing graduate students to a wide view of the role of mathematics.

This workshop was a great experience for me, and it has fulfilled my expectations. I have learned about a “hands on” project with strict deadlines and defined goals. I enjoyed working with my team very much, discussing ideas and solutions, and together improving our results. I really believe I have established many great contacts for the future. – Madalena Chaves, Rutgers University, Math Modeling Workshop participant

1.3 Programmatic mechanisms

The IMA conceives and executes a range of programs to implement its strategies.

- **Annual Programs.** Each year the IMA runs an annual thematic program lasting ten months and centered around an important area of application or investigation. These programs involve on the order of 1,000 participants including around 10 key senior visitors of three to ten months, six to eight postdocs selected for their interest in the program, and around 40 other visitors of a month or more. They are typically divided into a small number of

periods of concentration in specific areas under the general theme, and include between six and twelve workshops of about one week duration, each involving 30–120 participants, and regular seminar series when workshops are not in progress. Tutorial lectures are an important part of most annual programs, and public lectures, panel discussions, and other activities may be as well. Annual programs require four to five years of advance planning and are organized in collaboration with a group of distinguished senior scientists.

The IMA has an environment that is ideally suited for new and innovative research... The program of workshops, temporary postdocs, and a few long term visitors creates a unique environment for creative activities... I look back on my time at the IMA as very rewarding and productive. – Donald Turcotte, Maxwell M. Upson
Professor of Engineering, Geological Sciences, Cornell University and member, National Academy of Sciences

- **Summer programs.** Each year the IMA runs a small number of summer programs lasting from two to seven weeks. These more intensive, more focussed programs typically involve on the order of 100 participants. These require two to three years of advance planning and are organized in collaboration with a small group of excellent scientists.
- **Hot topics and special workshops.** Each year the IMA runs a small number of workshops unrelated to its annual and summer programs. These can be organized in a matter of months and last from a few days to a week. Hot topics workshops focus on a specific problem or area of exceptional contemporary interest and importance, and are often cosponsored by one or more of our industrial partners. Other workshops have special aims, for example enhancing minority participation or facilitating communication between the math sciences community and funding agencies on specific issues.

I am a control systems engineer interested in wireless networks but I am not an expert in this field. However, in those three days I gained a pretty complete overview of the whole field—most important people, most important problems, tools (mathematical) that are being used, language. Great. – Dobrivoje Popovic, Electrical and Computer Engineering, UC Santa Barbara

- **Industrial Mathematics Modeling Workshops for Graduate Students.** Biannually the IMA runs a workshop in which graduate students are exposed to industrial mathematical modeling, through the team solution and presentation of an industrial problem under the guidance of mentors from industry and the IMA mathematical community.

The main impact of the workshop for me was in developing experience in working as part of a research team, and at meeting and coming to understand a problem from industry... I'm sure the experience will stay with me and affect my future work and choices. – Maria Reznikoff, Courant Institute, Math Modeling Workshop participant

- **Participating Institution summer programs for graduate students.** The IMA provides financial support and logistical assistance to our academic partner institutions for running an intensive program aimed at math graduate students each year.
- **IMA Postdoctoral Program.** Each year the IMA selects six to eight postdocs to spend

one to two years in residence at the IMA and participate intensely in its programs. Postdocs are carefully mentored, and some are paired with industrial sponsors.

- **Participating Institution conferences.** The IMA lends financial support and logistical assistance to our academic partner institutions in running conferences at their campuses. A few of these are supported each year.
- **Seminar series.** Each year the IMA runs a variety of seminar series, such as one organized by and directed towards the IMA postdocs, one organized by and directed towards the long term visitors in residence, one directed toward the upcoming annual thematic program. It also runs the Industrial Problems Seminar, with speakers coming from our industrial partners and local industries.
- **Industrial Programs.** The IMA collaborates extensively with industrial scientists and corporations. This collaboration includes the Industrial Postdoctoral program where the postdocs devote half of their effort to industrial projects and work under the guidance of industry mentors. In addition, the IMA offers the Industrial Problems Seminar, a forum in which industry scientists present mathematical problems, and collaborates with industry on Hot Topics and special workshops.
- **Partnerships and governance.** The IMA seeks the advice and the participation of a large cross section of the mathematical sciences community by forming partnerships with universities and corporations. Partners are involved directly in IMA planning activities, and participation of their members in IMA programs is facilitated. The IMA also involves various groups of experts, especially its Board of Governors, in the realization of its mission.
- **Various outreach activities.** The IMA engages in a variety of outreach activities. The directors visit industrial laboratories and meet with scientists and managers. They host visits from industrial scientists and managers to the IMA. They visit a variety of universities and meet with faculty and administrators. They reach out to other departments at the University of Minnesota. The IMA also sponsors occasional public lectures on mathematical topics of direct importance to the general public.
- **Dissemination and communication.** The IMA maintains an extensive web space and has an extensive publication program to inform the scientific community of its activities and to disseminate the results of its programs. It maintains online research communities to facilitate communication among focussed groups of scientists.

2 IMA Activities for 2001-2002

2.1 Annual Program: Mathematics in the Geosciences

The 2001–2002 IMA annual program was conceived to address important problems in the geosciences, including those dealing with the solid earth, the ocean, and the atmosphere. Guided by the IMA mission of bringing mathematics of the highest calibre to bear on problems of great importance, the program’s goal was to create a focal point for a multidisciplinary assault on some of the outstanding problems from this field. The year was organized into three quarters, each addressing a major theme. The fall quarter concentrated on dynamical systems and ergodic theory as they arise in the analysis of spatio-temporal patterns and in the geosciences, and celestial mechanics and climate modeling. This was followed in the winter quarter by a program dealing with subsurface modeling, ocean and atmospheric models, continuum models of geologic materials, and computational methods for geophysics. The final quarter, spring, addressed geophysical inverse problems arising in weather data assimilation and in geophysical exploration, and point process modeling for earthquake prediction. The program was very successful in advancing the IMA’s primary goal of bringing mathematics of the highest calibre to bear on problems of great importance. The organizing committee for the annual program consisted of David Brillinger (UC Berkeley), Michael Ghil (UCLA), James M. Hyman (Los Alamos National Laboratory), William Newman (UCLA), Rick Schoenberg (UCLA), William Symes (Rice), Donald Turcotte (Cornell) and Mary Wheeler (University of Texas).

2.1.1 Personnel

VIVs: IMA Very Important Visitors are distinguished scientists who are resident at the IMA for at least a full quarter as part of the annual program, and who provide scientific leadership during the annual program. They play an essential role by mentoring IMA postdocs, interacting with other visitors, providing continuity among the different workshops in the annual program, and contributing to a stimulating scientific environment between workshops.

During the 2001–2002 program six VIVs spent a total of 23 months in residence at the IMA.

<i>Name</i>	<i>Home institution</i>	<i>Department</i>	<i>Dates of visit</i>
Robert Burrige	MIT	Earth Resources Lab	Jan 2002 to June 2002
William Newman	UCLA	Physics, Astronomy, Math.	Sep 2001 to Dec 2001
Robert O’Malley	University of Washington	Applied Mathematics	Jan 2002 to Mar 2002
Gerard Schuster	University of Utah	Geophysics	Apr 2002 to Jun 2002
Donald Turcotte	Cornell University	Geological Sciences	Sep 2001 to Dec 2001
David Vere-Jones	Victoria University	Statistics	Apr 2002 to Jun 2002

I have found my visit to the IMA both personally and professionally to be of immense value. – William Newman, Professor of Planetary Physics, Astronomy, and Mathematics, UCLA

Long-term visitors and general members: These are visitors who stay four weeks or more. They participate in the workshops, speak in seminars, and collaborate with other researchers, and

contribute to and benefit from the program in a variety of ways.

The visit resulted in valuable new personal contacts and opened up a number of new research avenues for me. I am very glad to have had the opportunity to visit IMA and hope very much to be able to return again. – Peter Lynch, Assistant Director of Irish Meteorological Service

<i>Name</i>	<i>Home institution</i>	<i>Primary field</i>	<i>Length of stay</i>
Mark Bebbington	Massey University	Statistics	3 months
Valera Chtcherbakov	Geophysical Observatory Borok	Geology	4 months
Fabio D'Andrea	MIT	Geology	1 month
Doug Dokken	University of St. Thomas	Math	10 months
Roger Fosdick	University of Minnesota	Mechanics	1 month
Andrei Gabrielov	Purdue University	Math	1 month
Hongjun Gao	Nanjing Normal University	Math	6 months
Agnes Helmstader	UCLA	Geology	1 month
David Harte	Statisticsistics Research Associates	Statistics	1 month
Felix Herrmann	MIT	Geology	1 month
Steven Jaume	College of Charleston	Statistics	1 month
Alexey Kaplan	Columbia University	Geology	1 month
Vladimir Keilis-Borok	UCLA	Geology	1 month
Vladimir Kossobokov	Russian Academy of Sciences	Geology	1 month
Peter Lynch	Met Eireann	Math	1 month
Alexey Lyubushin	Russian Academy of Sciences	Statistics	1 month
Dan Marchesin	IMPA	Math	1 month
Gueorgui Moltchan	Russian Academy of Sciences	Geology	1 month
Robert Nadeau	Lawrence Berkeley Lab	Statistics	1 month
Yosihiko Ogata	Institute of Statisticsistical Mathematics	Statistics	1 month
Jeong-Soo Park	Chonnam National University	Statistics	12 months
Thomas Pence	Michigan Statisticse University	Mechanics	1 month
Yanick Ricard	ENS Lyon	Geology	1 month
Alexander Shapoval	Russian Academy of Sciences	Geology	1 month
Kurt Scholz	University of St. Thomas	Math	6 months
Robert Shcherbakov	Cornell University	Geology	4 months
Stefan Siegmund	Georgia Institute of Technology	Math	4 months
Javier Thayer	Mitre Corporation	Math	12 months
Jianhua Wu	Shaanxi Normal University	Math	2 months
Ilia Zaliapin	UCLA	Geology	1 month

This month at IMA was very positive for me, not only for my ongoing research but also for the new ideas that I got in interacting with colleagues in the friendly and studious atmosphere. And I am ready to come back! – Yanick Ricard, Earth Sciences Laboratory, École Normale Supérieure, Lyon, France

Geosciences postdocs: During the 2000–2001 academic year, the IMA recruited and hired seven postdoctoral scholars with background and/or a strong interest in mathematical aspects of the geosciences. The IMA Geosciences postdocs not only benefited themselves from the IMA program, but provided much of vitality, energy, creativity, and continuity to the program.

<i>Name</i>	<i>Previous institution</i>
Dacian Daescu	University of Iowa
Gregory Duane	NCAR
Michael Efroimsky	Oxford University
Daniel Kern	Southern Methodist University
Anna Mazzucato	Yale University
Yvonne Ou	University of Delaware
Toshio Yoshikawa	University of Utah

Minnesota mathematics faculty: Seven faculty members from the School of Mathematics were awarded teaching release time in order to participate in and contribute to the 2001–2002 annual program. Beyond their participation in workshops and interaction with visitors, their contributions included mentoring of graduate students, delivering and organizing seminars, and, in the case of F. Reitich, collaborating on the organization of the Industrial Mathematics Modeling Workshop for Graduate Students. These faculty members were Maria-Carme Calderer, John Lowengrub, Willard Miller, Fernando Reitich, George Sell, Jianhong Shen, and Vladimir Sverak.

Second year postdocs: These three postdoctoral researchers are on the second of their two-year appointment having come to the IMA because of the 2000-01 Annual Program “Mathematics in Multimedia”. Many participated in the Geosciences program. Their activities during the year are reported in Section 2.6. All three will work in academic positions next year.

<i>Name</i>	<i>Previous institution</i>	<i>Next institution</i>
Jamylle Carter	UCLA	University of Minnesota
Selim Esedoglu	New York University	UCLA
Jianliang Qian	Rice University	UCLA

Industrial postdocs The IMA industrial postdoc program has been a model program for the education and engagement of young mathematicians in industry. IMA industrial postdocs split their time between the IMA and an industrial lab, where they pursue research in collaboration with an industrial mentor and a group. They are partially supported by industry. The three IMA industrial postdocs during 2001–2002 participated in the Geosciences program as well.

<i>Name</i>	<i>Previous institution</i>	<i>Affiliated company</i>
Santiago Betelu	University of Minnesota	Seagate
Christine Cheng	Johns Hopkins University	Telcordia
Aurelia Minut	Michigan State University	3M

2.1.2 Workshops in the Annual Program

A great deal of thought is put into the planning and organization of IMA workshops. The aims and goals of individual workshops are determined through discussions between the workshop organizers, program organizers, and IMA directors, and the format of the workshop tuned accordingly. As a general matter, the IMA puts a high priority on discussion and communication across disciplinary and scientific community boundaries. Therefore we are careful to leave ample time for discussion in our programs. Workshops often start with a few presentations that give a broad overview and help to cut through discipline-specific jargon. During the 2001–2002 program, we adopted “Second Chances” discussion periods at the end of the day for many workshops. During these sessions the day’s speakers had a chance to revisit a point from their lecture in light of the discussions that occurred afterward, and the participants, having had a chance to digest the lectures, had the opportunity to discuss more meaningfully. While an hour was usually set aside at the end of a day for “Second Chances”, in fact they often initiated discussions that continued well beyond the allotted time.

The content of the workshop was excellent. I actually got a chance to (finally) hear some in-depth presentations and really TALK to colleagues who work in the same field. It's a shame that the usual conferences do not provide such opportunities. – Malgorzata Peszynska, Associate Director for Subsurface Modeling, TICAM, University of Texas

The following workshops were held as part of the 2001–2002 annual program on Mathematics in the Geosciences. In the following, we list the workshops that were held at the IMA. Workshops 1 to 4 occurred in the first quarter which concentrates on the topic of Dynamical Systems and Ergodic Theory. The second quarter concentrated on Multiscale Phenomena and Renormalization, highlighted by workshops 5 to 8. The final quarter concentrated on Inverse Problems and the Quantification of Uncertainty.

Fall Quarter: Dynamical Systems and Ergodic Theory

1. Spatio-temporal Patterns in the Geosciences, September 25-29, 2001. Organizers: Leon Knopoff (UCLA), Andrei Gabrielov (Purdue), Michael Ghil (UCLA).
2. Complexity in Geophysical Systems, October 8-12, 2001. Organizers: William I. Newman (UCLA), Vladimir Keilis-Borok (UCLA), Jean Carlson (UC Santa Barbara).
3. Dynamical Systems in Celestial Mechanics and Climate Dynamics, October 29-November 2, 2001. Organizers: Michael Ghil, William I. Newman, Ferenc Varadi (UCLA).
4. Time Series Analysis and Applications to Geophysical Systems, November 12-15, 2001. Organizers: David R. Brillinger (UC Berkeley), Enders Robinson (Columbia), Frederic Schoenberg (UCLA), Robert H. Shumway (UC Davis).

Winter Quarter: Multiscale Phenomena and Renormalization

5. Quantifying Uncertainty and Multiscale Phenomena in Subsurface Processes, January 7-11, 2002. Organizers: Louis J. Durlofsky (Stanford), James G. Glimm (SUNY Stony Brook), David Sharp (Los Alamos National Laboratory), Mary F. Wheeler (University of Texas), C. Larrabee Winter (Los Alamos National Laboratory).

6. Reduced Descriptions of Coupled GFD Systems (Slow Manifolds in the Ocean and Atmosphere, February 11-15, 2002. Organizers: Darryl D. Holm (Los Alamos National Laboratory), James C. McWilliams (UCLA).
7. Numerical Methods in the Geosciences, March 13-15, 2002. Organizers: J.M. Hyman (Los Alamos National Laboratory), Mary F. Wheeler (University of Texas)

Excellent workshop. A mixture of people with cross-fertilizing interests. The best aspect was that there was plenty of time for discussion and debate, which really helped clarify the issues and possible future directions. I made a few new contacts and certainly learned something. – John Lister, Applied Mathematics and Theoretical Physics, University of Cambridge

8. Nonlinear Continuum Mechanics, Rheology and the Dynamo, March 18-22, 2002. Organizers: Gerald Schubert (UCLA), Shun-Ichiro Karato (Yale), Peter Olson (Johns Hopkins University), Donald L. Turcotte (Cornell University).

I am very positive on both the impact and the content... I had the opportunity to meet new colleagues, with whom I am corresponding now. Outside of my field, the workshop gave me an excellent opportunity to evaluate the present and future research. – Yves Gueguen, Earth and Atmospheric Sciences, École Normale Supérieure, Paris

Spring Quarter: Inverse Problems and the Quantification of Uncertainty

9. Inverse Problems and Quantification of Uncertainty, April 22-26, 2002. Organizers: William W. Symes (Rice University), Philip B. Stark (UC Berkeley), John A. Scales (Colorado School of Mines).

This was a wonderful workshop. The technical talks were all first rate and the discussion periods added a tremendous amount to my understanding of the field. – Juan Meza, Head High Performance Computing Research, Lawrence Berkeley Lab

10. Data Assimilation in the Oceanic and Atmospheric Sciences, April 29-May 3, 2002. Organizers: Robert N. Miller (Oregon State University), Olivier Talagrand (Ecole Normale Supérieure).

I have learned a lot during the workshop, and perhaps more importantly I think I've got the general picture of the current state of the field. It was a great opportunity to meet leading experts in the field. – Leonid Kuznetsov, Postdoc, Applied Mathematics, Brown University

11. Point Process Modeling and Seismological Applications of Statistics, June 10-14, 2002. Organizers: Frederic Paik Schoenberg (UCLA), David R. Brillinger (UC Berkeley), Bruce A. Bolt (UC Berkeley).

2.1.3 Tutorials

During the year, the IMA organized tutorials and short courses designed to give an introduction to specific topics in the geosciences. Some tutorials preceded workshops in the same topic. The tutorials are attended primarily by visitors and postdocs in residence, by scientists from the IMA Participating Institutions, and by students and faculty from the University of Minnesota.

1. Spatio-temporal Patterns in the Geosciences, September 24, 2001. Presenters: Vladimir Keilis-Borok (UCLA), Michael Ghil (UCLA), Donald Turcotte (Cornell), and Eli Tziperman (Weizmann Institute).
2. Wavelet Methods Seismology, February 18-20, 2002. Presenter: Felix Herrmann (MIT).
3. Ray Theory for the Elastic Wave Equation, March 4-6, 2002. Presenter: Robert Burridge (MIT).
4. Inverse problems and the quantification of uncertainty, April 19, 2002. Presenters: William Symes (Rice) and Philip Stark (UC Berkeley).

2.2 Summer Program: Geometric Methods in Inverse Problems and PDE Control

The summer program took place from July 16 to 27, 2001, and was organized by Christopher Croke (Pennsylvania), Irena Lasiecka (Virginia), Gunther Uhlmann (Washington) and Michael Vogelius (Rutgers). Connections have been made between the methods for establishing controllability of vibrating systems from the boundary and for proving uniqueness of inverse problems for partial differential equations. What is common to these methods is the reliance on techniques that are used in differential geometry. This two-week workshop brought together the three research communities to focus on the central theoretical issues facing these fields, and to attempt to find common ground from which to study these problems. This ‘horizontal’ integration of three well-developed areas in mathematics in order to make progress on significant problems furnished an excellent example of the IMA philosophy. Several new on-going collaborations have resulted from this workshop.

The meeting was very valuable for me as a researcher of inverse problems. It is one of the first workshop where control theory and inverse problems were brought together. . . The conference was one of the best and most interesting one which I have ever attended. – Matti Lassas, Rolf Nevanlinna Institute, Finnish Academy

The IMA workshop goals were to bring together geometers with researchers in inverse problems and control of PDEs to facilitate exchange of ideas and encourage collaboration; to make tools of differential geometry known to those working in inverse problems and control, and to open new areas of research in geometry. By these criteria, the IMA workshop was an undisputed success. – Irena Lasiecka, Department of Mathematics, University of Virginia

2.3 Hot Topics and Special Workshops

During 2001–2002 the IMA mounted four special workshops in response to the needs in the scientific and industrial research communities. In all these workshops, the IMA’s goal was to develop and nurture new interdisciplinary research efforts in which mathematics can play an essential role. It did this by promoting cross-disciplinary interchange, and by highlighting problems and opportunities for mathematics, and mathematical techniques potentially applicable to the problem area.

2.3.1 Mathematical Opportunities in Large-Scale Network Dynamics

Held Aug 6-7, 2001. Organizers: John Doyle (Caltech), Andrew Odlyzko (Minnesota), Ruth Williams (UC San Diego), and Walter Willinger (AT&T). This and the next workshop focussed on mathematical challenges in the design, operation, and understanding of communication networks. The problem of modeling the dynamics and studying the control of large networks was addressed in this workshop.

This workshop has, in my opinion, had significant influence on promoting communication and cooperative research in this multidisciplinary area and should be labeled an unqualified success. – John Lavery, Army Research Office

2.3.2 Wireless Networks

Held August 8-10, 2001. Organizers: P.R. Kumar (Univ Illinois), Rajeev Agrawal (Motorola), Venkat Anantharam (UC Berkeley), Piyush Gupta (Lucent), Debasis Mitra (Lucent), and David Tse (UC Berkeley). The workshop focused on the communication theory for wireless networks, and included several talks on the emerging area of ad hoc networks.

The conference was characterized by the fact that not only did it cover cellular systems, which in the future are expected to carry significant amounts of data in addition to voice, but also the emerging field of ad hoc networks. . . The cross fertilization between these two was a strong aspect of this workshop.

Another characteristic of the workshop was the strong role it gave to fundamental theory in this rapidly emerging field. Probability theory and stochastic processes were in fact at the center of most the fundamental results in the area.

To summarize, the Hot Topic Workshop in Wireless Networks truly lived up to its name. . . It featured the strong theory at the center of this rapidly growing field, and had speakers from startups, leading companies, leading academic institutions, students, faculty, and industrial researchers – P.R. Kumar, Franklin W. Woeltge Professor of Electrical and Computer Engineering, University of Illinois

2.3.3 Evolutionary Consequences of Biological Invasions

Held April 12-13, 2002. Organizers: David Andow, Peter Graham, Nicholas Jordan, Claudia Neuhauser, and Ruth Shaw (all from Minnesota). Cosponsored by the Minnesota Center for Community Genetics and the Invasion Biology Research Consortium, both at the University of Minnesota. The workshop dealt with modeling of biological invasion by exotic species, which represents a threat to the environment. In conjunction with the workshop, a public lecture, entitled “The Flood of Exotic Species Invasions of America’s Coastal Oceans: Why Now. Why We Should Care and What We Can Do About It.” was given by James Carlton Professor of Marine Sciences, Williams College, and Director of the Maritime Studies Program of Williams College and Mystic Seaport.

2.3.4 Numerical Relativity

Held June 22-28, 2002. Organizers: Douglas N. Arnold (Minnesota), Abhay Ashtekar (Penn State), and Pablo Laguna (Penn State). Jointly sponsored with the Center for Gravitational Wave Physics, Penn State. The workshop dealt with numerical solution of Einstein’s equations of general relativity. It was the first effort to involve the mathematical community in relevant areas outside of relativity, such as numerical analysis, partial differential equations, and geometry, into the tremendous challenge arising from the need to numerically simulate the Einstein equations, and it was successful beyond expectation. The meeting will likely prove a milestone in the development of numerical methods.

2.4 Programs for Graduate Students

2.4.1 Mathematical Modeling in Industry

The IMA ran its biennial graduate students workshop on mathematical modeling in industry from May 26 to June 3, 2002. The program was organized by Rachel Kuske, Fernando Reitich, and Fadil Santosa (Minnesota). Students in this program worked in teams of six under the guidance of an industry mentor who poses the problem. The workshop drew a pool of over 70 applications for the 36 available places. All 36 students accepted the offer within days of being informed of their selection.

I wanted to thank you and the IMA for the opportunity you gave me to taste from your wonderful institute. In this 9 days I have learned much more than I ever expected, and not only math! The atmosphere was wonderful as so the other participants. The constant support that I felt from you guys, the organizers, made me not wanting to leave. – Yaniv Gershon, Wayne State University, Math Modeling Workshop participant

Six industry scientists were selected as mentors for their ability to work with students, and for the substantial mathematics content their work which require sophisticated mathematics. The quality of the mentors and the problems they provided were certainly essential to the program. Here IMA’s extensive industrial contacts, and particularly its Participating Corporation program,

was instrumental.

On the last day of the workshop, each team delivered an oral presentation on their findings. A written report was submitted soon after. The program has been successful by any measure. Every team made significant progress on their problem, and it is highly likely that, as in past years, some of their work will be implemented in industry. In addition to learning new mathematics and learning about a new application, students also developed valuable teamwork and communication skills which are essential to research in industrial setting. Most importantly, the program opened students to a broader view of mathematics and its role in real-world situations.

I would like to thank you for inviting me to participate in Mathematical Modeling for Industry Workshop. It has been a great experience, and I've really enjoyed last ten days, that I've spent at IMA. I was lucky to get such a great student team. We have accomplished in ten day, much more than I've expected. – Sonja Glavaski, Honeywell, Math Modeling Workshop mentor

The projects and mentors for this year were:

- Team 1. *Modeling Planarization in Chemical-Mechanical Polishing*, Dr. Leonard Borucki (Motorola), mentor. Team members: Dilek Alagoz (Kentucky), Stephanie Hoogendoorn (Pittsburgh), Satyanarayana Kakollu (Mississippi State), Maria Reznikoff (New York University), Richard Schugart (NC State), Michael Sostarecz (Penn State).
- Team 2. *Modeling Networked Control Systems*, Dr. Sonja Glavaski (Honeywell), mentor. Team members: Madalena Chaves (Rutgers), Robert Day (Maryland), Lucia Gomez Ramos (UW Milwaukee), Parthasarathi Nag (Washington State), Anca Williams (Portland State), Wei Zhang (Kentucky).
- Team 3. *Designing Airplane Engine Struts Using Minimal Surfaces*, Dr. Thomas Grandine (Boeing), mentor. Team members: Sara Del Valle (Iowa), Todd Moeller (GA Tech), Siva Natarajan (Utah State), Gergina V. Pencheva (Pittsburgh), Jason Sherman (Kent State), Steven Wise (Virginia).
- Team 4. *Mobility Management in Cellular Telephony*, Dr. David Shallcross (Telcordia), mentor. Team members: Benjamin Cooke (Duke), Kwon Darongsae (Seoul National Univ), Dmitry Glotov (Purdue), Simon Schurr (Maryland), Daniel Taylor (Washington State), Todd Wittman (Minnesota).
- Team 5. *Optimal Design for a Varying Environment*, Dr. David Misemer (3M), mentor. Team members: Serguei Lapin (Houston), Xuan Hien Nguyen (Wisconsin), Jiyeon Oh (Cincinnati), Daniel Vasiliu (Michigan State), Pei Yin (Missouri), Ningyi Zhang (Delaware).
- Team 6. *Optimal Pricing Strategy in Differentiated Durable-Goods Markets*, Dr. Suzhou Huang (Ford), mentor. Team members: Miyuki Breen (Akron), George Chikhladze (Missouri), Jose E. Figueroa-Lopez (GA Tech), Yaniv Gershon (Wayne State), Yanto Muliadi (Stanford), Ivy E. Prendergast (Iowa).

By all accounts, the Math Modeling Workshop was very successful. . . We were extremely fortunate to secure the participation of a group of first-rate mentors from leading industries, all of whom presented modeling problems that combined deep mathematical challenges with true technological and economic relevance. All the teams made significant progress in the ten days allotted. In fact, the enthusiasm and excitement of the students was only matched by that of the mentors themselves, all of whom were explicitly thankful to have had the opportunity to present their problems and lead towards a solution a distinguished group of students. – Fernando Reitich, Department of Mathematics, University of Minnesota and organizer of the 2002 Industrial Math Modeling Workshop for Graduate Students

2.4.2 Participating Institute Summer programs for graduate students

Timothy Hodges (University of Cincinnati) organized a 4-week program on “Poisson and quantum structures” at his campus from June 18 to July 13, 2001. The program was conceived as a short course taught by distinguished researchers in this field for graduate students who were about to start their PhD research. The tutors, each of whom taught for for a week, and titles of their topics are:

Week 1. *Classical Hamiltonian Systems*, Ken Meyer (University of Cincinnati).

Week 2. *Introduction to Symplectic and Poisson Geometry*, Jiang-Hua Lu (University of Arizona).

Week 3. *Physical Combinatorics*, Tetsuji Miwa (Kyoto University).

Week 4. *Integrable Systems*, Michael Gekhtman (University of Notre Dame).

The program drew 13 students to the campus of the University of Cincinnati. Dmitriy Boyarchenko (Pennsylvania), Jeongoo Cheh (Minnesota), Kuo-Chang Chen (Minnesota), Lan Cheng (Pittsburgh), Adama Diene (Cincinnati), Robin Endelman (Cincinnati), Corey Gonzalez (Maryland), Damon Hay (Houston) Shu-hoi Pun (Maryland), Mark Riggs (Mississippi State), Yuho Shin (Kentucky), Charles Slade (Pennsylvania State), Maria Grazia Viola (Iowa).

In 2002 we will hold a 4-week program from July 1 to 26 on “Scientific Computing” at the University of Kentucky. Craig Douglas of the University of Kentucky serves as organizer for this event. The topics and instructors are

Week 1. *Parallel Computing and Visualization*, Craig C. Douglas and Jun Zhang (Kentucky).

Week 2. *Numerical Methods for Partial Differential Equations*, Jerome Jaffré and Jean Roberts (INRIA).

Week 3. *Sparse Matrix Methods*, Iain Duff (Rutherford Appleton Laboratories). ACTS workshop, Tony Drummond and Osni Marques (Lawrence Berkeley Laboratories).

Week 4. *Bioinformatics and Its Relation to Scientific Computing*, Toni Kazic (Missouri).

The program has attracted 27 students from IMA Participating Institutions.

2.5 PI Conferences

As part of the Participating Institute program, the IMA provides funding and advertisement for conferences proposed by, and held at, Participating Institutes. Moreover, IMA monies from the Participating Institute program can be used for participants to travel from a PI institution to any of these conferences. Proposals for IMA PI conferences are reviewed by representatives from the PIs and are selected for funding by a committee consisting of PI mathematics department chairs. These conferences are on a variety of topics and are valuable in promoting collaboration among Participating Institutions.

1. *Interphase 2001 – Numerical Methods for Free Boundary Problems*, Jan 9-12, 2002, held at University of Maryland. Organizing Committee: Ricardo H. Nochetto (Maryland), Eberhard Bänsch (Weierstrass Institute), C. David Levermore (Maryland), Jian-Guo Liu (Maryland), and Robert Pego (Maryland).
2. *Partial Differential Equations*, Mar 15-17, 2002, held at University of Kentucky. Organizers: Russell Brown, Peter Hislop, and Zhongwei Shen (all from Kentucky).
3. *Singularity Formation in Nonlinear Evolution Equations: A Conference in honor of the 60th birthday of Howard Levine*, Jun 8-9, 2002, held at Iowa State University. Organizers: Gary Lieberman, Paul Sacks, Michael Smiley, and Xiaoming Wang (all from Iowa State).

2.6 Postdoctoral program

Through its postdoctoral program the IMA has helped to train and to broaden many mathematicians during the early stages of their career. Many of our former postdocs are now leaders in their fields. Central to this career development program is the exciting research environment that the IMA provides. The IMA places a priority on careful mentoring of postdocs. Each postdoc is assigned a mentor drawn from the mathematics faculty at the University of Minnesota, or from other departments on campus. The postdocs are encouraged to collaborate with IMA long-term visitors.

My two year stay at the IMA was very fruitful and will leave a deep mark on my academic career. The IMA provides a very good environment for postdoctoral members to collaborate with outside visitors. Indeed most of my projects resulted from those kinds of collaborations. – Jianliang Qian, IMA Postdoc, 2000–2002

The IMA forms a hiring committee to evaluate the applications for postdoctoral positions. The committee consisted of Willard Miller, Fadil Santosa, William Newman, William Symes, and Micheal Ghil.

2.6.1 Geoscience postdocs

The IMA appointed seven postdocs for the annual program in Geosciences. One of them, Dr. Anna Mazzucato is leaving the IMA at the end of the year to return to her position as Gibbs Instructor at Yale University before moving to a tenure-track position at Penn State University. The rest will

remain at the IMA for 2002-03 to further pursue research. Some will take on teaching duties to round out their experience.

Dacian Daescu PhD 2001 from University of Iowa. Dr. Daescu's research area is data assimilation problems arising in atmospheric with complex chemical reactions. His mentor is Fadil Santosa.

Gregory Duane PhD 1997 from University of Colorado. Dr. Duane's research area is climate modeling and synchronized chaos. His mentor is George Sell.

Michael Efroimsky PhD 1995 from Oxford University. Dr. Efroimsky's research area is celestial mechanics, especially for bodies that deform. His mentor is Maria-Carme Calderer.

Daniel Kern PhD 1999 from University of Illinois Chicago. Dr. Kern's research area is stochastic optimal control as applied to ground water remediation, and mathematical biology. His mentor is Nicolai Krylov.

Yvonne Ou PhD 2001 from University of Delaware. Dr. Ou's research area is homogenization theory applied to ocean acoustics and inverse problems. Her mentor is Vladimir Sverak.

Anna Mazzucato PhD 2000 from University of North Carolina. Dr. Mazzucato's research area is analysis of partial differential equations, particularly those arising in fluid dynamics. She will return to her position of Gibbs Instructor at Yale University, and has accepted a position as assistant professor at Penn State starting 2003. Her mentor is Vladimir Sverak.

Toshio Yoshikawa PhD 2000 from University of Utah. Dr. Yoshikawa's research area is fluid dynamics and effective medium theory. His mentor is Arnd Scheel.

2.6.2 Second year postdocs

Three postdocs hired for the IMA 2001-2 thematic program in Multimedia chose to remain for a second year at the IMA. They are

Jaymille Carter PhD 2001 from UCLA. Dr. Carter's research area is image processing and computer graphics. Her mentor is Peter Olver, and she has been working with Victoria Interante. She has been awarded a postdoctoral fellowship supported by the Office of the Executive Vice President and Provost of the University of Minnesota, and will be in residence in the School of Mathematics for 2002.

Selim Esedoglu PhD 2000 from New York University. Dr. Esedoglu's research area is image processing, particularly in the analysis of the mathematical behavior of imaging methods. His mentor is Fadil Santosa. He collaborated with University of Minnesota math professor Jianhong Shen and IMA visitor Riccardo March. He will start as assistant professor at UCLA in Fall of 2002.

Jianliang Qian PhD 2000 from Rice University. Dr. Qian's research areas are in wave propagation and numerical analysis. His mentor is Bernardo Cockburn. He collaborated with Cockburn, and IMA visitors Robert Burrige, Li-Tien Cheng, Stanley Osher and William Symes. He will start as assistant professor at UCLA in Fall of 2002.

2.6.3 Industrial postdocs

Three industrial postdocs were in residence during the reporting period.

Santiago Betelu PhD 1997 from Univ. Provincia de Buenos Aires. Dr. Betelu worked on modeling of micromagnetics in collaboration with Seagate. His mentor is Fernando Reitich. He collaborated with Walter Littman and Robert Gulliver on scientific computing problems arising in control, with Donald Aronson on fluid dynamics, and with Guillermo Sapiro on image processing. He finished his 2 year position at the IMA and will start as assistant professor at North Texas State University in Fall 2002.

Christine Cheng PhD 1999 from Johns Hopkins University. Dr. Cheng worked on communications and data storage problems in collaboration with scientists at Telcordia. Her mentor is Rachel Kuske. She finished her 2-year position at the IMA and will start as assistant professor at University of Wisconsin in Milwaukee in Fall 2002.

Aurelia Minut PhD 2001 from Michigan State University. Dr. Minut worked on fiber Bragg grating design problems with scientists at 3M. Her mentor is Fadil Santosa. She will continue in this position in 2002-03.

2.7 Seminars

2.7.1 Industrial Problems Seminar

In its fifteenth year, this seminar series brings scientists from industry to the IMA to present a talk on industrial research. The aim is for the speaker to highlight how mathematics figures into their research, and to pose open problems that the company wishes to be addressed. The audience consist of primarily of IMA postdocs, visitors, and directors and faculty and students from Minnesota's School of Mathematics.

As can be seen from the list of speakers for 2001-2, the topics are varied and together expose the audience to a broad view of the utility of mathematics. Each speaker normally spends a day at the IMA and is given an agenda which includes speaking to postdocs and students, in addition to discussions with arise as the result of their presentation.

Through the industrial problems seminar, I have been exposed to a wealth of research projects from many industrial research laboratories. – Aurelia Minut, IMA Industrial Postdoc, 2001–2003

1. Fan Liu (Honeywell Laboratories), *Global positioning system and its applications.*
2. Sarah Patch (General Electric Company), *F. John's ultrahyperbolic equation and 3D computed tomography.*
3. Leonard Borucki (Motorola Digital DNA Lab), *Mathematical modeling of mechanical and fluid pressures in chemical-mechanical polishing.*
4. Sanjive Qazi (Parker-Hughes Cancer Center), *Screening for the effect of a potent new anti-HIV compound on HIV infected cells using oligonucleotide arrays to measure gene expression.*

5. Radu Victor Balan (Siemens AG), *A new class of speech signal stochastic models and applications to blind source separation problems.*
6. Carlos Tolmasky (Cargil), *On the spectral decomposition of empirical correlation matrices related to term structures.*
7. David K. Misemer (3M), *Finding a robust design for optical components.*
8. Lei X. Wang (Seagate Technology), *Micromagnetic Modeling of Writing and Reading processes in magnetic recording.*
9. Benoît Couët (Schlumber Doll Research), *How do we perform stochastic reservoir optimization?*
10. Cristina U. Thomas (3M) *Mathematics and materials: the role of mathematics in a materials development laboratory.*
11. Eric van den Berg (Telcordia Technologies), *Mathematical modeling in support of service level agreements.*
12. Michael I. Weinstein (Bell Laboratories), *Stopping light on a defect.*
13. Craig T. Poling (Lockheed Martin Tactical Defense Systems), *Mathematical problems arising in multi-sensor multi-platform precision registration.*
14. Brad Kahlbaugh (Donaldson Company), *Penalty function formulation for product design with mixed integer models.*
15. Veena B. Mendiratta (Lucent), *A simple ATM backbone network reliability model.*
16. Richard Jordan (Dynamics Technology Inc.), *Infectious diseases modeling at Dynamics Technology, Inc.*

2.7.2 IMA Postdoc Seminar

The seminar is organized by the IMA postdocs and meets weekly except during a workshop week. Speakers are drawn from the postdocs, other visitors, and School of Mathematics faculty. An important goal of the seminar is to generate interaction among residents of the IMA with the hope of creating new collaborations. This seminar also provides a forum for the IMA postdocs to communicate their findings with annual program members and to hone their presentation skills. It has been effective channel for generating interaction between these two groups with different interests.

2.7.3 Geosciences Seminar

A seminar on themes related to the annual program theme of mathematics in the geosciences was offered during the annual program. Speakers, frequently IMA visitors and postdocs, give informal lectures related to the theme of annual program. Many of the lectures are of the tutorial nature.

2.7.4 Computational Geosciences Seminar

This year we added a computational seminar series allied to the annual theme. Organized by University of Minnesota math professor John Lowengrub, the seminar met about once a month. The speakers were usually computational scientists visiting Minnesota. stress computational aspects of geoscience.

2.8 Industrial program

2.8.1 Industrial problems seminar

The IMA Industrial Problems Seminar was started in 1987. Goals of this series and details of the activities for 2001-2 are given in Section 2.7.1.

2.8.2 Industrial postdoc program

The IMA industrial postdoc program was established in 1990. The postdocs hired under this program works half time on a predetermined industrial project with a company during the 2-year appointment. Funding for the postdoc is split between IMA and the company. The success of this program has been due to the quality of the postdocs, the scientific projects, and the industrial mentors assigned to the projects. For a list of projects and personnel involved, please refer to Section 2.6.3.

2.8.3 Industrial outreach

Directors of the IMA make regular visits to Participating Corporations. These visits are normally day-long, and provide the directors with a chance to learn first-hand the present-day mathematical challenges facing industrial research, and to keep the industrial scientists informed about relevant activities at the IMA and relevant developments in mathematics. These visits also present valuable opportunities to get input for future IMA activities. We use them to identify program themes, seminar speakers, and postdoctoral projects.

2.8.4 Industrial advisory board

The IMA receives input from its Participating Corporation in part through the Industrial Advisory Board. The board meets once a year at the IMA for a day-long meeting. Membership of this committee is given in Section 3.3.

2.8.5 Math modeling in industry

The very successful biennial workshop on industrial math modeling for graduate students involve projects from industry. Mentors are present at the IMA throughout of the workshop supervising their teams. The program provides the companies with a chance pose problems and to interact with students whom they may wish to recruit. In some cases, the teams of students have provided the companies with very useful findings. Details of this year's program is provided in Section 2.4.1.

2.9 Impact assessment

The primary mission of the IMA is to foster interdisciplinary research linking mathematics and to strengthen the talent base of researchers able to carry out such research. Thus, the most important outcomes of the IMA's activities include new collaborations and new interdisciplinary research projects and results. While such outcomes grow from seeds planted at the IMA during IMA programs, they usually begin to grow and bear fruit at a distance, in both time and space, from the IMA. It is therefore challenging to assess our success in achieving such outcomes. The synopses that follow, collected from follow-up discussions and reports of IMA participants, provide examples of the kind of interactions and research that derive from IMA programs. There are many such examples (more of which can be found in the participants' reports in the attachments to this annual report), and undoubtedly many others of which we are not aware. Although difficult to quantify, it seems clear that the IMA is among the most successful institutions in the world in stimulating interdisciplinary mathematical collaborations and research.

Christine Cheng, who did her PhD in discrete mathematics at Johns Hopkins, is an IMA industrial postdoc with Telcordia Technologies. She and Chungmin Chen, a telecommunications engineer at Telcordia, developed new declustering schemes for spreading massive amounts of data among different storage devices. Their paper on this work was awarded the "Best Newcomer Paper" prize at the ACM Principles of Database Systems meeting in May 2002.

In a truly interdisciplinary spirit, IMA VIV Gerard Schuster, a geophysicist from Utah, and statisticians David Vere-Jones (Victoria Univ), also an IMA VIV, and Mark Bebbington (Massey University), a long-term visitor to the IMA, devised a strategy for determining geographic sites at which Schuster's imaging method of seismic trenching can be effectively used to obtain paleoseismic data in the Wasach fault. This work seems likely to lead to improved hazard estimates for the Salt Lake City region.

The IMA program on Geosciences allowed Jianhong Shen of the University of Minnesota to meet and interact with a number of geophysicists from the University. This has led to new research collaboration in using wavelets for studying terrain topology. Shen and geophysicist Efi Foufoula-Georgiou have submitted a proposal to the NSF program on mathematics in the geosciences.

IMA visitor Steve Marron, a statistician from the University of North Carolina, met with members of the CAIDA research group at UC San Diego at the IMA workshop on network dynamics, and they began an ongoing collaboration on statistical techniques to analyze internet traffic data.

Chun Liu (Penn State) met Anna Mazzucato (IMA postdoc) during an IMA workshop. This connection led to Dr. Mazzucato being offered a tenure-track position at Penn State. During her 6-month stay, Dr. Mazzucato worked on a problem suggested by her mentor, Vladimir Sverak (Minnesota), and finished an article on the project.

Discussion with IMA visitors Eugenia Kalnay and James Yorke of the University of Maryland has led Gregory Duane (IMA postdoc) to investigate the use of chaos synchronization for meteorological data assimilation.

Jianliang Qian (IMA postdoc) began studying problems in crystal optics with IMA VIV Robert Burridge (MIT). They have presented their joint work on conical diffraction at an IMA seminar and are completing a paper for publication. In addition, Qian has collaborated with Li-Tien Cheng

(former IMA postdoc now at UC San Diego) and IMA visitor Stanley Osher (UCLA) on the use of the Eulerian approach to multi-valued solution of the eikonal equations.

At the IMA, Robert Burrige also made contact with Rick Dean (University of Texas) who is an expert on geomechanics. Their discussion lead to a research on new ways of modeling solid deformation in porous, fluid-filled medium.

Michael Efroimsky (IMA postdoc) started a collaboration with IMA visitor Farenc Varadi (UCLA) on long-time evolution of Mars' obliquity as a result of an interaction at the IMA. He was also able to interact intensively with William Newman (VIV from UCLA), and is working with him on the use of multi-scale methods in celestial mechanics.

Research collaboration on image segmentation with depth was begun by Selim Esedoglu (IMA postdoc) and Riccardo March (IAC in Rome) during March's visit to the IMA. This has lead to a new method for image segmentation which has application in computer vision.

Daniel Kern (IMA postdoc) visited Mary Wheeler and Clint Dawson at University of Texas as a result of interacting with them at the IMA during the Geosciences program. The visit has provided Kern with new research directions.

During an IMA workshop on inverse problems, Yvonne Ou (IMA postdoc) heard a talk by Elena Cherkaeva (Utah) on inverse problems in electromagnetics homogenization theory. They are now collaborating on applying similar ideas to acoustic problems. Dr. Ou also started a collaboration with Valera Chtchekbakov (Moscow) and Robert Gilbert (Delaware) as a result of interacting with Chtchekbakov at the IMA.

IMA visitor Gerard Besson (CNRS France), Matti Lassas (Nevanlinna Institute) and Yaroslav Kurylev (Loughborough) started a project on a new geometric approach to analyzing inverse boundary problems. A new work on homogenization applied to geometry is a direct result of conversations Besson had with Shari Moskow (Florida) at the IMA.

During their visit, IMA VIVs William Newman (UCLA) and Donald Turcotte (Cornell), and graduate student Robert Sherbakov (Cornell) developed a new model for micro- and macroscopic rock fracture.

Andrei Gabrielov of Purdue was very active and interactive during his month visit to the IMA in fall 2001. He started several new collaborations, involving Don Turcotte (Cornell), Vladimir Keilis-Borok (UCLA), Ilya Zaliapin (UCLA), Susan Friedlander (University of Illinois at Chicago), Mikhail Visik (University of Texas), Vladimir Kossobokov (Russian Academy of Sciences), Eugenia Kalnay (University of Maryland), James Yorke (University of Maryland), and Robert Sherbakov (Cornell), in various combinations. Projects include the development of a new tool called "multiscale trend analysis" to decompose time series into hierarchies of linear trends at various scales; the application of averaging techniques developed for earthquake prediction to weather forecasting; an analysis of scale invariance in crime data using techniques adapted from seismology; and the use of wavelet methods for the analysis of meteorological and seismological data. These research program, which were started at the IMA, hold promise to advance weather prediction, earthquake prediction, and possibly even the prediction of crime waves.

Of course many insights gained through informal interactions catalyze important work without leading to formal collaborations. For example, IMA visitor Alexey Kaplan (Columbia University)

was greatly influenced by his discussions with Alberto Malinverno (Schlumberger), Robert Parker (Scripts Institute) and George Papanicolaou (Stanford), and, as a result, has begun a new approach to simulation and assimilation of data.

Similarly, IMA visitor Peter Lynch (Met Eireann, Ireland) discussed solar system dynamics with Michael Efroimsky (IMA postdoc) and as a result began studying the law of distribution of planets. He has also developed a mechanistic model of the El Niño phenomenon as a result of conversations with George Sell (Minnesota) at the IMA.

Inspired by the IMA workshop on Network Dynamics, Andrew Odlyzko (Minnesota), to start a project within Digital Technology Center at the University of Minnesota, which he directs, to exploit current and historical records of the campus data network and so gain insight into the evolution of the Internet.

During discussions with fellow IMA visitor Yves Gueguen (ENS Paris), Tom Pence (Michigan State) realized that his work in continuum mechanics is applicable to certain challenging problems in geomechanics. He reports that he is investigating new research directions as a result.

Dacian Daescu (IMA postdoc) was awarded a Research Scholarship by the Minnesota Supercomputing Institute to further develop and implement the new algorithms for data assimilation of chemical pollutant plumes resulting from his research at the IMA.

With 3M scientists, IMA industrial postdoc Aurelia Minut and Deputy Director Fadil Santosa produced a package to compute the behavior of long fiber Bragg gratings. The computational results have been verified against physical experiments. This computational tool has provided 3M scientists with the capability to design long gratings used in wavelength division multiplexing.

IMA postdoc Selim Esedoglu worked with University of Minnesota faculty member Jianhong Shen to develop a new method for repairing damaged digital images based on the Mumford-Shah Euler image model. This method, which improves on existing techniques, has been shown to be quite effective and may become important in application.

The IMA workshop on Wireless Networks was particularly successful in many regards. It drew the largest online registration of any IMA event. It features probability and statistics at the center of this rapidly growing field. The conference was attended by a mix of scientists from academia, industry and government labs.

Irena Lasiecka (University of Virginia), an organizer of the IMA summer program on Geometric Methods in Inverse Problems and PDE Control, reports that the program has not only revealed new geometric approaches to researchers in inverse problems and PDE control but has also generated new research in geometry.

The IMA workshop on Quantification of Uncertainty and Multiscale Phenomena in Subsurface Processes identified the need for error models in subsurface calculations. These error models are important not only for quantifying the accuracy of predictive calculations but also because they play a fundamental role in Bayesian estimation procedure. It is expected that progress in this field will occur rapidly as a result of this workshop. Organizers of the workshop further point to the workshop's success in bridging various gaps between diverse communities represented.

2.10 Demographic data for workshops and tutorials

We list below the gender and race breakdown of the attendees at the IMA workshops, tutorials, hot topics and special workshops, and the mathematical modeling workshop.

<i>Brief program title</i>	<i>Gender</i>		<i>Race</i>				<i>Minority</i>	<i>Total</i>
	<i>male</i>	<i>female</i>	<i>WNH*</i>	<i>BNS*</i>	<i>API*</i>	<i>HSP*</i>		
Geometric methods	70	21	65	1	23	2	26	91
Spatio-temporal patterns	45	9	33	3	16	2	21	54
Complexity in geosciences	34	6	30	2	7	1	10	40
Dynamical systems	43	5	30	2	15	1	18	48
Time series	37	7	23	2	16	3	21	44
Subsurface processes	36	8	28	4	10	2	16	36
Geophysical fluid dynamics	36	7	36	1	5	1	7	43
Numerical methods	42	11	40	2	10	1	13	53
Continuum mechanics	44	8	39	2	10	1	13	52
Inverse problems	43	11	36	2	11	5	18	54
Data assimilation	44	11	40	2	10	3	15	55
Point processes	35	11	35	2	8	1	11	46
Tutorial: Spatio-temporal patterns	37	8	23	3	17	2	22	45
Tutorial: Wavelet methods	24	6	17	1	12	0	13	30
Tutorial: Ray methods	21	3	19	0	5	0	5	24
Tutorial: Inverse problems	24	3	21	1	5	0	6	27
Network dynamics	63	10	46	1	26	0	27	73
Wireless	89	18	50	1	53	3	27	107
Keilis-Borok	31	5	25	2	8	1	11	36
Biocomplexity	31	23	48	0	4	2	6	54
Math modeling	28	17	25	14	1	5	20	45
Numerical relativity	38	7	32	2	7	4	13	45
CUMMULATIVE	895	215	741	50	279	40	369	1110

*WNH=White, non-Hispanic; BNH=Black, non-Hispanic; API=Asian/Pacific Islander; HSP=Hispanic.

2.11 Publications

2.11.1 IMA preprints

The following list of publications represents a fraction of the research output of the IMA. With the advent of web-based dissemination of papers, the need for and interest in preprint series like the IMA's has decreased. Nevertheless, many IMA visitors and members still submit their papers for posting on the IMA web page due to its wide reach. Below are the preprints in the series from 2001–2002, each preceded by its IMA preprint number.

- 1795 Bin Han, Computing the smoothness exponent of a symmetric multivariate refinable function.
- 1796 Bin Han, The initial functions in a subdivision scheme
- 1797 Jianliang Qian and William W. Symes, An adaptive finite-difference method for traveltimes and amplitudes
- 1798 Xiaobing Feng and Andreas Prohl, Numerical analysis of the Cahn-Hilliard equation and approximation for the Hele-Shaw problem, Part I: Error analysis under minimum regularities

- 1799 Xiaobing Feng and Andreas Prohl, Numerical analysis of the Cahn-Hilliard equation and approximation for the Hele-Shaw problem, Part II: Error analysis and convergence of the interface
- 1800 Tuncay Aktosun and James H. Rose, Wave focusing on the line
- 1801 Peter J. Olver, Jan A. Sanders, and Jing Ping Wang, Ghost symmetries
- 1802 T. Craig Poling and Aleksandar Zatezalo, Interferometric GPS ambiguity resolution
- 1803 Sungwhan Kim, Ohin Kwon, Jin Keun Seo, and Jeong-Rock Yoon, On a nonlinear partial differential equation arising in Magnetic Resonance Electrical Impedance Tomography
- 1804 Jianliang Qian and William W. Symes, Finite-difference quasi-P traveltimes for anisotropic media
- 1805 KyungKeun Kang and Seick Kim, On the Hölder continuity of solutions of a certain system related to Maxwell's equations
- 1806 Shantanu D. Rane, Jeremiah Remus, and Guillermo Sapiro, Wavelet-Domain Reconstruction of Lost Blocks in Wireless Image Transmission and Packet-Switched Networks
- 1807 Dirk Blömker, Jinqiao Duan, and Thomas Wanner, Enstrophy dynamics of stochastically forced large-scale geophysical flows
- 1808 Hongjun Gao and Jinqiao Duan, Dynamics of the thermohaline circulation under wind forcing
- 1809 Takashi Takiguchi, A generalization of Helgason's support theorem
- 1810 Biao Ou, Examinations on a Three-Dimensional Differentiable Vector Field That Equals its Own Curl
- 1811 I. Perugia, D. Schötzau, and P. Monk, Stabilized interior penalty methods for the time-harmonic Maxwell equations
- 1812 Selim Esedoglu and Jianhong Shen, Digital inpainting based on the Mumford-Shah-Euler image model
- 1813 Robert P. Gilbert and Miao-jung Ou, A uniqueness theorem of the 3-dimensional acoustic scattering problem in a shallow ocean with a fluid-like seabed
- 1814 Debra Lewis and Peter J. Olver, Geometric integration algorithms on homogeneous manifolds
- 1815 Michael Efroimsky, Euler, Jacobi, and missions to comets and asteroid
- 1816 Hongjun Gao and Jinqiao Duan, Dynamics of quasi-geostrophic fluid motions with rapidly oscillating Coriolis force
- 1817 Xiaobing Feng and Andreas Prohl, Analysis of a fully discrete finite element method for the phase field model and approximation of its sharp interface limits
- 1818 Lalit Mohan Upadhyaya and H.S. Dhami, Matrix generalizations of multiple hypergeometric functions
- 1819 Kyungkeun Kang, On regularity of stationary Stokes and Navier-Stokes equations near boundary
- 1820 Hongjun Gao and Jinqiao Duan, Dynamics of a coupled atmosphere-ocean model
- 1821 Lalit Mohan Upadhyaya and H.S. Dhami, On some multiple hypergeometric functions of several matrix arguments
- 1822 Jinqiao Duan, Kening Lu, and Björn Schmalfuss, Invariant manifolds for stochastic partial differential equations
- 1823 Selim Esedoglu, Stability properties of Perona-Malik scheme
- 1824 Antonin Chambolle and Fadil Santosa, Control of the wave equation by time-dependent coefficient
- 1825 Jessica Conway, From 2-D to 3-D: Algorithms to recreate a real-world scene from flat photographs
- 1826 Kyungkeun Kang, Regularity of axially symmetric flows in a half-space in three dimension
- 1827 Facundo Mmoli, Guillermo Sapiro, and Stanley Osher Solving variational problems and partial differential equations mapping into general target manifolds
- 1828 Michael Efroimsky, Mechanical alignment of suprathreshold paramagnetic cosmic-dust granules: the cross-section mechanism

- 1829 Tony F. Chan and Jianhong Shen, A good image model eases restoration - on the contribution of Rudin-Osher-Fatmi's BV image model
- 1830 Jinqiao Duan, Hongjung Gao, and Björn Schmalfuß, Stochastic dynamics of a coupled atmosphere-ocean model
- 1831 Sren Bartels and Andreas Prohl, Multiscale resolution in the computation of crystalline microstructure
- 1832 Lalit Mohan Upadhyaya and H.S. Dhimi, On Kamp De Friet and Lauricella functions of matrix arguments - I
- 1833 Long Wang, Frequency response of uncertain systems: strong Kharitonov-like results
- 1834 Long Wang, Wensheng Yu, and Lin Zhang, On the number of positive solutions to a class of integral equations
- 1835 Long Wang, Performance evaluation of switched discrete event systems
- 1836 Lalit Mohan Upadhyaya and H.S. Dhimi, On Lauricella and related functions of matrix arguments-II
- 1837 Kyungkeun Kang, Unbounded normal derivative for the Stokes system near boundary
- 1838 Peter Lynch, Hamiltonian methods for geophysical fluid dynamics: an introduction
- 1839 Long Wang, Zhizhen Wang, and Wensheng Yu, Stability of polytopic polynomial matrices
- 1840 Long Wang, A recipe for construction of the critical vertices for left-sector stability of interval polynomial
- 1841 Long Wang and Wensheng Yu, Geometric characterization of strictly positive real regions and its applications
- 1842 Long Wang, Robust performance of a class of control systems
- 1843 Long Wang and Wensheng Yu, Robust SPR synthesis for low-order polynomial segments and interval polynomials
- 1844 Michael Efroimsky, Equations for the Keplerian elements: Hidden symmetry as an unexpected source of numerical error
- 1845 E.G. Kalnins, G.C. Williams, W. Miller, Jr., and G.S. Pogosyan, On superintegrable symmetry-breaking potentials in N-dimensional Euclidean space
- 1846 E.G. Kalnins, J.M. Kress, G. Pogosyan, and W. Miller, Jr., Complete sets of invariants for dynamical systems that admit a separation of variables
- 1847 Donald L. Turcotte, William I. Newman, and Robert Shcherbakov, Micro- and macro-scopic models of rock fracture
- 1848 Lalit Mohan Upadhyaya and H.S. Dhimi, Appel's and Humbert's functions of matrix arguments - I
- 1849 Leonid Berlyand and Alexei Novikov, Error of the network approximation for densely packed composites with irregular geometry
- 1850 Kyungkeun Kang, On boundary regularity of the Navier-Stokes equations
- 1851 Jianhong Shen, Weber's law and weberized TV restoration
- 1852 G. Seregin and V. Sverák, The Navier-Stokes equations and backward uniqueness
- 1853 Lalit Mohan Upadhyaya and H.S. Dhimi, Appel's and Humbert's Functions of Matrix Arguments - II
- 1854 G.C. Hsiao and N. Nigam, A transmission problem for fluid-structure interaction in the exterior of a thin domain
- 1855 Jianhong Shen, On some quantum and analytical properties of fractional Fourier transforms
- 1856 Lalit Mohan Upadhyaya and H.S. Dhimi, Humbert's functions of matrix arguments-I
- 1857 Kiwoon Kwon and Dongwoo Sheen, Anisotropic inverse conductivity and scattering problems
- 1858 Peter Lynch, On the significance of the Titius-Bode Law for the distribution of the planets

- 1859 P.F. Tupper, Constructing stationary Gaussian processes from deterministic processes with random initial conditions
- 1860 Guillermo Sapiro, Is image steganography natural?
- 1861 Andrs Sol, Vicent Caselles, Guillermo Sapiro, and Francisco Arndiga, Morse description and geometric encoding of digital elevation maps

2.11.2 IMA Volumes

The IMA has long published a series of volumes, generally connected to its workshops. It is our belief that developments in electronic dissemination have greatly decreased the need for volumes published primarily for their archival value. Therefore, we have agreed with our publisher, Springer-Verlag, to limit the publication of future volumes to cases where materials of particular value, such as tutorial volumes, or state-of-the-art survey volumes, can be produced and similar high quality material does not exist. Our more recent volumes are indeed of this nature, and their value has been confirmed by improved sales. In the future there will be fewer volumes per year, but they will be higher quality and of more lasting value.

Volume 123: Codes, Systems, and Graphical Models. Editors: Brian Marcus and Joachim Rosenthal.

Volume 124: Computational Modeling in Biological Fluid Dynamics. Editors: Lisa J. Fauci and Shay Gueron.

Volume 125: Mathematical Approaches for Emerging and Reemerging Infectious Diseases: An Introduction. Editors: Carlos Castillo-Chavez with Sally Blower, Pauline van den Driessche, Denise Kirschner, and Abdul-Aziz Yakubu.

Volume 126: Mathematical Approaches for Emerging and Reemerging. Infectious Diseases: Models, Methods and Theory. Editors: Carlos Castillo-Chavez with Sally Blower, Pauline van den Driessche, Denise Kirschner, and Abdul-Aziz Yakubu.

Volume 127: Mathematics of the Internet: E-Auction and Markets. Editors: Brenda Dietrich and Rakesh V. Vohra.

Volume 128: Decision Making Under Uncertainty: Energy and Power. Editors: Claude Greengard and Andrzej Ruszczynski.

Volume 129: Membrane Transport and Renal Physiology. Editors: Harold E. Layton and Alan M. Weinstein.

Volume 130: Atmospheric Modeling. Editors: David P. Chock and Gregory R. Carmichael.

Volume 131: Resource Recovery, Confinement, and Remediation of Environmental Hazards. Editors: John Chadam, Al Cunningham, Richard E. Ewing, Peter Ortoleva, and Mary Fanett Wheeler.

Volume 132: Fractals in Multimedia. Editors: Michael F. Barnsley, Dietmar Saupe, and Edward Vrscay.

Volume 133: Mathematical Methods in Computer Vision. Editors: Peter J. Olver and Allen Tannenbaum.

3 Governance

3.1 Board of governors

The IMA Board of Governors oversees the IMA, provides a major source of input for its programs, and approves all major activities. and guides the IMA on its major activities. It is an important source of input and advice to the IMA. The members in the 12-member board serve for 3 years. The board meets once per year at the IMA, this year on October 13–14, 2001. New members to the board are elected by the current board. This year the board elected Richard James of the University of Minnesota, James Sethian of UC Berkeley, and Dimitris Bertsimas of MIT.

<i>Name</i>	<i>Affiliation</i>	<i>Expertise</i>
Marsha Berger	Courant Institute, NYU	Scientific Computing
Dimitris Bertsimas	MIT	Operations Research
Joan Feigenbaum	Yale University	Computer Science
Bill Gear	NEC Research Institute	Computer Science
Fan Chung Graham	UC San Diego	Mathematics
Richard James	University of Minnesota	Mechanics
Jon Kettenring	Telcordia Technologies	Statistics
Thomas G. Kurtz	University of Wisconsin	Mathematics
James Sethian	UC Berkeley	Mathematics
De Witt Sumners	Florida State University	Mathematics
William W. Symes	Rice University	Mathematics
James A. Yorke	University of Maryland	Mathematics

3.2 Industrial advisory board

Representatives appointed by the the IMA Participating Corporations constitute the IMA Industrial advisory board. This board is also an important source of input and advice to the IMA. The board meets annually.

<i>Name</i>	<i>Affiliation</i>	<i>Expertise</i>
Gerard van Oortmerssen	Centrum voor Wiskunde en Informatica	Computer science
David Chock	Ford Motor Company	Chemistry
Samuel P. Marin	General Motors Corporation	Mathematics
Tariq Samad	Honeywell	Electrical engineering
Brenda Dietrich	IBM Corporation	Mathematics
T. Craig Poling	Lockheed Martin	Physics
Lawrence Cowsar	Lucent Technologies	Mathematics
Leonard Borucki	Motorola	Mathematics
Lalitha Venkataramanan	Schlumberger-Doll Research	Physics
Albert Gilg	Siemens	Mathematics
Jon Kettenring	Telcordia Technologies	Statistics
David Misemer	3M	Physics
David H. Sharp	Los Alamos National Laboratory	Mathematics
Gregory Shubin	Boeing Aircraft Company	Mathematics
Michiel Bertsch	Istituto per Applicazione di Calcolo	Mathematics
David Womble	Sandia National Laboratories	Mathematics

3.3 PI math department representatives

Each IMA Participating Institution appoints a representative to the IMA, most commonly the chair of the Mathematics department. This body meets once a year and is consulted on all major activities of the IMA. The PI representative meet annually with the IMA directors. This year, due to the NSF VIGRE meeting, the meeting was held in Reston, Virginia on May 4, 2002.

<i>Name</i>	<i>Affiliation</i>
Richard Duke	Georgia Institute of Technology
Dan Maki	Indiana University
Justin Peters	Iowa State University
Andrew Tonge	Kent State University
Peter Bates	Michigan State University
Ratnasingham Shivaji	Mississippi State University
William Blair	Northern Illinois University
Peter March	Ohio State University
Gary Mullen	Pennsylvania State University
Leonard Lipshitz	Purdue University
William Rundell	Texas A&M University
Kevin Corlette	University of Chicago
Timothy Hodges	University of Cincinnati
Bill Fitzgibbon	University of Houston
Joseph Rosenblatt	University of Illinois
David Manderscheid	University of Iowa
Peter Perry	University of Kentucky
Ronald Gariepy	University of Kentucky
Dan Rudolph	University of Maryland
Alejandro Uribe	University of Michigan
Naresh Jain	University of Minnesota
Steven Buechler	University of Notre Dame
John Chadam	University of Pittsburgh
Alejandro Adem	University of Wisconsin
Lowell Hansen	Wayne State University

3.4 Administration and Staff

The IMA is run by its directors and staff. The Director, Douglas N. Arnold, who began his term at the end of August 2002, gave up the position of Distinguished Professor of Mathematics at Penn State to lead the IMA. He appointed Fadil Santosa, who had been involved in IMA administration before, to the position of full-time Deputy Director, and Robert Gulliver, who had served as Deputy Director in the past, to a half-time position as Associate Director. In September 2002 Scot Adams will replace Gulliver as Associate Director and the position will become full-time.

The IMA staff consists of 10 full-time employees assisted by a couple of part-time student employees. The Business Office is supervised by Kathy Boyer, Senior Administrative Director. Other members are Georgia Kroll, Workshop Coordinator; Judy Sweeney, Workshop Specialist; Mavis Swanson, Workshop Assistant; and Orbe Walther, Housing/Workshop Coordinator. Ines Foss single-handedly manages the IMA Accounting Office. The Computer Systems Office consists of Kumsup Lee, Systems Manager, and Chad Walstrom, Assistant Systems Manager. The Publications Office, also responsible for the IMA web space, consists of Patricia Brick, Information Technology Professional, and Dzung Nguyen, Applications Programmer.

Logistic support was perfect. The organization of the meeting was truly flawless. We felt like the entire staff of IMA was at our disposal. This included computer experts and technicians who were willing to help with all kinds of problems encountered (some of them highly nontrivial) during our stay at IMA. To be honest, many of us do not have similar support in our own departments. The IMA staff has displayed a high level of professionalism. – Irena Lasiecka, Department of Mathematics, University of Virginia

The IMA facilities and staff are second to none. I am very impressed with the professional way in which this IMA event was run, and have not seen a smoother process at any other meeting of this type. I think that the IMA should serve as a model to other mathematics institutes around the world for the “right way” that programmes of this type should be run. – John Stockie, Mathematics and Statistics, University of New Brunswick

The logistics were handled exceptionally well; it was probably the best-run meeting I have ever attended. The IMA staff was extremely helpful and I can't think of anything that should be changed. – John Knox, Biological and Agricultural Engineering, University of Georgia

4 Planning and outreach

4.1 Program planning

A major activity for the IMA directors is program planning. The directors work with a wide variety of volunteer organizers from the mathematical sciences and other communities to determine the best topics programs, and to arrange the best possible programs.

4.1.1 Annual Programs

The themes for annual programs for the next 4 years have been set. The programs are in various stages of planning.

2002-3: Optimization

The Optimization program was approved by IMA's Board of Governors in October 1999. The program was proposed to the IMA by a committee consisting of

- John Birge, Northwestern University,
- Thomas Coleman, Cornell University,
- William Cook, Princeton University,
- Brenda Dietrich, IBM Watson Research Center,
- William Pulleyblank, IBM Watson Research Center, chair,
- Prabhakar Raghavan, Verity.

The program is structured into 3 main parts:

Fall Quarter Supply Chain and Logistics Optimization

Winter Quarter New Optimization Paradigms and Approaches

Spring Quarter Information Technology and Optimization

Mathematical Optimization is experiencing substantial advances. Developments in the underlying methods include, for example, the emergence of interior methods for both linear and nonlinear optimization problems, the rediscovery of cuts as an effective tool for solving general integer programs, as well as for structured problems, and the emergence of new methods such as positive semidefinite programming which attack a broad variety of discrete and continuous problems. The problems being studied are much larger than before and the computing platforms are orders of magnitude more powerful.

At the same time, there are new and important application areas for optimization. The Annual Program has been designed to address 3 such areas. The first quarter of the Annual program will focus on the rapidly evolving area of supply chain, transportation and logistics optimization, as well as advances in integer programming. These are some of the fields placing increasingly large demands on the mathematical methods, as well as driving a focus on stochastic optimization and the notion of robustness.

In the second quarter, the program concentrates on simulation-based optimization. This field has become more important with the advent of better simulation tools, such as in aerodynamics,

crash simulations, and other physical phenomenon. Another area of focus is robust optimization and semi-definite programming, where there has been progress.

The innovative third quarter will deal with the connections between optimization and information technology. Application areas include network design and optimization, and optimization methods in search strategies. These are areas that are proving to be increasingly important and in which there are numerous opportunities for mathematical techniques, and so are likely to benefit significantly from a period of focus at the IMA.

The VIV (Very Important Visitors) for the year are

<i>Name</i>	<i>Home institution</i>	<i>Expertise</i>	<i>Visit</i>
Collette Coullard	Northwestern	Oper Res	9 months
John Dennis	Rice Univ	App Math	3 months
Mike Powell	Cambridge	App Math	3 months
Maurice Queyranne	British Columbia	Oper Res	3 months
Luis Goddyn	Simon Fraser	Math	3 months

Workshops during the Optimization year are:

1. The Role of Optimization in Supply Chain Management, September 23-27, 2002. Organizers: Brenda Dietrich (IBM), David Simchi-Levi (MIT), and George Nemhauser (GA Tech).
2. Computational Methods for Large Scale Integer Programs, October 23-27, 2002. Organizers: William Cook, Martin Savelsbergh, and George Nemhauser (all from GA Tech).
3. Travel and Transportation, November 11-15, 2002. Organizers: Ranga Anbil (IBM), Cynthia Barnhart (MIT), Ellis Johnson (GA Tech), William Pulleyblank (IBM).
4. Optimization in Simulation-Based Models, January 9-16, 2003. Organizers: Andrew Conn (IBM), Omar Ghattas (Carnegie Mellon), Jorge Nocedal (Northwestern), and Fadil Santosa (Minnesota).
5. Semidefinite Programming and Robust Optimization, March 12-19, 2003. Organizers: Donald Goldfarb (Columbia), Michael Todd (Cornell), Michael Overton (NYU), Michel Goemans (MIT), and Laurent El Ghaoui (UC Berkeley).
6. Network Management and Design, April 7-12, 2003. Organizers: Daniel Bienstock (Columbia University), Tami Carpenter (Telcordia), David Johnson (AT&T), Clyde Monma (Telcordia), Bruce Shepherd (Lucent).
7. Data Analysis and Optimization, May 7-13, 2003. Organizers: Ravi Kannan (Yale), Jon Kleinberg (Cornell), Prabhakar Raghavan (Verity), Christos Papadimitriou (Berkeley), organizers.

The following tutorials will be offered during the annual program.

1. Supply Chain and Logistics Optimization, September 9-12, 2002. Organizers: Cynthia Bardhardt (MIT), David Shimchi-Levy (MIT).
2. Industrial Strength Optimization, January 6-7, 2003. Organizer: John Dennis (Rice).

3. Optimization in Simulation-Based Models, January 8, 2003. Organizer: Jorge Nocedal (Northwestern)
4. Semidefinite Programming and Robust Optimization, March 11, 2003. Organizer: Mike Todd (Cornell).
5. Network Management and Design, Sunday, April 6, 2003. Organizer: Tami Carpenter (Telcordia).
6. Data Analysis and Optimization, Monday, May 5, 2003. Organizers: Jon Kleinberg (Cornell) and Andrew Tomkins (IBM).

2003-04: Probability and Statistics in Complex Systems: Genomics, Networks, and Financial Engineering. This annual program is organized by Marco Avellaneda (NYU), Bruce Hajek (Illinois), Richard Karp (UC Berkeley), Sallie Keller-McNulty (Los Alamos National Labs), Tom Kurtz (Wisconsin), Andrew Lo (MIT), and Michael Newton (Wisconsin). A total of 9 workshops and 3 tutorials have been planned for this program. Organizers and date for these events are already set. The IMA has already started contacting senior researchers in this field for possible visits as VIVs. Details will soon appear on the IMA web page.

2004-05: Mathematics of Materials and Macromolecules: Multiple Scales, Disorder, and Singularities. The proposal for this program has been approved by the Board of Governors. The organizers for the program are: Maria Carme T. Calderer (Minnesota), Richard D. James (Minnesota), Robert V. Kohn (NYU), Mitchell Luskin (Minnesota), John H. Maddocks (Lausanne), Rob Phillips (Caltech), James P. Sethna (Cornell), and Chris Wolverton (Ford). An outline of the program is available on the IMA web page.

2005-06: The Board of Governors has given approval to the IMA to develop an annual program in the area of imaging science.

4.1.2 Summer programs

2002: Special Functions in the Digital Age, July 22-August 2, 2002. Organizers: George Andrews (Penn State), Richard Askey (University of Wisconsin), Carl de Boer (University of Wisconsin), Arieh Iserles (University of Cambridge), Daniel Lozier (NIST), Willard Miller (University of Minnesota), Frank Olver (University of Maryland), Peter Olver (University of Minnesota), and Peter Paule (University of Linz). The purpose of this program is to formulate, through concrete examples and experiences, the role and character of digital libraries in mathematics, and the mathematical and applied fields that would benefit from such a library. The workshop is to have a very broad outlook, encompassing a wide range of subjects connected with special functions, as well as issues concerning digital libraries and the delivery of mathematics over the internet. A major portion of this program will be assessments of research progress and promising vistas for future research by distinguished experts in a variety of areas, with the aim of pointing out what is of greatest importance in the theory and applications, and what should be included in digital library projects. The remainder of the program will be devoted to Digital Libraries generally and, specifically, Digital Libraries and the Mathematical Sciences, including the delivery of mathematics over the Internet.

2002: The IMA will host the *Foundations of Computational Mathematics conference*, FoCM'02, from August 5-14, 2002. The conference is organized by Society for Foundations of Computational

Mathematics and will include plenary invited lectures in the mornings and theme-centred parallel workshops in the afternoons.

2003: Probability and Partial Differential Equations in Modern Applied Mathematics, Jul 28–Aug 8, 2003. Organizers: Edward C. Waymire (Oregon State) and Jinqiao Duan (Illinois Institute of Technology). This summer program will be devoted to the role of probabilistic and random dynamical systems methods in modern applied mathematics from perspectives of both a tool for analysis and in modeling. The first week of the workshop will be devoted to probabilistic methods for Navier-Stokes equations, while the second week will be devoted to the analysis random dynamics and stochastic PDE.

2004: The IMA is working with Peter May of the University of Chicago and John Baer of UC Riverside to plan an IMA summer program on n -categories and their applications in 2004.

4.1.3 Hot topics and special workshops

Hot topics and special workshops are usually organized quickly to take advantage of special opportunities. They are often organized in partnership with another interested organization. The following workshops are currently being planned.

1. Operational Modeling and Biodefense: Problems, Techniques, and Opportunities, September 28, 2002. This meeting, which will be cosponsored with the Society of Industrial and Applied Mathematics, will take place the day after the IMA workshop on the Role of Optimization in Supply-Chain Management, in order to benefit from the experts who will be assembled at the IMA for that workshop. The workshop will bring together a diverse group of scientists, engineers, and others from fields such as operations research, decision science, mathematics, economics, epidemiology, infectious disease, and public health to explore the use of mathematical techniques in countering the threat of terrorism.
2. Data-driven Control and Optimization, October 7-9, 2002. This workshop is being planned in conjunction with Honeywell.
3. Joint IMA/CRM Workshop: Distribution Systems: Location and Vehicle Routing, December 2-6, 2002. This workshop, which will be integrated into the IMA annual program on Optimization, is jointly sponsored with the Centre de recherches mathématiques and the Centre de recherche sur les transports, and will be held at the University of Montreal.

4.1.4 Programs for graduate students

Mathematical Modeling: In the past the IMA Mathematical Modeling Workshop for Graduate Students ran once every two years. However this program has been so successful, and the competition for places so intense, that we will be offering it again in 2003. For 2003, the IMA will join forces with PIMS (Pacific Institute for Mathematical Sciences) to offer a two-part program. The first part, which is offered as a training course lasting a week, will take place at the Banff International Research Station. The second part, which will involve solving problems posed by industry, will most likely take place in Seattle, Washington.

PI graduate student summer program: For 2003, the IMA plans to run a 4-week program in discrete mathematics and its applications on the campus of Georgia Tech. The lead organizer for the course is William Trotter.

4.1.5 PI conferences

Below is the list of IMA Participating Institutions conferences selected for the academic year 2003.

1. *Fifteenth International Symposium on Mathematical Theory of Networks and Systems*, August 12-16, 2002, University of Notre Dame. Symposium Chair: Joachim Rosenthal (Notre Dame).
2. *Topics in Linear Algebra*, September 13-14, 2002, Iowa State University. Leslie Hogben (Iowa State), Bryan Cain (Iowa State), Luz DeAlba (Drake), Irvin Hentzel (Iowa State), Mark Mills (Central College), Y. T. Poon (Iowa State), Huaiqing Wu (Iowa State)
3. *Current Trends in Mathematics and its Applications: A Conference in Honor of Avner Friedman's 70th Birthday*, November 8-10, 2002, University of Minnesota. Organizers: N. Jain, N. Krylov, W. Littman, F. Reitich, and F. Santosa (all from Minnesota)
4. *Image Processing and Computational Methods*, March 21-23, 2003 University of Kentucky. Organizers: Seongjai Kim, Peter Hislop, Sung Ha Kang, Daniel L. Lau, and Brent Seales (all from Kentucky).
5. *Automorphic Representations, L-functions and Applications: Progress and Prospects*, March 27-30, 2003, Ohio State University. Organizers: James Cogdell (Oklahoma State), Dihua Jiang (Minnesota), Stephen Kudla (Maryland), and Robert J. Stanton (Ohio State).
6. *Free Boundary Problems in Partial Differential Equations and Applications*, May 26-30, 2003, Wayne State University. Organizers: Guozhen Lu and Pau Liu (both from Wayne State).
7. *23rd Annual Great Plains Operator Theory Symposium*, May 28-June 1, 2003, University of Illinois at Urbana-Champaign. Organizers: Forin Boca, Marius Runge, and Zhongjin Ruan (all from Illinois).
8. *Conference of African American Researchers in the Mathematical Sciences (CAARMS9)*, June 24-27, 2003, Purdue University. Organizers: William Massey (Princeton), Carl Cowen (Purdue), Johnny Brown (Purdue), and Rodrigo Banuelos (Purdue).
9. *Summer School on Applications of Advanced Mathematical and Computational Methods to Atmospheric and Oceanic Problems (MCAO 2002)*, July 13-26, 2003, National Center for Atmospheric Research (NCAR). Organizers: Roger Temam (Indiana), Joel Tribbia (NCAR), and Shouhong Wang (Indiana).
10. *International Conference on Computability and Complexity in Analysis*, August 28-30, 2003, University of Cincinnati. Organizers: Kenneth Meyer, Bingyu Zhang, Dieter Schmidt, and Ning Zhong (all from Cincinnati).

4.1.6 Postdoctoral program

For the Optimization annual program, 2002-3, the following postdocs will be in residence at the IMA. The hiring committee consisted of Douglas Arnold, Brenda Dietrich (IBM), William Cook (Princeton), Michael Todd (Cornell), Fadil Santosa, and Vladimir Sverak (Minnesota).

<i>Name</i>	<i>PhD</i>	<i>Department</i>
Olga Brezhneva	Russian Academy of Sciences 2000	Mathematics
Lisa Evans	Georgia Tech 2002	Ind. & Sys. Engrg.
Balaji Gopalakrishnan	Georgia Tech 2002	Ind. & Sys. Engrg.
Jing Wang	Univ. Minnesota 2002	Mathematics
Tamon Stephen	Univ. Michigan 2002	Mathematics
Hervé Kerivin	Univ. Blaise Pascal 2000	Mathematics

In addition, we have 4 new industrial projects starting in the fall of 2002, and the following industrial postdocs have been hired.

<i>Name</i>	<i>PhD</i>	<i>Mathematics</i>	<i>Company</i>
Bilgin Altundas	Pittsburgh 2002	Mathematics	Schlumberger
Lili Ju	Iowa State 2002	Mathematics	US Veteran's Hospital
Haewon Nam	Texas A&M 2002	Mathematics	General Electric
Jun Zhao	Texas A&M 2002	Mathematics	Schlumberger

Returning second year postdocs, many of whom will be involved in the Optimization program, are Dacian Daescu, Gregory Duane, Michael Efroimsky, Daniel Kern, Yvonne Ou, Toshio Yoshikawa. See Section 2.6.1. for more details of their activities.

We are fortunate that Don Aronson agreed to serve as Director of Postdoctoral Program starting in fall 2002. He will take charge of the mentor-postdoc pairings, the IMA postdoc seminars, and coordinating follow-up with the mentors, and will take part in the postdoc selection. We expect the program to further improve under his leadership.

4.2 Outreach

4.2.1 Participation by mathematicians from underrepresented groups

The IMA has been working with a consortium called the Joint Alliance for Minorities in Mathematics (JAMM) to encourage participation in IMA activities by mathematicians from underrepresented groups. The primary goal of JAMM is to substantially increase the participation of minorities in research and education related activities throughout the mathematical community, with special emphasis on those that provide real-world problems arising in industry and government labs. The IMA consults the leaders of JAMM, Ray Johnson (Maryland) and James Turner (Florida State) for suggestions of minority mathematicians who should be contacted about specific programs at the IMA. In addition, the IMA is mounting career workshops on connecting young minority mathematicians with industry and government labs (such as the programs held at the IMA in 1996 and 2001).

4.2.2 Participation by women mathematicians

In order to increase participation of women mathematicians in IMA programs, the IMA is collaborating with the Association for Women in Mathematics (AWM). The AWM has formed a committee consisting of Suzanne Lenhart (Tennessee), Joan Feigenbaum (Yale), Pamela Cook (Delaware) and Denise Kirschner (Michigan), charged with identifying women mathematicians who should be contacted by the IMA on specific activities. This mechanism has proven to be quite effective, producing a list of about a dozen names, which later resulted in visits to the IMA. The IMA plans to hold a career workshop for women mathematicians like the one held at the IMA in the fall of 2000.

4.2.3 Director visits to academic institution, government labs and industry

During the reporting period, the IMA Director, Deputy Director, or both, visited a number of organizations for the purpose of promoting IMA, encouraging participation in IMA activities, and for soliciting ideas for future programs. Most visits last a full day and involve presentations by the IMA directors and numerous face-to-face meeting. Universities visited include Indiana University, University of Arizona, Rutgers University, University of Wisconsin, University of Stuttgart, University of Utah, University of Chicago, and UCLA. Companies visited include Ford, GM, Telcordia, Lucent, 3M, Honeywell, Signature Bioscience, Corning, Symbol, Donaldson Company, Siemens, Lockheed Martin, IBM. Visits to Sandia National Laboratories, Pacific Institute for Mathematical Sciences, NSF, ONR, and DARPA were also made.

4.3 Dissemination

The IMA has an extremely extensive web space with vast amounts of information about its past and future programs, and products of its activities such as lecture notes, slides, preprints, video, etc. The following table gives an account of the usage of IMA's web pages.

<i>Daily average</i>					<i>Monthly total</i>					
<i>Month</i>	<i>Hits</i>	<i>Files</i>	<i>Pages</i>	<i>Visits</i>	<i>Sites</i>	<i>KBytes</i>	<i>Visits</i>	<i>Pages</i>	<i>Files</i>	<i>Hits</i>
Jun 2002	37,563	29,928	13,018	2,252	37,580	20,696,939	54,051	312,454	718,279	901,529
May 2002	58,251	49,463	26,841	3,467	76,277	43,510,359	107,502	832,073	1,533,376	1,805,809
Apr 2002	83,401	74,428	54,706	2,618	52,757	49,554,281	78,560	1,641,186	2,232,866	2,502,053
Mar 2002	53,702	32,631	27,440	2,590	50,709	26,913,775	80,317	850,662	1,011,566	1,664,764
Feb 2002	41,950	33,861	15,226	2,535	45,247	20,859,911	70,981	426,340	948,134	1,174,606
Jan 2002	36,957	29,494	12,963	2,285	45,432	21,650,967	70,853	401,866	914,335	1,145,689
Dec 2001	35,406	28,438	14,471	2,218	40,069	29,378,928	68,782	448,617	881,590	1,097,594
Nov 2001	73,278	65,534	46,797	2,520	44,157	15,275,8895	75,617	1403,914	1,966,037	2,198,366
Oct 2001	41,354	33,168	14,799	2,441	43,841	21,508,722	75,680	458,785	1,028,234	1,281,994
Sep 2001	37,069	29,696	13,473	2,124	39,670	19,451,991	63,736	404,210	890,892	1,112,093
Aug 2001	35,322	28,987	16,104	2,000	33,766	23,615,558	62,010	499,242	898,609	1,094,999
Jul 2001	29,913	24,384	12,709	1,929	30,810	14,104,889	59,824	394,005	755,915	927,329
<i>Totals</i>						444,005,215	867,913	8,073,354	13,779,833	16,906,825