

Berkeley

Mathematics

Newsletter

A newsletter of the Department of Mathematics and Center for Pure and Applied Mathematics at the University of California at Berkeley

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NEW PERSPECTIVES IN TURBULENCE

G. I. BARENBLATT AND A. J. CHORIN

Turbulent fluid flow surrounds us, in the atmosphere, the oceans, in engineering and biological systems. First recognized by Leonardo, for the past century it has been intensely studied by engineers, mathematicians, and physicists, including giants such as Kolmogorov, Heisenberg, Taylor, Prandtl, and von Kármán. Every advance in a wide collection of subjects, from chaos and fractals to field theory, and every increase in the speed and parallelization of computers, is heralded as ushering in the solution of the "turbulence problem," yet turbulence remains the greatest challenge of applied mathematics as well as of classical physics. In particular, none of the main results of turbulence theory has been derived from first principles such as the equations of fluid mechanics, and all rest on additional assumptions which must

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PROFESSORS ALEXANDRE CHORIN & GRIGORY BARENBLATT

STATE OF THE DEPARTMENT

CHAIR CALVIN MOORE

Let me extend my warmest greetings to the faculty, students, staff, graduates and friends of the Department of Mathematics and the Center for Pure and Applied Mathematics. We have had an unusually good year and I want to bring you up-to-date on our programs and activities.



Lower Division Education

Our innovations in the calculus courses are entering their second year. What we have done in a number of our calculus courses is to replace the traditional two hours of discussion/recitation section by three hours of work in laboratory or workshop setting. (All of this is in addition to three hours of lectures by a senior faculty member.) In the workshops and computer labs, students work in small groups with worksheets and in some cases with computer-based modules, all under the supervision of a Graduate Student Instructor (GSI). This is a much more active learning environment where the students are working

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on challenging problems. The GSI will answer some questions about homework and the lecture, but will spend the majority of time circulating among the groups, keeping them working in the



PROFESSORS DAVID EISENBUD (LEFT) AND MARC RIEFFEL (RIGHT)

right direction and generally facilitating their work. The computer laboratory work is designed especially to help students visualize concepts and problems in calculus; something that has been so difficult to do. Students can also use the computational power of the machine to be able to deal with more realistic problems. The concept of these workshops and computer labs is based on the pioneering work of Uri Treisman here at Berkeley that was so successful for "at risk" students. We reasoned that if Treisman's methods worked so well for these students, it should work equally well for many more students.



PROFESSORS OLE HALD (LEFT) AND ALBERTO GRÜNBAUM (RIGHT)

The innovations have been successful, and in response to questionnaires, the students feel that they are learning more and learning it better. For next year, we are expanding the number of calculus sections where we use these methods. Our work is supported by two National

Science Foundation Grants and by a grant from the General Electric Foundation. We have posted the instructional materials we have developed on our Website (<http://math.berkeley.edu>) and they may be downloaded and used by anyone who is interested. If you do use them, we would especially appreciate your comments on them.

Faculty News

We have added four new regular faculty members this year. Professor Edward Frenkel has come from Harvard University and works in representation theory. Professor David Eisenbud comes from Brandeis University and works in commutative algebra and algebraic geometry. He is also the new Director of the Mathematical Sciences Research Institute (MSRI). Assistant Professor Bjorn Poonen comes from Princeton University and works in number theory. Finally, Professor Grigory Isaakovich Barenblatt, who works in applied mathematics, especially mechanics of fluids and the mechanics of solids, has joined the faculty. Professor Barenblatt occupied several distinguished positions in the Former Soviet Union and most recently was the G.I. Taylor Professor at Cambridge University. See the stories in this newsletter for additional information about these new faculty.

I am pleased to report that Assistant Professors Vera Serganova and Fraydoun Rezakhanlou were promoted to the rank of Associate Professor, with tenure, effective July 1, 1997.

Many of our faculty received honors this year; among them, Professor Grigory Barenblatt who was elected to the National Academy of Sciences and Professor Ken Ribet who was elected to the American Academy of Arts and Sciences. This brings to 13 and 21 respectively the number of our faculty who are members of these two Academies. Additionally, Professor Michael Christ received the Stefan Bergman Prize from the American Mathematical Society, and Professor Vel (William) Kahan received the John von Neumann Prize from the Society for Industrial and Applied Mathematics (SIAM).



PROFESSORS EMERY THOMAS (LEFT) AND LESTER DUBINS (RIGHT)

Graduate Program

This fall we enrolled 37 new students, including 9 women, in the Ph.D. program. The students, selected from among 300 applicants, make a very strong group. This year's class is slightly larger than last year's, and total enrollment is up very slightly. We feel we can sustain this increase while maintaining our policy of guaranteeing support to all students for five years, provided they are making good progress in the program. The Mathematics Opportunity Program (MOC) continues in its functions. The Department is committed through outreach, admissions, financial support, and academic advising and support to provide opportunities for graduate mathematics study at Berkeley for students



F. REZAKHANLOU



VERA SERGANOVA

who have demonstrated exceptional mathematical promise despite having encountered in their earlier education limited resources or other circumstances that may have affected their preparation. The Department remains especially interested in helping

women and underrepresented minorities students to successfully complete graduate study at UC Berkeley.

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WELCOME NEW FACULTY

David Eisenbud joined the faculty this July, at the same time he became Director of the Mathematical Sciences



DAVID EISENBUD

Research Institute (MSRI.) Before that he had been on the faculty at Brandeis University for twenty-seven years with sabbatical time spent in Paris, Bonn, and Berkeley (where he was a visitor at MSRI in 86-87 and in 92.) While most of his time is spent at MSRI, he has two thesis students and is teaching a graduate seminar on campus.

Eisenbud's mathematical interests have ranged widely. His first paper was about permutation groups, and his thesis and several subsequent papers were about non-commutative ring theory. His thesis advisors were Saunders MacLane and, unofficially, the English ring-theorist J.C. Robson. After graduating and moving to Brandeis, he turned to commutative algebra, and subsequently to singularity theory, knot theory, and algebraic geometry. Since the early 70s he has used computers to produce examples in algebraic geometry and commutative algebra and has been interested in developing algorithms to extend the power of computation in this area. In recent times he has mainly worked in commutative algebra, algebraic geometry, and computation, but his recent papers include one on a statistical application of algebraic geometry and one on juggling.

Eisenbud's interests outside mathematics include hiking, juggling and, above all, music. Originally a flutist, he now spends most of his musical time singing art-songs: Bach, Schubert, Schumann, Debussy, Britten. Having

left a full circle of musical friends in Boston, he is currently looking for accompanists in Berkeley.

Edward Frenkel was born and received his education in Russia. While doing his undergraduate studies at the Gubkin Institute in Moscow, he attended I.M. Gelfand's seminar at Moscow University and worked with B. Feigin and D. Fuchs. In 1989, upon graduating from college, Frenkel was among the first four people awarded a Harvard Prize Fellowship, a special postdoctoral position at Harvard University created for Russian mathematicians. (Two of the other three people were Nicolai Reshetikhin and Vera Serganova, current faculty in the Mathematics Department at UCB.) The youngest in the group, Frenkel spent a year at Harvard as a postdoc, although he did not have Ph.D. at the time. He enrolled in the Ph.D. program the following year and received a Ph.D. degree from Harvard in 1991. The following three years Frenkel was a Junior Fellow at the Harvard Society of Fellows. From 1994 to 1997 he was Associate Professor of Mathematics at Harvard. He was an invited speaker at the International Congress of Mathematicians in Zurich in 1994.

Frenkel's field is representation theory and its applications in geometry



EDWARD FRENKEL

and mathematical physics. Most recently his research has focused on Langlands type dualities in mathematics and physics. In particular, he has worked on the geometric Langlands correspondence, first proposed by Drinfeld, which relates local systems on algebraic curves and Hecke eigensheaves on the moduli stacks

of bundles on curves.

Frenkel hopes that his moving to California will, among other things, help improve his windsurfing skills, learned first on Corsica, and practiced on Maui.

Bjorn Poonen was born in Boston and grew up in its suburbs. He received an AB summa cum laude in Mathemat-



BJORN POONEN

ics and Physics from Harvard in 1989, and a Ph.D. in Mathematics from UC Berkeley under Ken Ribet in 1994. His three years away from UCB, before accepting an assistant professorship here, were spent at the Mathematical Sciences Research Institute (MSRI) and Princeton University as an NSF Postdoctoral Fellow. During the spring 1998 semester, Poonen will be doing research at the Newton Institute in Cambridge, England as a Rosenbaum Fellow.

Although Poonen's main research is in number theory, he has also written several papers on combinatorics and on random interval packing. His thesis was on Drinfeld modules (one-third of it became "Fractional power series and pairings on Drinfeld modules", *Journal of the American Mathematical Society* vol. 9 (1996), 783-812). More recently he has been developing practical methods for provably finding all the rational points on a curve.

He is one of four people in the 59-year history of the Putnam Competition who has won it four times. In his spare time Poonen is an amateur singer, composer, and arranger of music. Among his more subtle talents is the ability to whistle through his nose with his mouth closed.

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WELCOME VISITING FACULTY

HARUKO BRUCE

Charles B. Morrey Jr. Assistant Professors

The following individuals have been appointed to serve as a Charles B. Morrey Jr. Assistant Professor. These prestigious positions were created in honor of the late Professor Morrey, who was one of America's premier analysts.



YURI BEREST

Yuri Berest received his Ph.D. from the University of Montreal this past spring. His main research interests are in global analysis and analysis on manifolds.

Byunghan Kim received his Ph.D. in 1996 from the University of Notre Dame. Kim's main research interests are in mathematical logic and model theory. This year he was awarded the Sacks Prize for the best thesis in



BYUNGHAN KIM

Mathematical Logic. He will teach in Fall 1997 and will spend the Spring 1998 semester at MSRI as part of a special program in model theory.



ANDRAS VASY

Andras Vasy received his Ph.D. from the Massachusetts Institute of Technology this past spring. His main research interests are in partial differential equations.

NSF Postdoctoral Fellowship Recipient

We are pleased to have **Deborah Hecklen** visit the Department as an NSF Postdoctoral



DEBORAH HEICKLEN

Fellow. Dr. Hecklen received her Ph.D. from the University of Maryland this past summer. Prior to coming to Berkeley, she spent a year in Jerusalem participating in the "Special Year in Ergodic Theory" at Hebrew University while on a Fulbright dissertation fellowship. Her current research interests include classifying measurable dynamical systems.

Visiting Assistant Professor

The Department is honored to have **Theodore Voronov** as a Visiting Assistant Professor this semester. Dr. Voronov received his Ph.D. from Moscow State University in 1989. He taught at the Moscow State University as a Senior Research Fellow before coming to the United States. His research interests include global analysis, analysis on manifolds, differential geometry, and algebraic topology. Ω



THEODORE VORONOV

FACULTY HONORED

Professor Michael Christ Chosen for 1997 Stefan Bergmann Prize

The American Mathematical Society formally announced that **Professor Michael Christ** is one of the two awardees of the 1997 Stefan Bergmann Prize. He



MICHAEL CHRIST

was cited for "major contributions to a number of fields, mainly harmonic analysis, partial differential equations, and several complex variables." The committee cited "particularly striking contributions" in the latter field. We congratulate Michael on this splendid occasion!

(The other award recipient was David Barrett of the University of Michigan.)

Professor Ken Ribet Elected to the American Academy of Arts and Science

Professor Ken Ribet is a number theorist who did path-breaking work on 1-adic representations of Galois groups and modular forms.

In his early work on the converse of Herbrand's Theorem, Ribet revolutionized



KEN RIBET

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FACULTY HONORED

(cont. from page 4)

the classical subject of cyclotomic fields by introducing a technique of great originality, taken from algebraic geometry. In the hands of Mazur and Wiles, this technique led to the proof of the main conjectures on cyclotomic fields.

Ribet is best known for the crucial role that his work played in Wiles' recent proof of Fermat's Last Theorem, until then, the Holy Grail of number theory.

Professor W. Kahan Chosen as 1997 John von Neumann Lecturer

At the 45th annual meeting of SIAM (Society for Industrial and Applied Mathematics) at Stanford University, July 14-18, 1997, **Professor W. Kahan** gave the John von Neumann lecture on



W. KAHAN

Applied Mathematics. The citation presented to him before the lecture reads as follows:

"For (Kahan's) deep and influential contributions to applied mathematics, scientific computing, and computer science. Across the breadth of scientific computing, his profound insights have shaped the field. His energy and persistence have been critical to computing standards that ensure accurate, efficient floating-point computation."

The title Kahan chose for his lecture was: *The baleful effect of computer languages and benchmarking upon Applied Mathematics, Physics, and Chemistry.*

This surprising linkage of inaccuracy

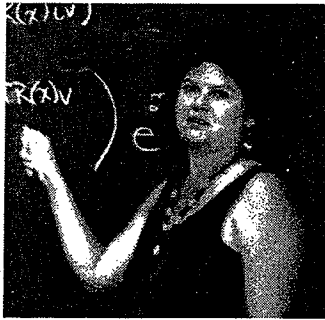
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VISITING PROFESSORSHIPS FOR WOMEN

MONICA VAZIRANI

Since women are underrepresented in nearly all science and engineering disciplines, the National Science Foundation (NSF) supports efforts aimed at increasing the number of women in the nation's research enterprises.

The Visiting Professorship for Women (VPW) Program is one of these efforts. It provides opportunities for women scientists and engineers to undertake major research at host institutes, increases the visibility of women scientists in the academic environment, and encourages other women to pursue careers in science and engineering.



LYNNE WALLING

1997-98 VPW Awardee

Lynne Walling is a tenured professor in the Mathematics Department at the University of Colorado in Boulder, teaching there since 1990. Previously, she taught at Bates College, Maine and St. Olaf College, Minnesota as assistant professor and at Dartmouth College, New Hampshire and Sonoma State University, California as instructor. She received her Ph.D. from Dartmouth in 1987. Her doctoral advisor was T. R. Shemanske.

No stranger to Berkeley, Lynne was a Visiting Associate Professor at Mills College, Oakland in 1995-96 and worked at the Summer Mills Institute as Seminar Leader during the Summer of '95. Before that, in 1994-95, Lynne did research at the Mathematical Sciences Research Institute and took part in MSRI's special program on automorphic forms.

Lynne works in the area of modular forms and has published work on Hecke eigenforms and newforms of half-integral weight.

1996-97 VPW Awardee

Lynne Butler is a professor of mathematics at Haverford College, whose faculty she joined as an associate professor in 1991. Previously, she was an assistant professor at Princeton and a postdoctoral fellow at the Institute for Mathematics and Its Applications. She received her BA from The University of Chicago in 1981 and her Ph.D., under the direction of Richard P. Stanley, from MIT in 1986. Her research is in algebraic and enumerative combinatorics; she collaborates with an economist and a chemist on a curriculum development project; and she enjoys teaching algebra and topology as well as linear optimization and game theory. Lynne has worked three summers as a cryptanalyst at the Institute for Defense Analysis Centers for Communications Research and two summers leading seminars for the Summer Mathematics Institute for women undergraduates.



LYNNE BUTLER

This past year Lynne was visiting the Mathematical Sciences Research Institute (MSRI) and UC Berkeley (teaching Math 274 this past Spring) on a National Sciences Foundation funded Visiting Professorship for Women. She has been incredibly active and supportive, and has brought new vision to the role.

The financial support from her grant was made one hundred times more valuable when combined with her mathematical and personal support. For instance, this past Spring, Lynne subsidized the women graduate students attending an MSRI

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be reexamined as knowledge expands. This is exactly what we have done.

Consider for example turbulent flow in a pipe — one of the most common, familiar, and useful flows. It is surely surprising that it should be poorly understood, in important respects less understood than the structure of stars. The scientific study of pipe flow began when Osborne Reynolds discovered, in the previous century, that pipe flow becomes turbulent when the “Reynolds number” Re , the mean velocity across the pipe \bar{u} times the pipe’s diameter d divided by the fluid’s viscosity ν , is sufficiently large. Once turbulence sets in, the fluid’s velocity and pressure fluctuate unpredictably. For engineering reasons, it is important to know how the time averaged velocity u varies as the distance y from the wall increases. Long ago, after much painstaking labor, engineers determined a “power” relation between u and y :

$$(1) \quad u = Ay^n,$$

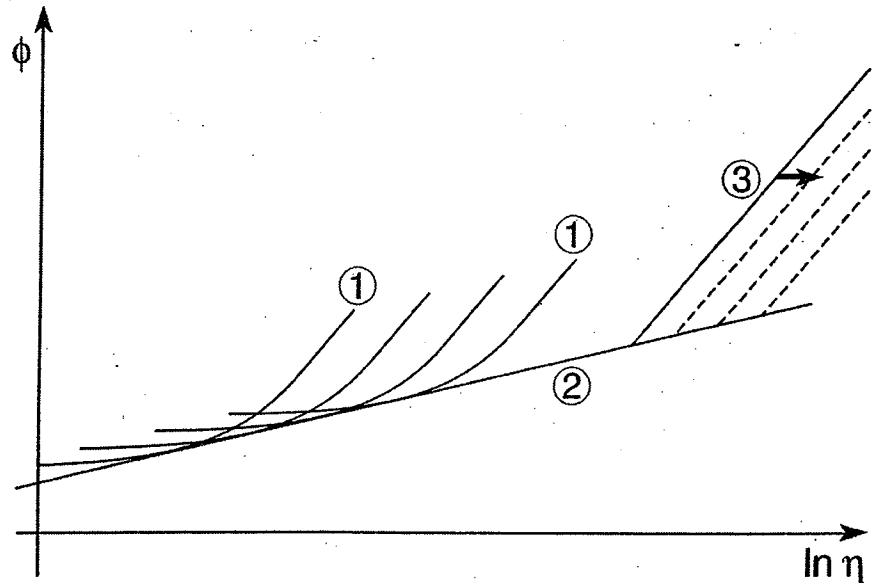


FIGURE 1: A SCHEMATIC OF THE POWER LAW CURVES IN A PIPE, THEIR ENVELOPE AND THEIR ASYMPTOTIC SLOPE. THE APPARENT MOTION OF THE CURVES TO THE RIGHT IS DUE TO THE CHANGES IN REYNOLDS NUMBER. (1) THE VELOCITY AS A FUNCTION OF THE DISTANCE TO THE WALL (IN APPROPRIATE UNITS), (2) THE ENVELOPE OF THE POWER LAWS (FORMERLY MISTAKEN FOR THE CURVES THEMSELVES), (3) THE ASYMPTOTIC SLOPE.

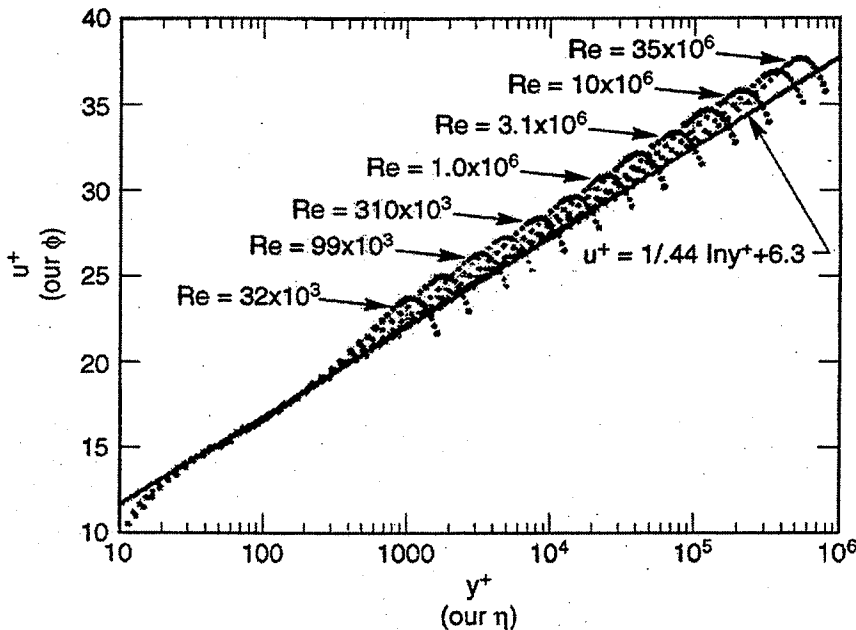


FIGURE 2: THE CORRESPONDING EXPERIMENTAL DATA (REPRODUCED WITH PERMISSION FROM M.V.ZAGAROLA ET AL, AIAA PAPER 96-0654, 1996). THE CURVES TURN DOWN AT THE CENTER OF THE PIPE, WHERE THE THEORY ABOVE IS INVALID.

where the power n and the coefficient A were known to depend slightly on Re and were determined from experiment. This law was supposed to hold everywhere except very near the wall and the centerline, and was good enough for practical applications. However, at the beginning of the thirties two famous fluid dynamists, von Kármán and Prandtl, convinced the world that, in truth, the relation between u and y had the “universal logarithmic” form:

$$(2) \quad u = u_* \left(\frac{1}{\kappa} \ln \frac{u_* y}{\nu} + C \right),$$

where u_* is a certain reference velocity, and κ , C should be “universal” constants, independent of the Reynolds number Re . The argument for the “universal” law was purely theoretical. It can be derived by requiring that the relation between u and y be independent of the units of measurements and that certain functions that appear in the analysis remain bounded and not vanish. Then Izakson, Millikan and von Mises (IMM) provided what seemed to be a second mathematical derivation of (2) based on un-

available principles, and a famous series of experiments by Nikuradze did not contradict the logarithmic law too much. This law hardened into dogma and became one of the pillars of turbulence theory and a mainstay of engineering science, widely taught and used.

We originally became suspicious of the logarithmic law on mathematical grounds: A more detailed analysis cast a doubt on the boundedness assumptions in the original von Kármán-Prandtl argument. Then a careful processing of the Nikuradze data, based on new mathematical tools, showed that they were compatible with the law:

$$(3) \quad u/u_* = \left(\frac{1}{\sqrt{3}} \ln Re + \frac{5}{2} \right) \eta^{3/2 \ln Re},$$

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where $\eta = u_* y / \nu$, which has the power law form (1). There is a big difference between this law and the logarithmic law. In particular, according to the logarithmic law, the relation between u and y is independent of Re , while according to the proposal (3) it does depend on Re .

Could the logarithmic law be wrong, could most people have been mistaken for seventy years, and could the engineering community not have noticed that a conclusion of such practical significance was in error? The answer is yes, and the reasons are subtle.

The family of curves produced by the power law (3) has an envelope which is nearly identical to the graph of the von Kármán-Prandtl law with the usual values of its constants. If one plots points for many values of Re on a single graph, as is natural if one believes with von Kármán and Prandtl that Re does not play a role, then one produces a cloud of points whose boundary, the envelope, acquires a spurious prominence. This envelope can thus easily be mistaken for the curves themselves. In addition, as the viscosity decreases, the slopes of the family of power law curves (3) tend to a finite, constant limit. This is enough for the power law to be permitted by the IMM argument, a possibility that had been overlooked.

In fact, there is a fixed angle between the envelope and the asymptotic slope in the power law which should be observable in good data. By a happy coincidence, new experimental data have recently become available, and they verify the proposed law (3). Indeed, an anomaly that could have slightly altered the constants in (3) (but not its form) allowed us to identify a flaw in the *experimental* procedure. Figure 1 shows a schematic of the power law curves in $(\ln \eta, u / u_*)$ coordinates and Figure 2 exhibits the corresponding experimental data for a pipe. A detailed comparison is available. The logarithmic law must be jettisoned.

Why are these results important? Engineers have long known that conclusions drawn from the logarithmic law, for example friction coefficients and other quantities of practical interest, are unreliable. They use instead empirical functions that fit the data. They will presumably be happy to hear that now the empirical fits can be derived from a better law. Laws such as (2), (3) and their generalizations to other geometries enter into various computer models of turbulence, which now will presumably be upgraded. However, the main significance of our work lies in its impact on theory. It corrects but also solidifies our understanding of key issues in turbulence and has broad implications.

Consider for example another pillar of turbulence theory, the Kolmogorov-Obukhov law, which applies to turbulence far from a wall. Turbulent flow has many scales of motion, just as a detailed weather map contains patterns that encompass continents and others that affect mere neighborhoods. The larger scales are determined by what stirs the fluid, while the smallest scales simply dissipate energy by friction. It is the range of scales in between, the "inertial range of local structure," that is the proper locus of a general theory and that controls effects such as the diffusion of pollutants in the atmosphere or of fuel in a turbine. The great mathematician Kolmogorov and his student, Obukhov, proposed a theory for that range of scales which has been challenged over the years on various grounds. The tools we used in pipe flow can be used here too, and affirm the basic correctness of the Kolmogorov-Obukhov theory.

More generally, the solutions of the equations of motion in fluid mechanics are chaotic when the Reynolds number Re is large, and the most minute perturbations change them. What is of interest is not specific solutions, which may never be observed, but the properties of collections of solutions with attendant probability measures. Such "random solutions" are also more amenable to analysis. We have made progress towards describing them, and indeed this progress contributed to the analyses above. We have also been able to calculate numerically, from the statistical theory, some of the properties of the inertial range and found that they are consistent with the new understanding. The general statistical theory is thus validated by the data in special cases. It is our contention that this happy agreement constitutes a step towards a fundamental theory of turbulence. Ω

PROFESSORS N. GOLDENFELD (URBANA-CHAMPAIGN), O. HALD (BERKELEY), AND V.M. PROSTOKISHIN (MOSCOW) PARTICIPATED IN SEVERAL ASPECTS OF THIS WORK.

Grigory Isaakovich Barenblatt received his MS, Ph.D., and D.Sc. degrees from the Department of Mechanics and Mathematics of Moscow University. His



GRIGORY ISAAKOVICH BARENBLATT

first teacher was B. M. Levitan; his thesis adviser and mentor was A. N. Kolmogorov, and he also had a close association with Ya. B. Zeldovich. He has worked at the Soviet Academy of Sciences (at the Institute of Petroleum and the Institute of Oceanology), at Moscow University, and at the Moscow Institute of Science and Technology. He was the first holder of the G.I. Taylor Chair of Fluid Mechanics at Cambridge University. He is a Foreign Member of the American Academy of Arts and Sciences and a Foreign Associate of both the US National Academy of Engineering and of the US National Academy of Sciences. His other honors include membership in the European Academy, the Modesto Panetti Medal and Prize, and several honorary doctorates. Professor Barenblatt joined our faculty as Professor in Residence on July 1, 1997 and also holds a research appointment at the Lawrence Berkeley Laboratory. Ω



THE NOETHERIAN RING

CHRISTINE HEITSCH

The Noetherian Ring is an organization devoted to strengthening the community of women in mathematics at Berkeley. Our membership is drawn primarily from the graduate students in the Berkeley Mathematics Department, but also includes post-docs, visitors, faculty, and undergraduates. In recent years, a particular effort has been made to include interested people from the Mathematical Sciences Research Institute (MSRI) as well as the departments of Statistics, Computer Science, Education, and other mathematically-related disciplines.



1997-98 N-RING OFFICERS (LT TO RT): MONICA VAZIRANI, LAURA DEMARCO, DIANE MACLAGAN, LUBNA CHUNAWALA

The core of the Noetherian Ring is our weekly Thursday afternoon meetings which are intended to provide a peer forum for female graduate students to present topics in our areas of research. Recently, we have also welcomed a number of young women faculty who spoke to us about their research and experiences after graduate school. The weekly talk is preceded by a half hour of informal socializing over refreshments. While the support and advice of more advanced students is particularly cherished, each person (male or female) attending the meetings contributes to the community of women in mathematics at Berkeley.

We maintain a visible presence in the department by sponsoring women in the departmental colloquia, who become our role models and potential mentors. In the past two years, we have been able to invite and/or fund visits by prominent women mathematicians such as Margaret Wright, Fan Chung, Judith Grabiner, Cathleen Morawetz, and Olga Ladyzhenskaya. We also make a concerted effort to contact and host prospective graduate students, assist with departmental functions like



LEFT TO RIGHT: L. WALLING, G. BARENBLATT, C. REID, C. MOORE

the recent book signing for *Julia* (Constance Reid's biography of her sister, Professor Julia Robinson), have luncheons honoring visiting women mathematicians, and hold a series of events designed to welcome new women students to Berkeley. To find out about current Noetherian Ring activities, see our webpage at <http://math.berkeley.edu/~nring>. The Noetherian Ring Speakers Series has been a great success based on the overwhelming positive feedback we have received. In an effort to continue this level of quality, the Noetherian Ring has begun raising funds for a university endowment, the interest from which would be used to support our Speaker Series. We eagerly anticipate the opportunity to interact with many more mathematicians world-wide. With your donations, we can continue this endeavor. If you wish to make a donation to the endowment, please designate "Noetherian Ring" at the fourth box of the gift form (pg. 15) or contact the Noetherian Ring at nring@math.berkeley.edu. Ω

THE NOETHERIAN RING PRESIDENTS

Susan Shepler (Fall 1991)

I started graduate school at Berkeley in 1990. I felt lonely and a little overwhelmed. A few of us had the idea to start a group for women mathematicians. We had no firm idea about what this group would do or could do, but I remember putting up posters around Evans Hall saying something like "Come to a meeting for women in math - Room 1015." My office mate, Steven Hillion, came up with the name for the group — an inspired one, I think.

I think, personally, I was looking for a place to get to know the older women in the department and to talk about our experiences in math. At the first meeting, we decided that math should always be a large component of the meetings and that the meetings should always include a half hour for socializing and a half hour for a math talk by one of our members. I think that format has turned out to be a near perfect mix. I remember those talks as among the highlights of my life as a math student.

Although I am no longer a mathematician, I remember the Noetherian Ring and my term as the first president of the group very proudly. I am especially heartened to know that the group continues to thrive and change to meet the needs of its members.

Leanne Robertson (Fall 1992-94)

Participating in the Noetherian Ring was one of my most positive experiences in graduate school. It was wonderful to meet and learn about the research of women graduate students, post docs, and professors at UC Berkeley and MSRI. As president, I helped start a program of bringing women mathematicians to Berkeley to give the department colloquium, and I am very pleased that the speaker series is continuing today.

Gillian Elston (1994-95)

I gave a presentation about the Noetherian Ring at the Association for Women in Mathematics Workshop during the Joint Mathematics Meeting in January of '95. Several months later, I

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THE NOETHERIAN RING PRESIDENTS *(cont. from page 8)*

found out that some graduate students at MIT had heard the presentation and started a Noetherian Ring at MIT. It was amazing to me to think that this group that had started at Berkeley just a few years earlier could have an influence on another university in that way.

Concha Gomez (Spring 1992 and 1995-96)

My first term as president was during the first year of the group. Before we formed the Noetherian Ring, I didn't know any women in the math department. It really meant a lot to me to meet people who had similar backgrounds and experiences in grad school.

My second term as president was after the Noetherian Ring had become an established and well-known group in the department. By then, I had made it through some of the most stressful years of graduate school, and I wanted to be there for the new women students the way people had been there for me. I think it really does make a difference.

Christine Heitsch (1996-97)

As the fifth president of the Noetherian Ring, I was pleased that we were able to increase the scope of our activities this past year; from welcoming incoming and returning students in the fall to phoning prospective women students in the spring; from inviting and/or funding colloquium speakers like Fan Chung, Judith Grabiner, Cathleen Morawetz, and Olga Ladyzhenskaya to working with Lynne Butler who invited a variety of outside speakers to our regular Thursday meetings. We organized a trip to the joint AMS/MAA conferences and maintained a vital and significant presence in the Berkeley Mathematics Department. The Noetherian Ring enjoyed an active and mathematically stimulating year!

Monica Vazirani (1997-98)

More than anything, I want to build on the foundation past members have set, to insure the Noetherian Ring will continue to exist and thrive. From day one, on entering Berkeley, I have relied not only on the informal mentoring of older members to guide me through this maze, but more recently on the mathematical mentoring of our invited speakers. It will be a full-time job just to continue the projects Noetherian Ring has started in the past years—I have some big shoes to fill.

When a friend heard I'd been elected Noetherian Ring president this year, she wished me congratulations, and then on second thought, condolences. Ω

VISITING PROFESSORSHIPS FOR WOMEN *(cont. from page 5)*

workshop. Besides introducing them to each other and to other workshop participants, she had the fantastic idea to have a three-hour crash course on the major themes of the workshop. It made a huge difference in being able to follow and



NOETHERIAN RING DINNER WITH L. BUTLER

enjoy the workshop talks.

On arrival to Berkeley, Lynne contacted the Noetherian Ring and immediately began working with us. She continued the tradition of using VPW funds to in-

voke prominent women mathematicians to speak in the departmental colloquium. In fact, Lynne herself gave a colloquium, choosing a topic and pitching it at a level appropriate for graduate students. Lynne expanded her role to invite women at earlier stages of their career, who could comment on their immediate post-graduate school experiences and on their careers and lives as women mathematicians, to the weekly meetings of the Noetherian Ring. She also took steps to invite graduate students from other schools who wanted to "seed" branches of the Noetherian Ring at their home institutions, or who already had similar groups and wanted to exchange ideas.

Lynne increased the level of participation between the Noetherian Ring and MSRI. She encouraged the women at MSRI to attend our meetings and/or give talks at them. She also invited several Noetherian Ring members in a combinatorics course to form a study group and come up to MSRI to work out problems (even offering to drive us if we couldn't catch the bus). Under her guidance, we would receive hints, if needed, and chocolate cake. In fact, you would know she'd been baking that day if she showed up wearing one of her favorite T-shirts. It pictured a very traditional-looking woman from the '50s (à la Donna Reed) in front of a blackboard filled with formulas and a caption reading "If a woman can bake a cake, she can build a bomb."

Lynne took us under her wing; she was always ready to explain a theorem, or introduce us to her colleagues, or play a hand of bridge. The Noetherian Ring loved having her at Berkeley and will miss her. In Lynne Butler we have a strong mathematical mentor and a dear friend. Ω



LEFT TO RIGHT: MONICA VAZIRANI, LEANNE ROBERTSON, SUSAN SHEPLER, CHRISTINE HEITSCH, CONCHA GOMEZ

GRADUATE PROGRAM

DON SARASON

We had an entering class of 46 this fall; 37 in the Ph.D. program and 9 in the MA program. Of the 9 in the MA program, at least 5 hope eventually to advance to the Ph.D. program. Among the 46 already started in the Ph.D. program are 20 international students from 14 different countries: Switzerland, Columbia, Singapore, Canada, Germany, Turkey, Bulgaria, Peoples Republic of China, Spain, Argentina, Romania, Russia, Portugal, and New Zealand. This is more than twice the number of international students who entered a year ago. The increase was made possible by a re-

structuring of nonresident tuition. Under the new scheme, once a Ph.D. student has advanced to candidacy, nonresident tuition is reduced by 75% for up to three years. The department will see that all entering Ph.D. students who continue to make satisfactory progress receive at least five years of support.

In order to get graduate students more involved in how things are run, Chair Moore has appointed some of them to a number of departmental committees. He has also instituted a new student-faculty committee, the Graduate Program Policy Committee. Its charge is to advise the department on policies relating to the

graduate program, such as the size of the entering class and the allocation of resources. The appointment of graduate students to departmental committees is something graduate students have been proposing for a number of years. Those of you who are now faculty members are perhaps astounded that anyone not required to do so would actually WANT to serve on a committee. Our graduate students certainly are unusual (usually delightfully so!) Ω

Grad Student News

THE 97/98 MGSA OFFICERS: BEN DAVIS, TOM INSEL, DIANE MACLAGAN AND WAYNE WHITNEY

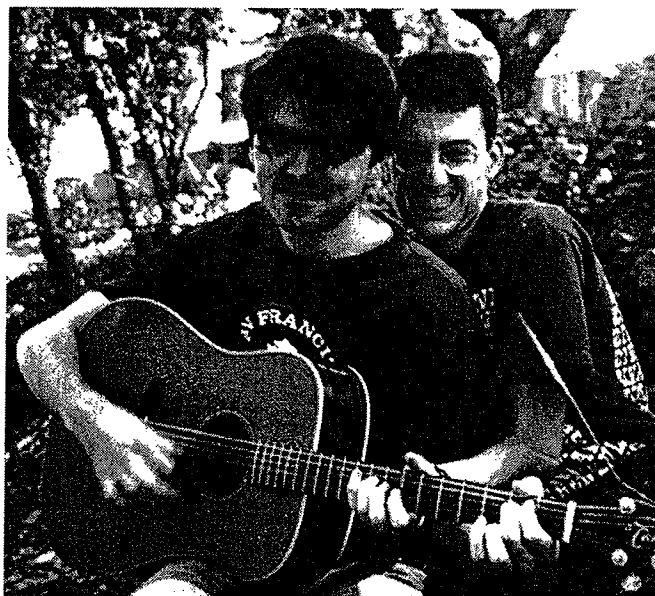
Graduate student life took a turn for the better last year, with the introduction of a free phone in 708 Evans. The Department has generously agreed to take over funding of the phone, and another phone is in the works for 938 Evans Hall. Another new resource in 708 is the non-circulating library, a growing collection of frequently used math references and documentation for computer packages such as Mathematica and TeX. Last, but not least, the hours have been extended until 10 pm weekdays for 1015 Evans and the ninth floor seminar rooms, providing more social space and an opportunity to watch the sun set over the Golden Gate. (See editor's note below for use of 1015 policy details.)

Now in its third year, the Graduate Student Colloquium is a series of introductory talks giving students a chance to share their interests with each other. Organized last year by Michael Kleber and Arturo Magidin, this successful series gives a non-technical peek into the frontiers of Berkeley mathematics. The current organizers are Diane MacLagan and Lawren Smithline.

Those about to face the dreaded qualifying exam will be excited to hear about the on-line list of past qual questions. The collection, generously compiled by

Arturo Magidin, is available from the MGSA web page (<http://math.berkeley.edu/~mgsa/>). This web page also points to Paulo Ney de Souza's compilation of past preliminary exams.

Singing and jubilation abounded at this year's mathematics picnic as folks whiled away a mild summer afternoon at gorgeous Live Oak Park. With a turnout of around sixty, members of the department were seen



BEN DAVIS AND STEPHEN BIGELOW

wolfing down garden burgers and consuming drinks at an alarming rate. David Eisenbud, the director of MSRI, was spied passing juggling clubs with "first-years" and the dapper Hendrik Lenstra narrowly avoided getting trapped in a giant soap bubble. Faculty turnout was especially improved over last year, creating a unique opportunity for students and faculty to get to know each other in an especially informal setting. Ω

Editor's note: Departmental Policy for use of 1015 Evans Hall

1015 Evans Hall is the common room of the Department of Mathematics at UCB. It is departmental policy to allow use of 1015 Evans Hall only to the mathematics community at Berkeley. Any organized group activity in 1015 Evans needs to be processed by departmental staff. See Rondi Phillips in 957 Evans (rondi@math.berkeley.edu) for reservations and required forms.

MSRI IN 1997 AND BEYOND

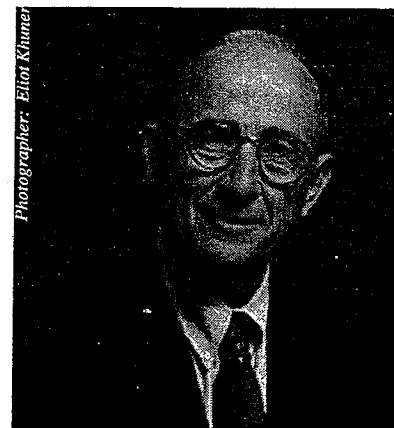
DAVID EISENBUD

I'm very pleased to report to you on activities at MSRI. Starting work at the Mathematical Sciences Research Institute (MSRI) has been an amazing experience for me. I enjoyed both my past visits to the Institute immensely, and thought it would be lovely to return, but the idea of returning as director didn't even occur to me. Chern, Kaplansky, Thurston—these great figures are hard to follow, but I've plunged in and find the work rewarding, challenging, and consuming. My Deputy Director is Hugo Rossi. He has many MSRI connections: he appears in some of the photos from the groundbreaking and served as Chairman of MSRI's board of Trustees as well. His broad administrative experience, for example as Dean of Science at the University of Utah, have been enormously helpful.

At the heart of MSRI's activities each year are three major programs. This year Stochastic Analysis runs through both semesters, with different special emphases at different times, while Harmonic Analysis runs through the fall, and Model Theory of Fields



DAVID EISENBUD, DIRECTOR



HUGO ROSSI, DEPUTY-DIRECTOR

(continued on page 14)

TeachMath

TeachMath is a program designed to recruit math majors at Berkeley for a teaching career in high school or junior high. There is at present a critical shortage of mathematically knowledgeable teachers in the schools. The importance of a strong mathematical background in good teaching is being increasingly recognized, and the original impetus of TeachMath was the realization that our own math majors could be part of the solution of this pressing problem. If we can encourage more of these majors to go into the teaching profession, we would be making an important, if small, contribution. To this end, TeachMath was created to give some incentive to joining the teaching profession while paying special attention to mathematical achievement.

TeachMath is sponsored jointly by the Mathematics Department and the Graduate School of Education. It is a two-year program that leads math majors to a single-subject Teaching Credential in Mathematics. Majors who are accepted into the program will enroll in a suggested course of study in their senior year which includes courses in the Graduate School of Education and participation in supervised teaching in school classrooms. After their successful completion of the AB degree, they continue with the suggested course of study as graduate students in the School of Education, but will be required to take two more math courses for the year. They will be paid a stipend of \$2000 for the first (their senior) year, and \$4500 for the second.

There is significant interest on the part of the Oakland School district in placing TeachMath students within the district both during and after their supervised teaching period. It is expected that most successful TeachMath graduates will be offered mathematics teaching positions at one of the many large high schools in the Bay Area.

Currently there are two fellows in TeachMath: Delphine Hwang and Nicole Scaramozzino.

Students interested in this program should apply no later than February 28, 1998. For more information, please contact Professor H. Wu in 733 Evans (wu@math.berkeley.edu), or Robert Mattison in 985 Evans (robert@socrates.berkeley.edu), or Dan Zimmerlin (danz@socrates.berkeley.edu).



DELPHINE HWANG



NICOLE SCARAMOZZINO

PROTTER LIBRARY ENDOWMENT

Professor and Mrs. Murray Protter have generously donated funds for the establishment of the Murray H. & Ruth R. Protter Library Endowment Fund.



RUTH AND MURRAY PROTTER

Income from the endowment will support the UC Berkeley Library in furthering the University's research archives in mathematics. The Endowment is dedicated to the purchase of research-level documents and advanced mathematics monographs. The students and faculty of the Department will benefit greatly with these additions to mathematics in the library. The Department most heartily thanks Murray and Ruth for their generosity. Ω

MANAGER'S REPORT

CAROLYN KATZ

Welcome New Staff

I am pleased to welcome **Barbara Peavy**, Supervisor of Student Services Unit. Barbara joined the Mathematics Department in March this year. She comes to us with over 14 years experience in student services, working with both graduate and undergraduate students in the Haas School of Business and International and Area Studies. She is learning her office, unit, and departmental operations quickly and I am impressed at how smooth the transition has been.



BARBARA PEAVY

Another Year of Outstanding Staff Work!

The staff for the Department of Mathematics has once again been honored for outstanding work and achievement. I am delighted to acknowledge seven of our staff who received individual Distinguished Services Awards this past spring. These were awarded by the College of Letters & Sciences and included a cash award. We thank faculty and students who submitted nominations in this process, and assure you that our goal is to see that all deserving staff are recognized over the course of the upcoming years. **Recipients of the 1996-97 Distinguished Service Awards:**



DAVE HERNES

Ω **Dave Hernes**, for his versatility and performance in handling just about any job, including facilities matters, such as repair of all Evans Hall windows in his role as Building Coordinator, purchasing and computing assistance, and volunteering to serve on departmental and campus projects.



SUI JEN

Ω **Christina Hong**, for her development of the "Survival Guide to Calculus," special informational flyers for undergraduate students, and her outstanding service to the Department of Mathematics as the Undergraduate Assistant.



CHRISTINA HONG

Ω **Sui Jen**, for the accuracy, speed, and volume of payroll, travel, and purchasing transactions that she processes on a daily basis for the Math Department, achieving not only a 100% job in 75% time, but a job exceptionally well done.



RONDI PHILLIPS

Ω **Lou Maull**, to quote her staff's nomination for Lou in their successful 1996 Excellence in Management Award application: "Lou is the kind of person who consistently goes above and beyond her specific Personnel & Finance unit duties to assure that everyone in the Math Department (not just her unit) is getting the kind of support they need to perform their duties in an environment that is both safe and supportive."



LOU MAULL

Ω **Rondi Phillips**, for her ongoing enthusiasm for learning new responsibilities and developing new skills, and her independent functioning and attention to detail in her dual roles as Events Coordinator and Newsletter Editor.



JANET YONAN

Ω **Marsha Snow**, for her sustained superior performance in the daily operation of the Math Department's Main Office, where she has received consistent praise from students, faculty, and staff for her exceptional interpersonal skills and willingness to go the extra mile to help the many people who require service.



MARSHA SNOW

Ω **Janet Yonan**, for her work and invaluable suggestions for the campus project team developing the graduate student database; as well as for her professionalism and efforts to promote efficiency in the myriad administrative aspects of the Math Department's Graduate Office, and in all aspects of her job.

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LECTURE NOTES

The **Berkeley Mathematics Lecture Notes** are now published jointly by the Center for Pure and Applied Mathematics and the American Mathematical Society. They are distributed by the AMS and can be ordered on line from the AMS bookstore (<http://www.ams.org/bookstore/>) or by calling 1-800-321-4AMS.

At present, two volumes are available. Both are based on courses taught by their authors at Berkeley:

- *Lectures on the geometry of quantization* by Sean Bates and Alan Weinstein (notes for a graduate course on symplectic geometry and quantization.)
- *Companion to Euclid: A course of geometry, based on Euclid's Elements and its modern descendants* by Robin Hartshorne (a text for an undergraduate course on the foundations of geometry.)

More volumes will appear in 1998.



MANAGER'S REPORT (cont. from page 12)

I would also like to mention the outstanding efforts this past year by our *Mathematics Web Team members*: **Robert Campbell, Paulo Ney de Souza, Bernice Gangale, David Hernes, Christina Hong, and Kathleen Valerio** (who serves as Team Leader). I serve as a member of the Team and can attest to how much time and effort they have given for this project. We are close to releasing our new revised Home Page structure and we welcome your suggestions after you've had a chance to review it. Thanks to this team for their hard work.

All of our staff members are outstanding. I continue to enjoy working closely with them as we seek together to reach our goals for administrative operation.

Farewell and Best Wishes

It is with mixed feelings that we say good-bye to two staff members:

Robert Campbell has decided to retire this year. We appreciate his year with us; he transferred to Math from Information Systems & Technology a year ago, after working there for 17 years. We were pleased that IS&T agreed to transfer his position and duties for support of our network infrastructure to direct Mathematics control. This has strengthened our computing technical support group. His help to Kathleen Valerio with our new improved web page was invaluable, and his reliable service to the network has been priceless. He was almost invisible to all in the Department, but few people realize that is the true nature of a system administrator; the more transparent, the better. Bob's absence is felt. We all wish Bob the best in his retirement.

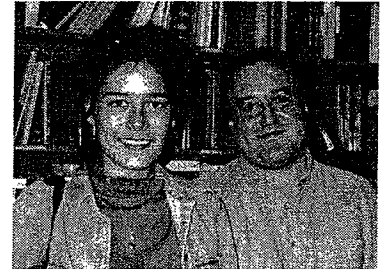


ROBERT CAMPBELL

Christina Hong has accepted a position as an Evaluator (of undergraduate degree candidates) for the College of Letters & Science. Her last day in the Department was Friday, October, 3. Christina had been with Mathematics for just a little over 3 years and left an indelible mark with projects that have proved to be of great benefit to our undergraduate math students. She and Ole Hald collaborated on the "Survival Guide to Calculus" and the "Frequently Asked Questions" flyers which help our students make the transition from high school math to college math. During the transition of supervisors in the Student Services Unit earlier this year, she took an active role. Christina will be sorely missed. We wish her a most wonderful and successful future. Ω

MUSA

MUSA is the Mathematics Undergraduate Student Association of the Department of Mathematics at UC Berkeley. Our goal is to promote mathematics through events such as the MUSA lecture series,



1997 MUSA OFFICERS: MARIA BANIADAM & VICTOR SCARFURO

MSRI tours, career day, and various social events. We also have updated graduate school files and applications in our office.

In addition to academic and social events, MUSA is responsible for choosing the recipient of the Distinguished Teaching Award presented each year at the May Commencement Ceremony. This award honors the instructor whom the undergraduate students feel has contributed greatly to their mathematical studies.

MUSA is selling Math T-shirts!

Our 100% cotton shirts, featuring a design by Professor D. Auckly, come in six colors: natural, gray, navy blue, moss green, burgundy, and black, and in four sizes: small, medium, large, and extra large. Contact us by email, phone, or come to our office during our office hours if you would like to buy one.

Check out our web page for dates and times of the lecture series, tours, other social events or for our office hours.

MUSA office:

1064 Evans; **Email:**

musa@math.berkeley.edu

Web page:

<http://math.berkeley.edu/~musa>

THE RUFUS BOWEN LECTURES

The Bowen Lectures were established by friends and colleagues as a memorial to Rufus Bowen after his untimely death at age 31 in 1978.



RUFUS BOWEN

Born in 1947 in Vallejo, California, Robert Edward (Rufus) Bowen was awarded the AB with prizes for scholarship by

the University of California at Berkeley in 1967. His doctorate in Mathematics was completed at Berkeley in 1970 under the direction of Stephen Smale. In that year he was appointed to the faculty of the Department of Mathematics at UCB. He was promoted to the rank of Professor in 1977.

Bowen worked in mathematical dynamics systems theory. His pioneering studies of topological entropy, symbolic dynamics, Markov partitions, and invariant measures are of lasting importance; much of today's research is inspired by his ideas.

Each year the Department of Mathematics invites an outstanding mathematician to deliver the Bowen Lectures on important topics of mathematical research.

At this year's Bowen Lectures, November 4-6, 1997, we are pleased to invite Professor Simon Donaldson to speak. Donaldson was born in 1957 in Cambridge, England. He obtained his BA from Cambridge University in 1979 and his doctorate, under the supervision of Sir Michael Atiyah, from Oxford University in 1983. In 1986 he received a Fields Medal at the International Con-

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MSRI IN 1997 AND BEYOND

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through the spring. There will be periodic workshops on special topics in each of these areas; see our web page, <http://www.msri.org> for details on these and other MSRI activities. The MSRI-Evans Colloquium on Monday afternoons (roughly every other week) aims to share these activities with a broad audience through accessible lectures by visitors to MSRI. The 1998-99 topics, by the way, are Symbolic Computation and Foundations of Computational Mathematics in the fall, and Random Matrices in the spring. We are now collecting applications. Deadlines are the end of October for Research Professors and the end of November for Postdocs. Forms can be found on the web page.

The subjects for the special years are typically planned three years in advance; we are now working on the year 2000-2001. The Scientific Advisory Council, which selects the programs and participants for the Institute, currently includes Vaughan Jones from our own faculty; the other members, aside from Rossi and me, are Elias M. Stein (Chair), Kevin Corlette, Raymond Johnson, Dusa MacDuff, George Papanicolau, Karl Rubin, and Margaret Wright. We plan to add a statistician to broaden the group's reach still further.

The biggest event on MSRI's horizon is the coming recompetition. As many of you remember, MSRI was created as a result of an NSF competition 15 years ago. The NSF has announced that it will hold a "recompetition" for its Mathematics Institutes this year; the deadline for the proposal is February 2, 1998. As Director, I feel that MSRI has a big advantage coming from its wonderful track record, and from the enthusiasm of mathematicians the world over who have enjoyed stays at the Institute. But to be successful, MSRI has to do more than rest on its laurels. I feel that the keys to success will be continued emphasis on programs in fundamental mathematics of the highest quality, continued inventive use of that excellence in the training of postdocs and in other activities that have a broad impact on American mathematics, and increased attention to connections with users of mathematics in scientific and industrial settings. In addition, although I expect the NSF Mathematics program to be the primary source of support for MSRI in the future as it has been in the past, I think that we must pay increased attention to getting support from industry and from government agencies other than NSF. I hope to have lots of help from MSRI's sponsoring institutions in formulating specific new ideas for the recompetition. If you have some thoughts about this, please let me know! Ω

GRATEFUL THANKS TO OUR FRIENDS

The Department of Mathematics extends heartfelt thanks to all our donors over the past years for their generous support. Our donors have contributed to the strength and vitality of our students and the Department. The following is a list of our donors since 1996-97. We apologize if we have omitted anyone. Please do let us know if that is the case. A special thanks to all our donors who wish to remain anonymous.

1996-97

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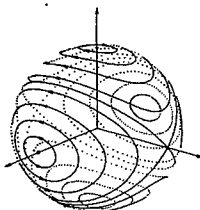
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THE RUFUS BOWEN LECTURES

(continued from page 14)

gress of Mathematicians in Berkeley. He is currently a Professor at Stanford University. His research interests center on differential geometry, particularly complex differential geometry and its connections with gauge theory, low-dimensional topology, and symplectic geometry.



SIMON DONALDSON

The title of his talks is "The Moment Map in Differential Geometry." To read the abstract of Donaldson's lecture, click on *Departmental Events* on the Mathematics webpage at <http://math.berkeley.edu/>.

To continue this lecture series, we hope to establish an endowment, the interest from which will pay expenses, including a reception as well as speakers' costs for coming to Berkeley. To contribute to the Bowen Lecture Endowment, please designate "Bowen Lecture Endowment" in the fourth box of the gift form (page 15) or contact Lou Maull at (510) 642-3865 or maull@math.berkeley.edu. Ω



STATE OF THE DEPARTMENT

(cont. from page 2)

Fund Raising

I would like to thank all of you who have generously donated to the Department. I want to encourage many more of you to make contributions, not only on an annual basis, but also to entertain the possibility of providing an endowment that will fund a program or activity on an ongoing basis. It is clear that resources from the State alone, in the long run, will not be sufficient for what we need in order to maintain and improve our research and teaching programs and to maintain our top national ranking. Private donations have been and will continue to be essential for us to achieve these goals. Ω

THE LATEST UCB & MATH HOMEPAGE

VISIT OUR NEW HOME PAGE — The new campus home page is more attractive, more dynamic and more user-friendly. Launched on Feb. 10, 1997, the web site remains at: <http://www.berkeley.edu/>. There's a new News & Events site too, and it has a new web address: <http://www.berkeley.edu/news/index.html>. For direct links to the Department of Mathematics home page, special events, on-line newsletter and much more go to: <http://math.berkeley.edu/>.

FACULTY HONORED

(continued from page 5)

to linguistic rigidity would be hard to believe but for the examples that Kahan showed us. They can be found on his web page in cs.berkeley.edu/~wkahan/SIAMjvnl.ps (PostScript file to be printed on a Laser-Printer or viewed via GhostView) and in the works cited there. An elementary treatment of the trigonometric examples is in .../Triangle.ps, and a linear system is discussed in .../Cantilever.ps. Ω

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