1990 Norbert Wiener Prize in Applied Mathematics Awarded in Columbus

The Norbert Wiener Prize in Applied Mathematics was awarded at the Joint Mathematics Meetings in Columbus, Ohio. The 1990 Wiener Prize was awarded jointly to MICHAEL AIZENMAN, New York University - Courant Institute of Mathematical Sciences, and to JERROLD E. MARSDEN, University of California at Berkeley.

The Prize was established in 1967 in honor of Professor Norbert Wiener and was endowed by a fund from the Department of Mathematics of the Massachusetts Institute of Technology. The Prize is normally awarded every five years, beginning in 1970, and is awarded jointly by the American Mathematical Society (AMS) and the Society for Industrial and Applied Mathematics (SIAM). The current award is $4,000.

Previous recipients of Wiener Prizes are Richard E. Bellman (1970), Peter D. Lax (1975), Tosio Kato (1980), Gerald B. Whitham (1980), and Clifford S. Gardner (1985).

The Prize is awarded by action of the Councils of the AMS and SIAM on the recommendation of the joint AMS-SIAM Committee to select the Winner of the Wiener Prize for 1990. The members of this Committee are I. M. Singer, Elliott H. Lieb, and Stephen Smale.

The text that follows contains the Committee's citations for each award, the recipients' responses to the award, and a brief biographical sketch of each of the recipients.

Michael Aizenman

Citation

To Michael Aizenman for his outstanding contribution of original and non-perturbative mathematical methods in statistical mechanics by means of which he was able to solve several long open important problems concerning critical phenomena, phase transitions, and quantum field theory.

Response

I am delighted to receive the Norbert Wiener Prize awarded by the American Mathematical Society and the Society for Industrial and Applied Mathematics. The citation offers a generous portrayal of my work, but I also take the award to be an implicit recognition of the depth of an area of research, which was acquired through the contributions of a larger collection of individuals. One of my earliest debts is to Gideon Cain, a friend and a fellow student, for discussions in which our scientific orientations were shaped and some early insights were developed. Since Gidi did not live to fulfill his potential, I would like to honor his memory at this opportunity.

Michael Aizenman

As a research area, mathematical physics is rewarding in a number of ways. For a mathematician the requirement of relevance of the work to theories of physics is an added pressure, but it is also a guide to fertile grounds. Although much of the progress in physics has occurred without the immediate presence of mathematical rigor, its structure becomes very brittle in the absence of firm mathematical support for its concepts, claims, and conjectures—for at least several not uncharacteristic cases. That task often requires new mathematical notions and leads to ideas of novel mathematical content. Thus mathematical physics enriches both fields. Working in an interdisciplinary area makes one strongly aware that a subject may be perceived and analyzed from a variety of perspectives. I find this observation to be both profoundly intriguing and very useful at the level of problem solving. Related to it, is the wide diversity of methods which have been applied and developed in the study of topics arising, for example, in mathematical statistical mechanics. In works extending beyond my own contributions, insights were derived from a range of fields including probability, harmonic analysis, partial differential equations (and inequalities), complex analysis, topology, and some elementary number theory. At least some of these fields have in return benefited from this contact. While the nominal goal of mathematical physics is to address issues of physics, we have seen—and one should expect to see more—contributions flowing truly in both directions.

Biographical Sketch

Michael Aizenman, born on August 28, 1945, grew up in Israel, though his birthplace is N. Tagil U.S.S.R. and his first few years were spent in Poland. His undergraduate education was at the Hebrew University in Jerusalem, and his Ph.D. is from Yeshiva University (1975), where his thesis advisor was Joel Lebowitz.

Professor Aizenman had postdoctoral positions at the Courant Institute of Mathematical Sciences (Visiting Member 1974-75) and at Princeton University (1975-1977). During 1977 to 1982 he was an assistant professor at Princeton University in the Physics Department. He then moved to Rutgers University as an associate professor of mathematics and physics and was promoted to professor in 1984. He was also a member of the Institute for Advanced Study in 1984-85, and has repeatedly been a visitor at the Institut des Hautes Etudes Scientifiques. In 1987 he returned to Courant Institute as a professor of mathematics, with a joint appointment in the NYU physics department. In September 1990 he will assume a position of professor of physics and mathematics at Princeton University.

Michael Aizenman was a Sloan Fellow from 1981 to 1984, and a Guggenheim Fellow in 1984-85. He shared the Guido Stampacchia Prize awarded by the Scuola Normale Superiore di Pisa in 1982, was awarded the Rutgers' Board of Trustees award for excellence in research in 1987, and was invited to give the Britton Lectures at McMaster University in 1989. He presented an Invited Address at the International Congress of Mathematicians in Warsaw (1983) and made a number of presentations at AMS meetings, including an AMS Invited Address in Denver in 1984.

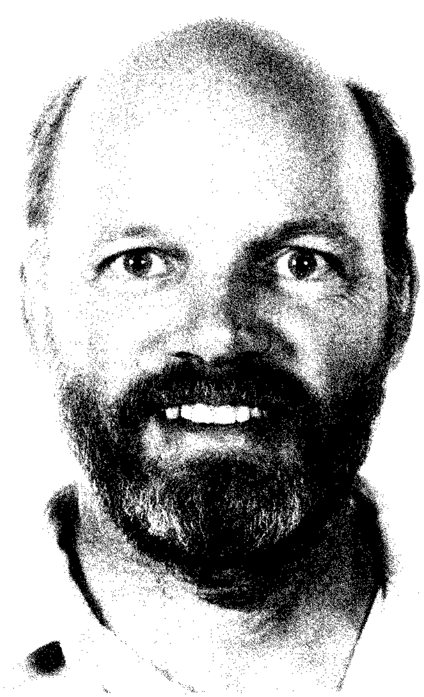
Professor Aizenman is a section editor for *Communications in Mathematical Physics.* He was on the editorial boards of *Journal of Mathematical Physics* and *Communications in Pure and Applied Mathematics,* and he is currently on the editorial boards of *Journal of Statistical Physics, Annals of Probability,* and *Reports in Mathematical Physics.*

Michael Aizenman has broad interests in areas related to mathematical physics. The main focus in his publications has been on mathematical analysis of issues arising in statistical mechanics and quantum field theory.

Jerrold E. Marsden

Citation

To Jerrold E. Marsden for his outstanding contributions to the study of differential equations in mechanics: he proved the existence of chaos in specific classical differential equations; his work on the momentum map, from abstract foundations to detailed applications, has had great impact.



Jerrold E. Marsden

Response

I am delighted to be a recipient of the 1990 Norbert Wiener Prize. Norbert Wiener was a model mathematician in many ways, but a trait I find especially admirable is that he was not classifiable as a pure or an applied mathematician. He had breadth and depth that worked together in a mutually supportive way. I will return to the pure-applied question at the end.

Before going on, I want to acknowledge that, like others who deal with "applied" mathematics, I often do joint work. My collaborators, students, and colleagues, many, but not all, of whom are mentioned below, have my deepest thanks for their help and support.

My main area of research is mechanics. That is a large field—it is like one saying their research area is analysis. To be more specific, I have been interested in *geometric mechanics* and the role of *symmetry*. This interest was already evident in my 1967-68 thesis, written under the direction of Arthur Wightman at Princeton, with much inspiration from Ralph Abraham who was at Princeton at the time. One has to admit that, in graduate school, those of us who were lucky enough to mingle with the masters had a tremendous advantage. Those days were inspiring with Bargmann, Wigner, Wheeler, Kruskal, Wightman, and Abraham there. Building on my undergraduate professors at Toronto, especially Ray Vanstone and Hanno Rund, I had the geometric mechanics treasure chest in front of me. The thesis itself was in fact not very eventful—the most interesting thing was that I independently discovered some of the basic properties of momentum maps, but not as elegantly as the masters Kostant and Souriau, and I developed some things about Hamiltonian semigroups, including quantum mechanics. Shortly after this, Abraham or Wightman (I cannot remember which) suggested I read Arnol'd's 1966 paper on fluid mechanics that had just come out and, in light of my thesis, see what I could say about it. This was probably the most important suggestion in my career. At this time of course Arnol'd was not able to travel, but his writings did travel. I got to meet him only in 1989 at the Mathematical Sciences Research Institute in Berkeley.

I moved to Berkeley in the fall of 1968 and there teamed up with David Ebin to write what I still think is one of the nicest papers of my career (it appeared in the *Annals* in 1970). We built directly on Arnol'd's work—not only did we make his setting analytically precise with the right function spaces, etc., but we showed that the Euler equations when written in material form (as geodesic equations on the group of volume preserving diffeomorphisms) are a smooth vector field, so in fact are not pde's at all, but are ode's!! This result had a number of nice consequences and more are being found to this day. These first years at Berkeley were very exciting times. Being able to talk with the likes of Smale and Kato, and attend their lectures, was quite an experience. How I managed to get so much done with a newborn son (Chris) in the house now baffles me.

I must confess that I never seriously thought about quitting "classical" mechanics, because it has been so full of life. I could not understand my physics friends who said that classical mechanics was dead and I should stop wasting my time—I never remembered Wigner or Wheeler saying such things. (Today I like to rebut this by pointing out that quantum mechanics is a *special case* of classical mechanics—commutators *really are* Poisson brackets and unitary transformations *really are* classical canonical transformations, *etc.*)

In 1972 more exciting things started to happen. I began a collaboration with Arthur Fischer on relativistic field theories, which started as an exercise to see what the Hamiltonian structure was for general relativity, but ended in a very beautiful work some 15 years later with Judy Arms, Vince Moncrief, Jim Isenberg, Mark Gotay, Richard Montgomery, Jedrez Sniatycki and Phil Yasskin on the structure of the space of solutions of relativistic field theories. We were able to show that even though the equations of general relativity (and other field theories as well) were algebraically complex, the singularities in the space of solutions were *only quadratic*. In this project (the *GIMMSY* project—an acronym for the authors' names), we attempted to break a record for the longest non-dead project in preparation—it had its 10th anniversary recently.

The second exciting thing in 1972 occurred while I was thinking about the new edition of my book with Abraham on *Foundations of Mechanics*, first published in 1967. I was trying to understand Smale's work on simple mechanical systems with symmetry (*Inventiones*, 1970) in the general context of symplectic manifolds, and what it had to do with all the examples I had been studying. At this point, I hooked up with Alan Weinstein and we wrote our paper on reduction theory. Later, we applied this to fluid and plasma dynamics. Since then, the literature on reduction theory has grown so fast that it is hard to keep up with it; a situation both gratifying and frustrating. This work had an excellent impetus with work we both did with Darryl Holm at the Center for Nonlinear Studies in Los Alamos. We pushed the Arnol'd stability technique for many fluid and plasma stability problems. It was fun to recognize former Princetonians like Martin Kruskal who was one of the early major players in this subject. Henry Abarbanel and Tudor Raţiu were also key players in this whole enterprise.

Starting around 1975 I turned attention to questions in nonlinear elasticity. I learned much on the subject from my friends Tom Hughes and Juan Simo in Applied Mechanics at Stanford, but with Berkeley training. My book with Tom on *The Mathematical Foundations of Elasticity* was the result. It has been very gratifying that geometric mechanics has proven itself useful in the development of specific numerical codes; in fact some of Simo's codes for shells are amongst the best anywhere. We have continued the work to the present and in fact in the last couple of years have written a series of recent papers with Tom Posbergh (Minnesota) and Debra Lewis (Institute for Mathematics and its Applications and Santa Cruz) on an improved version of the Arnol'd work on stability of relative equilibria, separation of rotational and internal modes that I think are quite important. We began by trying to fix a problem with the nonexistence of Casimir functions in the original Arnol'd method that I mentioned in the last paragraph. We were rewarded in a very lucky way and stumbled into some real miracles. I still remember sitting in the student lunch room at Cornell in the fall of 1988 with Juan Simo (a Mathematical Sciences Institute visitor at the time) and seeing several hundred terms in a big calculation all cancel—we had bumbled across a fundamental normal form in mechanics. I was so happy!! More recently I have also turned some attention to control of mechanical systems; here work with P. S. Krishnaprasad, Tony Bloch, and Richard Montgomery has been especially stimulating.

I have worked off and on in bifurcation and dynamics with excellent people like Marge McCracken, David Chillingworth, Steve Wan and Jürgen Scheurle. In particular, around 1980 Phil Holmes and I started some work on chaos in mechanical systems—here I was fortunate to link up with someone of extraordinary quality. We were able to merge his work on the Poincaré-Melnikov method for detecting Smale horseshoes, with reduction theory and with work I had done on pde's. Simultaneously with work of Kopell and Howard on reaction diffusion equations, we were able to demonstrate the existence of homoclinic chaos in a realistic pde. My work with Phil led to pleasant times at Cornell University.

During the last few years, I have become even more convinced that an extremely important role for mathematics is its outreach to other disciplines and in education. My own work in nonlinear elasticity, fluids, plasmas, and dynamics and bifurcation theory has often been driven by such goals. When in a cynical mood, I sometimes point out the *unpleasant* but *true* statement that too large a majority of pure mathematicians think that applied mathematics consists of plugging special numbers into or taking special cases of preexisting theorems, while a majority of nonmathematical scientists think that pure mathematics consists of useless philosophical ramblings. Both are of course wrong. Is it conceivable that the great heritage of Poincaré, Hilbert, Gauss, Lagrange, Birkhoff, Wiener, etc. is being slighted? I have worked hard to help heal these rifts and will continue to do so. It is to the benefit of science that the pure and applied aspects work in harmony. (Sometimes divorce is necessary, but it is not what nature intended.)

I hope you agree that these comments partially reflect Wiener's work and ideals—I encourage the community to sustain and strengthen them.

Biographical Sketch

Jerrold E. Marsden was born August 17, 1942 in British Columbia. He received his Ph.D. in 1968 from Princeton University. After holding a position as instructor at Princeton (1967-1968), he became a lecturer at the University of California at Berkeley, where he advanced to the rank of professor in 1976. While at Berkeley, he was appointed Miller Research Professor during 1981-1982 and served as director of the Research Group in Nonlinear Systems and Dynamics from 1984 to 1986.

Professor Marsden has held visiting positions at numerous institutions, including the Institute for Advanced Study in Princeton (1971), Institut des Hautes Etudes Scientifiques (1972), University of Toronto (1970-1971, 1975), University of Warwick (1980), Center for Nonlinear Studies in Los Alamos (1983), and University of Hamburg (1989). In addition, he has held the position of Professeur d'Echange at the University of Paris VI (1975, 1979), Carnegie Fellow at Heriot-Watt University (1977), and Killam Visiting Scholar at the University of Calgary (1979). He has also been associated with Cornell University, in the Mathematics Department and the Mathematical Sciences Institute (1988-1989).

Professor Marsden has received a number of awards and honors, including First Prize (with Arthur Fischer) in the Relativity Essay Contest sponsored by the Gravity Research Foundation (1973) and the Humboldt Prize (1990-1991). In 1989-1990, he presented the Aisenstadt Lectures in Montreal, and has been named a Fairchild Fellow at the California Institute of Technology for 1991-1992.

Professor Marsden serves as editor for a number of journals and is a prolific author of papers, research monographs, and textbooks. Sixteen students have received doctorates under his direction. A member of the Society since 1971, he has served on the Committee on Joint Summer Research Conferences (1983-1986) and the Committee on Science Policy (1989-1992).

During his career, Professor Marsden's research interests have ranged over a number of mathematical areas, including Hamiltonian systems and fluid mechanics, general relativity, geometric mechanics, nonlinear elasticity, and bifurcation theory and dynamical systems. His current research interests center on the application of mathematical techniques to mechanical systems of importance in physics and engineering.