Lax Receives Abel Prize

Peter D. Lax

The Norwegian Academy of Science and Letters has decided to award the Abel Prize for 2005 to Peter D. Lax of the Courant Institute of Mathematical Sciences, New York University, for his groundbreaking contributions to the theory and application of partial differential equations and to the computation of their solutions. The prize amount is 6 million Norwegian kroner (about US$980,000).

Ever since Newton, differential equations have been the basis for the scientific understanding of nature. Linear differential equations, in which cause and effect are directly proportional, are reasonably well understood. The equations that arise in such fields as aerodynamics, meteorology, and elasticity are nonlinear and much more complex: their solutions can develop singularities. Think of the shock waves that appear when an airplane breaks the sound barrier.

In the 1950s and 1960s, Lax laid the foundations for the modern theory of nonlinear equations of this type (hyperbolic systems). He constructed explicit solutions, identified classes of especially well-behaved systems, introduced an important notion of entropy, and, with Glimm, made a penetrating study of how solutions behave over a long period of time. In addition, he introduced the widely used Lax-Friedrichs and Lax-Wendroff numerical schemes for computing solutions. His work in this area was important for further theoretical developments. It has also been extraordinarily fruitful for practical applications, from weather prediction to airplane design.

Another important cornerstone of modern numerical analysis is the "Lax Equivalence Theorem". Inspired by Richtmyer, Lax established with this theorem the conditions under which a numerical implementation gives a valid approximation to the solution of a differential equation. This result brought enormous clarity to the subject.

A system of differential equations is called "integrable" if its solutions are completely characterized by some crucial quantities that do not change in time. A classical example is the spinning top or gyroscope, where the conserved quantities are energy and angular momentum.

Integrable systems have been studied since the nineteenth century and are important in pure as well as applied mathematics. In the late 1960s a revolution occurred when Kruskal and coworkers discovered a new family of examples that have "soliton" solutions: single-crested waves that maintain their shape as they travel. Lax became fascinated by these mysterious solutions and found a unifying concept for understanding them, rewriting the equations in terms of what are now called "Lax pairs". This developed into an essential tool for the whole field, leading to new constructions of integrable systems and facilitating their study.

Scattering theory is concerned with the change in a wave as it goes around an obstacle. This phenomenon occurs not only in fluids, but also, for instance, in atomic physics (Schrödinger equation). Together with Phillips, Lax developed a broad theory of scattering and described the long-term behavior of solutions (specifically, the decay of energy). Their work also turned out to be important in fields of mathematics apparently very distant from differential equations, such as number theory. This is an unusual and very beautiful example of a framework built for applied mathematics leading to new insights within pure mathematics.

Peter Lax has been described as the most versatile mathematician of his generation. The impressive list above by no means states all of his achievements. His use of geometric optics to study the propagation of singularities inaugurated the theory of Fourier integral operators. With Nirenberg, he derived the definitive Gåarding-type estimates for systems of equations. Other celebrated results include the Lax-Milgram lemma and Lax's version of the Phragmén-Lindelöf principle for elliptic equations.

He is also one of the founders of modern computational mathematics. Among his most important contributions to the high performance computing and communications community was his work on the National Science Board (NSB) from 1980 to 1986. He also chaired the committee convened by the NSB to study large-scale computing in science and mathematics—a pioneering effort that resulted in the "Lax Report".

A distinguished educator who has mentored a large number of students, Lax has also been a tireless reformer of mathematics education. His work with differential equations has for decades been a standard part of the mathematics curriculum worldwide.

Lax stands out for having joined together pure and applied mathematics, combining a deep understanding of analysis with an extraordinary capacity to find unifying concepts. He has had a profound influence not only by his research, but also by his writing, his lifelong commitment to education, and his generosity to younger mathematicians.

Peter Lax was born on May 1, 1926, in Budapest, Hungary. He was on his way to New York with his parents on December 7, 1941, when the United States joined the war. He received his Ph.D. in 1949 from New York University with Richard Courant as his thesis advisor. In 1950 Lax went to Los Alamos for a year and later worked there for several summers as a consultant. He joined the faculty at NYU in 1951 and became a full professor in 1958. Lax served as director of the Courant Institute from 1972 to 1980. At NYU he has also served as director of the AEC (Atomic Energy Commission) Computing and Applied Mathematics Center.

His work has been recognized by many honors and awards. He was awarded the National Medal of Science in 1986, the Wolf Prize in 1987, and the Chauvenet Prize of the Mathematical Association of America in 1974. He received the AMS Steele Prize for Lifetime Achievement in 1993 and the AMS-SIAM Norbert Wiener Prize in 1975. He served as both president (1977–80) and vice president (1969–71) of the AMS. He was elected to the U.S. National Academy of Sciences in 1982.

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