

MANDELBROT AND ZEWAIL WIN 1993 WOLF PRIZES IN PHYSICS, CHEMISTRY

The Wolf Foundation of Herzlia, Israel, has chosen Benoit B. Mandelbrot of IBM's Thomas J. Watson Research Center to receive the 1993 Wolf Prize in Physics. Ahmed H. Zewail, the Linus Pauling Professor of Chemical Physics at Caltech, has been named the winner of the 1993 Wolf Prize in Chemistry. They received their awards at a ceremony at the Knesset on 16 May.

Mandelbrot's citation says, "By recognizing the widespread occurrence of fractals and developing mathematical tools for describing them, he has changed our view of nature." Mandelbrot developed the geometric idea of fractals from the study of scaling in various problems, including $1/f$ noise, turbulence, the distribution of galaxies and the Earth's topology.

Mandelbrot had postulated scaling in the study of securities markets in the early 1960s and was aware that the quantity he used to measure market volatility could be interpreted as a fractional dimension. He introduced both fractals and multifractals as concepts with physical

meaning in 1974, in a paper concerned with turbulence that appeared in the *Journal of Fluid Mechanics*. Fractals are geometric objects that have the same shape at all scales, and multifractals are in effect density distributions with the same irregularity at all scales. Mandelbrot's "hand-waving" arguments, as he calls them, were soon made mathematically rigorous.

In 1975 he wrote the first book on fractals, in French; an English translation was published in 1977. His 1982 book *The Fractal Geometry of Nature* is widely quoted and has had a wide impact.

While visiting at Harvard in 1979–80, Mandelbrot, Amnon Aharony and Yuval Gefen worked on the role of fractal dimension in the Ising model—deliberately selecting a problem that physicists know well. During that time Mandelbrot also developed what became known as the Mandelbrot set of the transform $z \rightarrow z^2 + c$. The work of those years was key in gaining acceptance for fractals in condensed matter theory and also in the study of dynamical systems and in mathematics.

Mandelbrot is a pioneer of the use of computer graphics, which he claims led to the current wide acceptance of fractals. He says a friend jokes, "This way of working was orthogonal to what everyone else was doing."

Mandelbrot's current work centers on diffusion-limited aggregation.

Mandelbrot says he's gratified that fractals have gained wide application in many fields, including education. Schoolchildren find fractals more interesting than Euclidean shapes, he says. For one thing, Euclidean shapes are rare in the real world, so "it takes a lot of learning to become convinced" that circles, cones and the like are interesting. For another, fractals have layer upon layer of structure—"a form of white magic," he calls it.

Mandelbrot attended the Ecole Polytechnique in Paris, then earned an MS in aeronautical engineering from Caltech in 1949 and a doctorate in mathematics from the University of Paris in 1952. In 1958, after holding positions at the Centre National de la Recherche Scientifique in Paris; Lille University in Lille, France; and the Ecole Polytechnique, Mandelbrot became a research staff member at IBM. He has been an IBM fellow since 1974. Since 1987 he has also been an adjunct professor of mathematical sciences at Yale University.

In giving the chemistry prize, the Wolf Foundation cited Zewail for "pioneering the development of laser femtochemistry. Using lasers and molecular beams, femtochemistry has now made it possible to probe the evolution of chemical reactions as they actually happen in real time." Zewail's femtochemistry went beyond merely measuring the energies of a chemical reaction's end products to observing the reaction's dynamics during the transition state.

In 1979 Zewail started experiments with picosecond time resolution and

Benoit B. Mandelbrot



Ahmed H. Zewail



succeeded in studying in real time phenomena, such as energy redistribution, that occur on this time scale. Soon after, he was able to improve the time resolution of the experiments by at least two orders of magnitude, taking them into the femtosecond epoch.

Since nuclei move at speeds of approximately 1 km/sec in the course of a chemical reaction, having femtosecond time resolution enabled Zewail and his group to record the elementary stages of a chemical reaction. "There was a natural evolution of the field that opened up exciting opportunities," Zewail told us. He said the group was fortunate to be working when Charles Shank (Bell Labs) developed lasers with the necessary time resolution.

Because a laser pulse of several femtoseconds is so short, Zewail and his group could localize the wavefunction of a given structure using what is referred to as a clocking pulse. A series of "probe" pulses, properly tuned, views the motion of the atoms through the transition states. This method allowed unimolecular reactions to be clocked and studied in real time.

To study bimolecular reactions, Zewail used the clocking pulse to initiate the reaction of one reactant molecule with another. "We used the novel methodology of Curt Wittig [University of Southern California] and Benoit Soep [Orsay, France] to form a well-defined geometry of reactants," says Zewail. That technique is a way to get two different molecules, for example AB and CD, to bond to one another through the van der Waals force. In a femtochemistry study, the clocking laser pulse excites AB and breaks its intramolecular bond. Then one of the atoms, say B, reacts with CD. The nuclei pass through the transition state $[BCD]^\ddagger$ to form the products $BC + D$. Because the probes disturb the molecules, the experiments cannot follow particular molecules through the reaction, but instead sample an ensemble of molecules that start from the same coherent state.

More recently Zewail and his group have begun to develop ultrafast electron diffraction to observe images of reactions. Instead of using a second photon pulse to observe the reaction initiated by the first, the group shoots in an electron beam and observes how it diffracts.

Zewail's group is investigating several possible new directions for femtochemistry. One is to study reactions of increasing complexity, such as those involving proton and electron

transfer and solvation by other atoms or molecules. Another is to try to control nuclear motion using ultrashort pulses.

Zewail got his PhD in chemical physics in 1974 from the University of Pennsylvania. He subsequently spent two years as an IBM research fellow at the University of California, Berkeley. He joined the Caltech faculty in 1976.

IN BRIEF

The British Royal Astronomical Society awarded its 1992 Gold Medals to **Eugene Parker** for astrophysics and to **Dan McKenzie** for geophysics. Parker is Subrahmanyan Chandrasekhar Distinguished Service Professor of Physics at the University of Chicago. McKenzie is a professor in the department of Earth sciences at Cambridge University.

Joel A. Snow will become director of the Institute for Physical Research and Technology at Iowa State University on 1 July. He currently oversees research at Argonne National Laboratory as associate vice president for research at the University of Chicago.

Pennsylvania State University has appointed **Abhay Ashtekar** as the first holder of the Eberly Family Chair in Physics, which he will assume this autumn. He is currently Holden Professor of Physics at Syracuse University.

The Society of Polymer Science, Japan, gave the 1993 Award for Distinguished Service in Advancement of Polymer Science to **Leo Mandelkern** for his "contributions to the basic understanding of the crystallization behavior of polymers." Mandelkern is R. O. Lawton Distinguished Professor of Chemistry at Florida State University.

The Astronomical Society of the Pacific has announced its awards for 1993. **Martin Rees** of the Institute of Astronomy at the University of Cambridge, England, earned the 1993 C. W. Bruce Award. He was cited for "his pioneering accomplishments in the theory of active galactic nuclei and gravitationally collapsed objects."

David Morrison of the NASA Ames Research Center won the 1993 Klumpke-Roberts Award for his "ability to communicate the results and implications of astronomical research to the general public."

The 1993 Trumpler Award for PhD thesis research went to **Megan Donahue** of the Observatories of the Carnegie Institution of Washington.

The Overseas Chinese Physics Association gave out its 1993 awards at the April meeting of the American Physical Society in Washington, DC. The OCPA Achievement in Asia Award went to **Zhong-can Ou-Yang** of the Institute of Theoretical Physics of the Chinese Academy of Sciences, Beijing, for his "contribution to the application of liquid crystal theory to the study of lipid bilayers."

The two winners of the OCPA Outstanding Research Award were **Terence Hwa**, a postdoctoral fellow at Harvard University, and **Zhi-Xun Shen**, an assistant professor in the applied physics department at Stanford University.

Cécile DeWitt-Morette, the Jane and Roland Blumberg Centennial Professor of Physics at the University of Texas, Austin, recently received the Prix des Sciences Physiques et Mathématique from the French Committee on Radiation in recognition of her role as founder in 1951 of the Theoretical Physics Summer School at Les Houches, France.

OBITUARIES

Cyril S. Smith

In the present rush to pursue success in specific and narrow areas, it is common to bemoan the scarcity nowadays of many-faceted geniuses such as Leonardo DaVinci and others who combined scientific knowledge and creativity with enormous knowledge and talent in the arts. Actually, there still exist among us a few individuals who can be called Renaissance persons. Cyril S. Smith, an Institute Professor at MIT, who died on 25 August 1992, was a prime example.

Although Cyril's official métier was metallurgy—which in most people's minds is associated with engineering—in fact his sphere of interest and expertise was much broader. He was typical of what the Germans call *Schöngeist* or the French *grand esprit*. It was indeed a pleasure to hear him discussing trends in modern architecture and sculpture, the reasons for the shapes of trees and leaves, or the role of symmetry in life in general.

Cyril was born in Birmingham, England, in 1903 and went to the university there. He obtained his PhD in metallurgy at MIT in 1926.