

member of the university's Center for Soft Matter Research. He left a position as a professor of physics with the University of Chicago, where he had been on the faculty since 1992.

In October, **Arthur Ramirez** became director of the condensed matter physics research department at Lucent Technologies' Bell Labs in Murray Hill, New Jersey. Ramirez, who also joined Columbia University as an adjunct professor of applied physics and applied mathematics, was previously the group leader of the materials integration science

laboratory at Los Alamos National Laboratory.

Andrew K. Rogers began his new position last October as a senior scientist/senior oceanographer with the Woods Hole Group in East Falmouth, Massachusetts. He is responsible for, among other tasks, managing scientific research, consulting, and technical support efforts in applied information technology, including remote sensors and acoustics. He was formerly senior principal scientist with Planning Systems Inc in Reston, Virginia.

Obituaries

Ilya Prigogine

Ilya Prigogine, the 1977 Nobel laureate in chemistry, died on 25 May 2003 in Brussels, Belgium, of cancer.

Born in Moscow on 25 January 1917, Prigogine fled the Soviet Union with his family in 1921. After short stays in Lithuania and Germany, they settled in Belgium in 1929. A talented musician deeply interested in history, philosophy, and archaeology, Prigogine toyed with the idea of becoming a professional pianist, but instead chose to study chemistry and physics.

He received a PhD in 1941 from the Free University of Brussels (ULB) and was greatly influenced by Théophile de Donder, the founder of the Brussels school of thermodynamics. One of de Donder's major contributions was the development of a relationship between macroscopic entropy production and the rate of a chemical reaction via introduction of a new thermodynamic function, the affinity. Perhaps it was that influence that led Prigogine to study irreversible phenomena almost exclusively, first from the macroscopic point of view, then from the molecular point of view.

For the past two decades, Prigogine focused his research on a reformulation of quantum mechanics to account for irreversibility via the structure of the space of states. Although sometimes controversial, his contributions were of outstanding intellectual merit and addressed the most fundamental issues. Arguably equally important was Prigogine's creation of a school of theoretical chemical physics at the ULB.

The 1977 Nobel Prize in Chemistry cites Prigogine's "contributions to non-equilibrium thermodynamics, par-

ticularly the theory of dissipative structures." Those contributions pertain to his creation of a systematic framework to analyze a wealth of phenomena in systems far from equilibrium, such as chemical systems with multiple stationary states, oscillatory systems, the formation of stable and oscillatory macroscopic spatial structures, and chemical waves. The first important step in that development, in 1945, was his proof, with great generality, of the principle of minimum entropy production. That proof followed a clue provided in a statement by Lars Onsager that implied that a physical system open to fluxes evolves until it attains a stationary state in which the rate of dissipation is minimal. But in this near-equilibrium regime, the entropy production is a Lyapunov function, which suggests that stationary states are always stable; hence, a system near equilibrium cannot evolve spontaneously to gener-

ate spatial-temporal structures.

The second important step followed from studies in the 1960s of systems with nonlinearities such as those generated by autocatalysis or feedback loops in chemical reactions driven far from equilibrium. Prigogine's new finding was that, as the system is driven far from equilibrium, it may become unstable and generate spatial-temporal structures, which Prigogine called dissipative structures, signatures of coherent behavior. The dissipative structures are maintained by flows of energy and matter.

The third step, in the late 1960s, was Prigogine's development of a thermodynamic theory, including a theory of stability based on analysis of entropy production, that spans the entire range from equilibrium to far-from-equilibrium phenomena. Prigogine often stressed the philosophical implications of his work. He contrasted the ubiquitous role of the second law of thermodynamics in the physical sciences with its description of evolution toward states, with the greatest disorganization and the ubiquitous role of Darwinian evolution in the biological sciences, and with its description of ever increasing complexity of organization. He emphasized different laws are not required for these two situations; rather, there exists one set of fundamental laws. A characteristic feature of those laws, he said, is that near-equilibrium temporal evolution typically destroys structure. In contrast, far from equilibrium, beyond the limit of stability of the near-equilibrium behavior, nonlinear kinetic processes associated with flows of matter and energy can generate structure, and both processes are consistent with the second law of thermodynamics.

Prigogine's studies of the microscopic theory of time evolution of many-body systems focused heavily on the approach to equilibrium, with only a few forays into applications such as the theory of transport in liquids. The principal tools in his studies were the concept of temporal evolution of correlations and the use of infinite order perturbation theory with partial summation of terms to generate equations of motion. In later developments, he incorporated the role of deterministic chaos (in classical mechanics) into the basic description of the approach to equilibrium. His findings addressed fundamental issues of the apparent conflict between the time reversibility of the basic equations of classical and quantum mechanics and the irreversibility that



Ilya Prigogine

is embodied in the second law of thermodynamics and that describes the macroscopic behavior of matter.

Perhaps the most daring—and most controversial—of Prigogine's work was his attempt to reconcile the microscopic–macroscopic irreversibility dichotomy by modifying the fundamental equations of motion. The conventional picture is that the equations of motion of quantum or classical mechanics are “exact” and that the second law of thermodynamics is to be interpreted as a macroscopic consequence of loss of correlations in the motions of the particles through averaging, or loss of information, or loss by some other means. Prigogine turned the question around and asked that if one accepted the second law of thermodynamics as “exact,” would it be possible to modify the equations of motion to preserve what is known about solutions to those equations and also have the second law emerge as an exact description of macroscopic behavior without use of further hypotheses. He and coworkers postulated such a modification and showed that, at least in solutions generated by perturbation theory, it had the desired features. It remains to be seen whether this development will fundamentally alter our worldview or will prove to be an interesting but fruitless theoretical byway.

I had a very warm, personal relationship with Prigogine. I met him when I was a graduate student and he was a visiting professor at Harvard University. We became friends immediately, and our friendship endured for 48 years. He was a warm and generous person, loyal to his friends and the institutions he served. He also was a spokesperson for science and for the integration of science with all other aspects of culture and society. He is missed.

Stuart A. Rice
University of Chicago
Chicago, Illinois

Vernon Ellsworth Derr

Vernon Ellsworth Derr, a pioneer and leader in optical remote sensing of the atmosphere, died on 24 July 2003 in Boulder, Colorado, of complications of Parkinson's disease.

Born on 21 November 1921 in Baltimore, Maryland, Vernon served in the US Army Signal Corps with the rank of captain. He then entered St. John's College in Annapolis, Maryland, and graduated with an AB in 1948. He was awarded a PhD in



Vernon Ellsworth Derr

physics by Johns Hopkins University in 1959. His thesis work, conducted under the guidance of Richard Cox, was on the irreversibility of quantum mechanical systems perturbed by random forces; it led to a *Physics Review* paper in 1960.

Vernon then joined the Martin Co in Orlando, Florida, as principal scientist in charge of the quantum electronics group, which used wavelengths spanning the range from millimeter waves to UV to study molecular structures. For spectroscopic studies, the group developed instruments, including lasers, masers, and a millimeter-wave molecular beam machine, for applications such as nuclear pumping of lasers and atomic frequency standards.

In 1967, Vernon joined the newly formed Wave Propagation Laboratory of the Environmental Science Services Administration (now the National Oceanic and Atmospheric Administration, NOAA). This remote-sensing laboratory, a descendant of the Central Radio Propagation Laboratory of the National Bureau of Standards, already had expertise at radio frequencies ranging up to 100 GHz. The inclusion of Vernon (and three other members of his Martin team) added critically needed competence in millimeter, IR, and optical frequencies. As head of the submillimeter section, Vernon pioneered the development of an extraordinarily wide range of active (radarlike), passive (radiometric), and line-of-sight (attenuation) studies of the atmosphere and its constituents.

During the early 1970s, his research group developed one of the first transportable light detection and ranging systems for the study of air

pollution. The scannable LIDAR system transmitted IR, visible, or UV radiation, which enabled multi-wavelength studies of the scattering and transmission characteristics of atmospheric aerosols. That system was deployed in several experiments, including some of the earliest studies of air pollution—the Denver Brown Cloud—in the Denver, Colorado, basin. In keeping with Vernon's insatiable scientific curiosity and broad range of interests, he also used LIDAR to study ice characteristics in cirrus clouds and to investigate the feasibility of Raman LIDAR measurements of profiles of temperature and water vapor.

Working with Ron Schwiesow of the submillimeter section, Vernon also developed one of the earliest carbon dioxide Doppler LIDAR systems to measure atmospheric winds. Mounted initially in a small camper and later deployed in a light aircraft, the continuous-wave instrument obtained some of the earliest measurements of airflow in desert dust devils and waterspouts. That research set the stage for many later applications of Doppler LIDAR to study a wide variety of atmospheric phenomena, including canyon and valley flows, sea breezes, low-level jets, wake vortices, thunderstorm outflows, and forest fires.

A unique contribution was Vernon's organization and editing of the 30-chapter, 650-page text *Remote Sensing of the Troposphere* (NOAA, 1972). The book is a landmark overview of the physics of the lower atmosphere and the application of remote-sensing techniques to atmospheric problems.

In 1981, George Ludwig selected Vernon as deputy director of the Environmental Research Laboratories, the 1300-person, 10-laboratory research arm of NOAA. From 1983 to 1988, he served as director of NOAA-ERL and then, until his retirement in 1991, as senior scientist in NOAA's Office of Oceanic and Atmospheric Research. From 1991 to 1994, he was a senior scientist in the jointly sponsored NOAA–University of Colorado Cooperative Institute for Research in Environmental Science at CU Boulder.

Vernon was an excellent scientist and science administrator. A stimulating communicator, teacher, and mentor, he taught an optical remote-sensing course at Colorado for many years as an adjunct professor. His awards included a US Presidential Distinguished Rank Award in 1988 and the Department of Commerce's highest award, the Gold Medal, in 1991.