the corresponding neutrino form an isotopic doublet and that the weak interaction is isotopically invariant.

The effects of parity violation in atomic transitions proposed by Zeldovich for heavy elements were experimentally demonstrated only two decades later, accompanied by strong disputes in several groups of experimenters. His contribution to the confirmation of the standard model of electroweak interactions appears absolutely doubtless.

Meanwhile quite different distance scales caught his attention. The 1960s witnessed the beginning of his work in astrophysics and cosmology, which brought him worldwide recognition in the 1970s and 1980s.

Zel'dovich possessed a literary talent of remarkable force. It revealed itself with brilliance and power not only in his scientific books and reviews, but also in memoirs, comic essays, plays and poems permeated with his rare sense of humor.

I hope someday to bring to readers of popular scientific journals the rich collection of the letters, notes and sketches he used to drop into my letter box during the decades our apartment doors were next to each other, as well as the comic play that we wrote and staged together in 1946 on the 50th anniversary of our teacher Semenov.

His many friends find it hard to realize that he is no longer with us; we will never have enough time to get used to the thought. I would like to add that the members of the large and united Zel'dovich family have always lived for each other, and for physics. The talents of his children and their achievements were objects of pride and joy for our dear late friend, and consoled him in the unavoidable cloudy hours of his life.

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(*Editor's note:* A discussion of Zel'dovich's work in astrophysics will appear in a later issue of PHYSICS TODAY.)

James Barcus

James Roy Barcus, professor of physics at the University of Denver, died 3 January 1988 at his home in Denver after a long battle with lung cancer.

Jim was born in Kansas City, Missouri on 30 September 1930. He served in the US Navy before enrolling as an undergraduate at the University of New Mexico, where he obtained both his BA and his PhD. His doctoral research under John R. Green was on extensive air showers of cosmic radiation. In 1961, following graduate school, Jim became a research scientist at the University of California, Berkeley.

Jim came to Berkeley at a time when the use of high-altitude balloons to measure auroral x rays in the polar regions was still in its infancy. He played a leading role in organizing and carrying out electron precipitation studies with simultaneous measurements from magnetically conjugate regions in the Northern and Southern Hemispheres. Also while at Berkeley, Barcus pioneered the combined use of balloon-borne photometric and x-ray detectors in auroral studies. In addition, he obtained the first information about the spatial features of electron microbursts, through the use of multiple, spatially separated balloon flights.

He joined the University of Denver in 1965, and became a full professor there in 1970. He continued with conjugate studies and began balloon flights in Antarctica during his early Denver years.

In 1974 Jim began an active and fruitful interest in using sounding rockets to study the response of the middle atmosphere to various high-energy inputs such as auroral x rays produced by bremsstrahlung and relativistic electrons, and in middle-atmospheric electrodynamics. This work involved collaboration with a large number of scientists at various US and foreign institutes and universities. The more notable programs in which he participated included Antarqui and Condor in Peru; Ararozone I and II in Alaska; Middle Atmosphere Electrodynamics I, II and III, conducted in Norway and Alaska; and, most recently, MAC/Epsilon, carried out in Norway in October 1987. His important contributions include the discovery of relativistic electron showers associated with most, and perhaps all, auroral events, and the discovery of micropulsations in relativistic electron showers, which he also observed in Norway in 1980. The latter phenomenon eventually became the PhD thesis topic of his graduate student Karl Hudnut. Barcus also contributed to studies of the effects of the x-ray star Sco X-1 on the middle atmosphere, anomalously large electric fields in the mesosphere, the influence of very low frequency electromagnetic waves produced by manmade transmitters and lightning on magnetospheric electron preciptation and, most recently, neutral atmospheric-wave-induced turbulence in the mesosphere. His spirit and drive helped him maintain a keen and productive interest in his research nearly up to the time of his passing.

Barcus also served as a program director of the Solar–Terrestrial Program at the National Science Foundation, and he was a member of the scientific committee on Antarctic research. He had excellent skills as an experimenter and was particularly adept at instrument and electronics development. His enthusiasm for experimental work was infectious, particularly under the often difficult and demanding circumstances of field work.

Barcus had a clear insight into the physics underlying his experimental observations. He enjoyed discussing the salient features of the data he collected from balloon expeditions with colleagues from various research specialties, and they in turn sought his criticism and advice. He mixed easily with colleagues from many countries and cultures.

He enjoyed teaching undergraduate classes, where he always insisted that his students think for themselves. His students always responded by doing more than the minimum required to pass, and many returned to see him after several years, to thank him for challenging them. His colleagues and students from many countries will miss him.

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James Wittke

James P. Wittke died unexpectedly on 31 October 1987. A universally respected physicist, he was known for his keen analytical abilities, the breadth of his interests, and his willingness and ability to deal with any problem. Jim's contributions extended from quantum mechanics to optical communications to manufacturing technology; his interest in gardening, for instance, led him to develop computer programs to analyze the effects of temperature and rainfall on his own garden. Jim spent his entire professional career, after one year as an instructor at Princeton Universi-

ty, at RCA Laboratories in Princeton, New Jersey, retiring in April 1987. He became a Fellow of the Technical Staff in 1978.

Born on 2 April 1928 in Westfield, New Jersey, Jim earned his undergraduate degree in mechanical engineering from Stevens Institute of Technology in 1949. Then, in his words, he "traveled all the way to Princeton" for graduate work in physics. Jim's doctoral research under Robert H. Dicke involved a microwave spectroscopic measurement of the hyperfine splitting of the ground state of atomic hydrogen—the first experimental use of collision reduction of the Doppler broadening of a spectroscopic line. At the time, this was the most accurate determination of the hyperfine splitting of atomic hydrogen. He received his PhD in 1955. Wittke became widely known as the coauthor with Dicke of the textbook *Introduction to Quantum Mechanics*. This book is known in many parts of the world, and after 28 years is still being used in an appreciable number of courses.

Jim's research shifted to magnetic resonance and microwave masers in the early years of their development, then to optically excited crystal lasers and to motions and properties of impurities in rutile. He also worked on several classified projects. In 1967 Jim was awarded an RCA Fellowship for a year of study abroad, which he spent at the Clarendon Laboratory at Oxford University. On returning, he studied the luminescence and photoconductivity of heavily doped GaAs, helped to develop new infrared-stimulated light-emitting phosphors and used mode-locking techniques to generate ultrashort laser pulses. In fiberoptic communication systems he made measurements of the transmission properties of various fibers and of the frequency response of light-emitting diodes, and he developed techniques for coupling the light from semiconductor light sources into fibers. He then developed applications of high-power lasers to materials processing and to production problems. At the time of his death Wittke was a consultant to the David Sarnoff Research Center of SRI (the organizational descendant of RCA Laboratories).

Through all of his varied career, Wittke's work generated consistent respect and admiration among his peers. As one of his grateful coworkers, I valued his perceptive analyses; his collaboration was a virtual assurance against making a mistake.

As a friend also, I share in the strong sense of loss among those whose lives were enriched by this fine, quiet man of absolute integrity.

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Carlos Graef-Fernández

On 14 January 1988 Carlos Graef-Fernández died in Mexico City after a long illness. Graef was beloved by many generations of Mexican scientists. He attended the National University of Mexico for his undergraduate studies in physics. He later obtained his PhD at MIT under the direction of another famous Mexican physicist, Manuel Sandoval Vallarta. Graef initially worked in cosmic-ray theory; he later collaborated on an alternative mathematical formulation of general relativity with the mathematician David Birkhoff (Princeton University).

After returning to Mexico Graef was appointed director of the Institute of Physics of the National University of Mexico, where he remained for ten years. In that position he reorganized the national effort in physics. He strongly promoted the theoretical physics group under Marcos Moshinsky and the experimental physics group under Fernando Alba. He persuaded the government to purchase a 2-MeV Van de Graaff electron accelerator, which was the big booster of Mexican experimental physics in the 1950s. He later served as director of the School of Sciences of the National University of Mexico and as director of the Mexican Nuclear Center in Salazar. He served in many national and international organizations (such as the International Atomic Energy Agency and the Organization of American States) and was elected professor emeritus of the National University of Mexico in 1972.

Above all Graef had a warm and enthusiastic personality, and he was always willing to help students with homework problems or to discuss physics with colleagues. Listening to his class made one feel that physics was a beautiful and enjoyable science, worth being part of. Probably his best obituary was an anonymous note that appeared on the wall outside his classroom the day his death became known, written on a student's piece of paper: "Graef we loved you, we will miss you."

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