Mario's selfless service to his profession is exemplified by the Iona family gift, in 2000, of a lounge within DU's department of physics and astronomy for members of the Society of Physics Students and Sigma Pi Sigma. His colleagues and former students remember him with great appreciation and high personal regard for his academic integrity and for his devotion to physics education.

Herschel Neumann
University of Denver
Denver, Colorado
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Edwin Albert Power

Edwin Albert Power, emeritus professor of applied mathematics at University College London, distinguished for his pioneering contributions to nonrelativistic quantum electrodynamics (QED), died on 31 January 2004 in London after a short illness.

Edwin Albert Power

Power was born in Honiton in southwestern England on 12 February 1928. He entered University College London in 1945 at age 17 and graduated with a BSc (1948) and an MSc (1949), both in mathematics. For postgraduate study, he worked on meson production in proton–proton collisions with John Gunn at the University of Glasgow. In 1951, the university awarded him the Kelvin Prize for the best physics thesis submitted for a PhD that year. He then returned to the mathematics department at University College, where he was promoted to professor of applied mathematics in 1967 and, in 1991, was made a fellow of University College for his contributions to mathematics and services to the college.

In 1953, Power was awarded a Commonwealth Fund Fellow (now called Harkness fellowship) and traveled to the US to spend one year at Cornell University and another year at Princeton University. At Princeton, he and John Wheeler wrote an important paper in 1957 on thermal geons (their abbreviation for gravitational–electromagnetic entities), which they studied within the framework of classical Einstein–Maxwell theory. The paper was republished in a collection of Wheeler's papers entitled *Geometrodynamics* (Academic Press, 1962).

Power's research was on the interaction between the quantized radiation field and particles—nuclei and atomic or molecular electrons—moving at nonrelativistic speeds. Using methods he and his colleagues had largely developed themselves, he worked within the framework of nonrelativistic QED. In 1959, he and Sigurd Zienau published in the *Philosophical Transactions of the Royal Society of London* a seminal paper on the Coulomb gauge in QED and its applications to the shape of spectral lines, the nonrelativistic Lamb shift, and other phenomena. The work was timely, given the rising experimental interest in low-energy particles in atoms and molecules that interact with each other and with radiation when relativistic corrections are negligible. Power's results were more precise, and gave a clearer physical picture, than the conventional semiclassical calculations, which did not consider the quantization of the radiation field.

Power's interests included circular dichroism and optical activity, interactions between chiral (optically active) molecules, and nonlinear optics. Other researchers have used his methods in resonance energy transfer and aspects of intermolecular forces. In these applications, the underlying theory, known as molecular QED, involves the coupling of molecular multipole moments to the quantized radiation field. Power had a gift of expressing his results in ways that were easily visualized; for example, in *Magic Without Magic* (W. H. Freeman, 1972), a volume dedicated to Wheeler, he showed how the retarded Casimir–Polder potential between neutral atoms could be seen as the consequence of zero-point energy depression of the modes of the radiation field coupled to polarizable matter systems.

Power retired in 1992 but continued to be active in research until 2003. His last research effort, which involved a collaboration with one of us (Thirunamachandran), was the derivation of the electric and magnetic fields of moving multipoles by solving Maxwell's equations without specifying the gauge or using the electromagnetic potentials. They first used the method to get the Feynman formulas for the fields of a moving charge. A central feature of the derivation is that it requires the integration of a differential equation that is first order in time.

Power's much-used book, *Introductory Quantum Electrodynamics* (American Elsevier, 1964), was based on postgraduate lectures he gave in Chile and in Boulder, Colorado. He lectured carefully and lucidly, and his introductory talks on mathematics for chemists at University College were models in their combination of well-judged content and precision. He was an entertaining speaker. At a conference on the electromagnetic vacuum, he said of his work, "For several years I have been working on nothing, and the college has been paying me!"

Although Power's academic base was University College, he held visiting appointments elsewhere, including at Cornell University, the University of Southern California, Australian National University, the University of Palermo, and the University of the West Indies. His graduate courses in QED inspired many to take up research in the field.

Power appeared reserved but formed close friendships and showed a warm interest in colleagues, collaborators, and friends. He was a devoted family man. He and his wife, Anne, took pleasure in the pastime of orienteering, in which they had to race on foot to find their way, point-to-point, with map and compass and a minimum of clues. He was a modest, nonassertive scientist and an effective communicator who made important forward steps in his field. There are few like him. He is sadly missed.

David Craig
Australian National University
Canberra
Thuraiappah "Thiru" Thirunamachandran
University College London
London, England

Peter Wootton

Peter Wootton, medical physicist and professor emeritus of radiation oncology at the University of Washington, Seattle (UW), died at his home in Bellevue, Washington, on 3 May 2004 after a 3½-year battle with pancreatic cancer.

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Peter Wootton

Peter was born on 30 April 1924 in Peterborough, England. He attended Birmingham University, where he received a BSc in physics with honors in 1944. After serving in His Majesty's Antisubmarine Establishment, he took a position as a radiation physicist at the Royal Infirmary in Glasgow, Scotland. In 1951, he came to the US as an instructor in medical physics at the University of Texas M. D. Anderson Cancer Center, where he worked with Robert Shalek and Gilbert Fletcher on the calculation of radiation dose from radium and cobalt-60 in water and tissue.

When Peter left M. D. Anderson in 1953 to take a position at Swedish Hospital's Tumor Institute (now the Swedish Cancer Institute) in Seattle, he was the only full-time medical physicist in the Northwest. At that time, radiation therapy and medical physics were considered part of radiology. The Tumor Institute, a separate facility devoted to radiation oncology, was a rare exception, perhaps unique in the US.

In 1964, Peter joined the faculty of UW's radiology department, which followed the more common model of combining radiation therapy and medical physics with diagnostic radiology. He served as head of the department's medical physics division. In 1978, that division was incorporated into a new radiation oncology department, and Peter continued as division head until his retirement in 1995.

Peter was deeply committed to the service of cancer treatment. In 1966, he started a medical physics service, known as the Regional Medical Physics program, at UW. The service evolved into a freestanding institution, now called the Northwest Medical Physics Center, which still provides medical physics services to radiation therapy facilities throughout the Northwest.

Peter worked closely with radiation oncologist Robert Parker while at Swedish Hospital, and later at UW, where Parker became chairman of the new radiation oncology department, in the investigation of high-pressure oxygen as an enhancement to radiation therapy. The procedure is based on the so-called oxygen effect, in which the response of some kinds of tumors to radiation increases with increased oxygenation of the tissues. Conversely, tumors poorly infused with oxygen are more resistant to radiation. The oxygen enhancement ratio (OER) is the ratio of radiation dose required for a given endpoint under oxygen-deficient conditions to that required for the same endpoint under oxygen-rich conditions. The OER for a typical high-energy photon therapy beam is 2.5–3.0, which makes oxygen one of the most powerful radiation sensitizers known. Despite heroic efforts, it was not possible in a clinical setting to increase the perfusion of tumors sufficiently to take advantage of this effect.

The oxygen effect is somewhat less pronounced for fast neutrons than for photons (the OER for neutrons is only about 1.5–1.8), so the use of fast neutrons for cancer treatment has been explored for many decades. Because normal tissue is already typically much better perfused with oxygen than tumor, the lower OER for neutrons gives an enhancement of tumoricidal effect relative to normal tissue, and not just a scaling of the required dose. In 1971, clinical trials of neutron radiotherapy, using the NPL cyclotron, began at UW's Nuclear Physics Laboratory. Peter directed the medical physics component of that project.

When the National Cancer Institute decided to expand its facilities for investigation of particle-beam radiotherapy, Peter worked with George Laramore, then an assistant professor at UW, on a proposal for a dedicated cyclotron-based neutron therapy facility at UW. Peter directed the construction phase, and his visionary approach resulted in a unique structure representing a significant step forward in radiotherapy facility design. Peter insisted on the importance of a multileaf collimator for neutron therapy, even though it was well beyond the state of the art even for x-ray therapy.

His judgment was borne out later in clinical trials. The UW facility saw significantly less adverse normal tissue response than the other neutron therapy facilities without multileaf collimators, even though the dosimetric characteristics of the various neutron beams appeared to be very close. Today, 20 years after it first began operating, the UW clinical neutron therapy facility continues to be the state of the art in neutron therapy and serves a worldwide patient base.

Peter pursued clinical aspects of fast neutron therapy with an interest in the possible application of boron neutron capture therapy. He advocated the use of sodium activation as an assessment of potential boron capture dose enhancement, and worked with Ruedi Risler—whom he hired as technical director of the clinical neutron therapy facility—on the measurements. That therapy is still limited by the unavailability of drugs that would deliver sufficient boron to tumor sites.

As a teacher, Peter was superb. He supervised many master's students, several PhD students, and a series of postdoctoral trainees. He served as a mentor to numerous others who have benefited greatly from his personal and professional qualities.

When the American Association of Physicists in Medicine was incorporated in 1965, Peter was a member of the initial board of directors and a signatory of the organization's articles of incorporation. He served a yearlong term as AAPM president in 1978.

For as long as he was able, following his retirement, Peter participated in weekly physics conferences at the UW radiation oncology department. His experience, wisdom, and insight were invaluable and are greatly missed.

Ira J. Kalet
University of Washington, Seattle ■