transitions between Zeeman sublevels, where the atom absorbs several photons—not just one—during the transition. Other results included the observation of the narrowing of the magnetic resonance curves in the excited state due to coherent multiple scattering and the prediction and observation of light shifts.

I joined the group at the Ecole Normale in 1955 and recall the exceptional atmosphere that prevailed in the lab. There was a great intellectual complicity between Kastler and Brossel, combined with a complementarity of their talents. Kastler was a "poet" of physics who had numerous elegant ideas, whereas Brossel was an outstanding experimentalist who had a deep understanding of the physical processes. It was Brossel who first gave a transparent interpretation of multiphoton resonances in terms of conservation of the total energy and angular momentum during the transition. He was also the first to interpret the narrowing of magnetic resonance curves when the vapor pressure increases as being due to a partial transfer of the phase relations between the coefficients of the excited wavefunction from one atom to another in a multiple scattering process. Because Brossel made crucial contributions to the results obtained by the group, it was especially sad that he did not share the 1966 Nobel Prize that Kastler won.

A new period in Brossel's career began when he became the lab's director in 1967. He was very good at identifying young, bright physicists and encouraging them to start promising lines of research with complete freedom. He also led the rise of the atomic physics group at the Ecole Normale to become one of international repute. With teaching as one of his concerns, Brossel created a physics graduate program that played an essential role in the formation of generations of young physicists, not only in atomic physics, but also in particle physics, condensed matter, statistical mechanics, and astrophysics. And during his term as head of the physics department (1973–85), he attracted several new research groups in different areas of physics.

Brossel devoted his life to science and to the development of his students. He set very high standards for himself and his colleagues. Until the end of his life, he continued his experiments, even blowing glass and filling cells. He was rather shy and very discreet; people who didn't know him were not easily inclined to approach him. But once they overcame this barrier, they discovered a warm and kind person, who enjoyed art, music, and history and also had a great sense of humor. Brossel's former students, colleagues, and friends deeply miss him.

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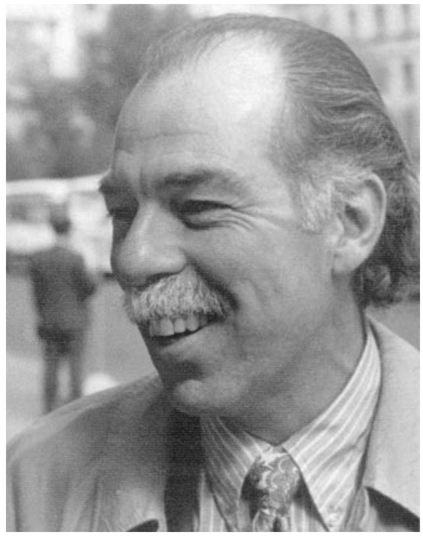
Earl Robert Callen

Earl Robert Callen, physicist, teacher, and advocate for human rights, died on 9 December 2002 at his home in Chevy Chase, Maryland, after a long struggle with cancer. His was a multifaceted career that included research work in government laboratories, research and teaching at the American University, and service as a representative of the US Office of Naval Research in Tokyo.

Earl was born on 28 August 1925 in Philadelphia, Pennsylvania, where he attended public elementary and secondary schools. Drafted into the US Army in 1943, he served in the Pacific theater until the end of hostilities. On his return to civilian life, he attended the University of Pennsylvania, where he majored in English and mathematics. He earned both his bachelor's (1948) and master's (1951) degrees at Penn.

Influenced by his older brother, Herbert, who was on Penn's physics faculty, Earl decided to become a physicist. After a year of taking courses there, including Herb's course in thermodynamics, Earl entered MIT as a graduate student. In his autobiography, he describes his entry there as a turning point in his life. His studies at Penn had not gone well. He had applied to, and was turned down by, three medical schools. But things changed for him at MIT: He went through the undergraduate physics textbooks and did all the problems in them—twice. As he put it, he was beginning to catch on. He became one of 15 research students working for a PhD under J. C. Slater. He earned his doctorate in 1954; his thesis dealt with the configuration interaction method applied to the hydrogen molecule.

After spending a year back in Philadelphia, where he worked at the Philco Research Laboratory, he went to the Washington, DC, area, where he joined the National Security Agency as a physicist, a position he held for five years. In 1959, he joined the Naval Ordnance Laboratory (NOL) to head the magnetism group.



Earl Robert Callen

It was at that time that he began what would become a fruitful collaboration with his brother on the statistical physics of magnetic materials; in particular, they studied the temperature dependence of the anisotropy energy and the magnetostriction of ferromagnets. In two seminal papers (1963 and 1965), the Callen brothers developed a quantum-statistical theory of the temperature and field dependence of magnetostriction, forced magnetostriction, and thermal expansion of ferromagnets. They derived expressions for the strains in terms of thermal and quantum mechanical averages of angular momentum operator functions. They then showed that those averages could be written as products of functions of magnetization direction cosines times temperature-dependent momentum correlation functions.

The great advantage of their theory over the prior thermodynamic approach was that, now, the arbitrary coupling constants of the previous approach were replaced by averages that are easily expressed in terms of the magnetization. Using measured values of those magnetizations, one could predict the temperature dependence of the strains. There are no adjustable parameters. Earl and colleagues at NOL showed that the theory gave excellent agreement with the temperature dependence of the magnetostriction of yttrium iron garnet. Subsequent tests of the theory for several rare earth metals and compounds showed that the theory works remarkably well for almost all magnets made up of atoms having localized angular momentum.

While on sabbatical at Osaka University in 1965, Earl became interested in the electronic properties of magnetite. On his return to NOL, he introduced an itinerant-electron model of magnetite that stimulated a worldwide outpouring of experimental papers. He published both work that extended the theory of the coupling of magnetic atoms in metals and papers on the coupling of electromagnetic waves (helicons) to magnetic excitations in metals. Most of his work while he was at NOL was collaborative; he had a way of engaging his colleagues with his enthusiasm.

In 1969, Earl left NOL and became a professor of physics at the American University in Washington, DC. Besides teaching the standard physics courses, he created and taught a course on physics and society. In 1972, the American Physical Society organized the Forum on Physics and Society, and Earl became its first chairman. In that position, he saw to it that the APS held symposia on topics including how government censorship of scientific papers affected the physics community, the Soviet government's mistreatment of their scientists wishing to emigrate, environmental concerns, and women and minorities in physics. He appeared before a congressional committee to testify against government censorship of scientific publications. His account of a trip he made to the Soviet Union in support of dissident scientists was published in the May 1974 issue of the *Atlantic Monthly*. In 1975, he traveled extensively in Asia, under the auspices of the Physics Interviewing Project, to interview prospective candidates for graduate study in physics in the US. He was one of several American physics professors who toured Asian campuses under the project, which was supported by a consortium of physics departments at several universities.

In 1987, he retired from the American University and returned to Japan as a scientific liaison for the US Office of Naval Research. In the three years he spent there, he published several reports on topics in magnetism, metallurgy, and other fields. He credited his easy access to Japanese research to the warm relations he had maintained with his old colleagues at Osaka and with younger ones who had come to work with him at the American University and NOL.

On returning to the US, Earl devoted his time to family, dancing, and tennis, despite his illness. Although he is sorely missed, his family and friends remember him with gratitude.

James Robert Cullen
University of Maryland, College Park

Ludwig Genzel

Ludwig Genzel would possibly be the last scientist to desire an obituary written on his account, because he would have thought the author's time could be more wisely spent doing science, listening to Beethoven, or appreciating the fine architecture of Europe. He was one of the cardinals of infrared spectroscopy and perhaps the reigning pope for Fabry–Pérot interferometry in the far-infrared (FIR) during the post-diffraction-grating era. For several decades, his "Genzel interferometer," with its novel in-focus beam splitter, was an industry standard. Ludwig was a mentor of outstanding pedagogical ability at the Max Planck Institute for Solid State Research. He died of pneumonia on 27 January 2003 in Stuttgart, Germany.

Ludwig Genzel

Ludwig was born on 17 February 1922 in Bad Nauheim, about 30 miles northeast of Frankfurt. Following the Great Depression and the early death of his mother, the family moved closer to Frankfurt, and Ludwig received his *abitur* (high-school diploma) in 1940 before being drafted into the German army.

The horrors of World War II must have been terrible for him because he was a gentle and impeccably sensitive person. He refused offers to be an officer—staying as far as possible from any connection with Nazism.

He managed to join a flak battery and so was involved only in defense operations. Nevertheless, he felt a deep sense of responsibility for the pain that Germany inflicted on other nations, and throughout his life acted to redress those crimes in his position as a director of a major scientific institute. His department at the Max Planck Institute for Solid State Research was a model of cultural and ethnic diversity. During his tenure, a couple of anti-Semitic incidents took place. He firmly and effectively dealt with them, leaving no doubts as to where he stood.

In 1949, Ludwig earned his *diplom* in physics from the University of Frankfurt am Main under the direction of Marianus Czerny. Two years later, he received his *promotion* (PhD) from the University of Frankfurt. With the aim of studying condensed matter systems such as dielectric crystals, he and his students built one of the first modern FIR interferometers in 1954. In 1958, he and his coworkers constructed a rapid-scan interferometer for the millimeter and submillimeter range.

Ludwig stayed in Frankfurt until 1960, when he accepted an invitation from the University of Freiburg to join its faculty. But he first spent a year at Ohio State University, which, at that time, had one of the highest-resolution FIR spectrometers. He fondly remembered that stay and the warmth and friendship of his hosts.

At Freiburg, Ludwig made his most original scientific contributions. In 1962, he conceived of and constructed a Fabry–Perot etalon from a metallic mesh for the FIR. For cognoscenti in Brillouin spectroscopy, seeing a "flat" made of ordinary aluminum with a lattice of holes is quite an enlightening experience.

Presumably in the late 1960s, Ludwig had a conversation with Werner Heisenberg in which Heisenberg asked him to help establish the Max Planck Institute for Solid State Research. In April 1970, Ludwig was appointed its first founding director.

In the early 1970s, Ludwig and coworkers measured the IR transmission of microcrystals of magnesium oxide. The crystals contained only about 50 ions. They applied lattice dynamics to obtain the eigenvalues and eigenvectors for the microcrystals. In 1974, he and his colleagues published their highly cited work on long wavelength optical modes in mixed crystals in *Physica Status Solidi*. Ludwig also published influential work on the dielectric function of extremely small metal particles in *Surface Science* in 1985. He showed how quantum effects shifted the plasma resonance absorption.

Ludwig published one of his first papers in biological physics, on