

Obituary

Jean Brossel (1918–2003)

Jean Brossel passed away on 4 February 2003 in Périgueux, Dordogne, the city of his birth. He was one of the founding fathers of the modern French school of quantum optics and co-founder, with Alfred Kastler, of the Laboratoire Kastler Brossel at the Ecole Normale Supérieure, in Paris.

Brossel entered the Ecole Normale in 1938, completing his studies in 1945 (after a two-year interruption due to the Second World War). Physics research in France was devastated by the war, and lagged behind the scientific developments in Britain and the United States. To catch up, Kastler advised Brossel to begin his research in the United Kingdom. Brossel took his advice and joined Samuel Tolansky's group in Manchester, in the laboratory headed by Patrick Blackett. There he learned how to apply interferometry to the study of surfaces, and to use Fabry–Perot interference techniques for the measurement of hyperfine structure in electronic transitions inside the atom. Throughout his life, Brossel acknowledged the value of the expertise he acquired in Tolansky's laboratory.

On Brossel's return from England, Kastler recommended that he go to the United States to work for a PhD with Francis Bitter at the Massachusetts Institute of Technology. Bitter had just informed Kastler about exciting new ideas for Doppler-free spectroscopy (in which Doppler broadening of optical emission lines does not limit the resolution) that might extend radio-frequency studies of atomic resonances to excited states. Bitter's idea turned out to be incorrect, but it proved a fruitful starting point for Brossel that later led to his invention of the method of 'double resonance': in this Doppler-free method, the atoms are subjected to simultaneous irradiation with light and a radio-frequency field, and resonant effects are detected by measuring the polarization of the fluorescent light emitted by the atoms (equivalent to the angular momentum of the photons), instead of its frequency (the energy of the photon).

While Brossel was finishing his thesis with Bitter, Kastler followed a similar line of work in Paris and devised 'optical pumping', by which atoms in their lowest-energy (or ground) state acquire angular momentum through successive cycles of absorption of polarized optical radiation, followed by spontaneous emission. The final result is a selective

population of magnetic sublevels inside the ground state.

In 1951, Kastler and Brossel founded a research group together at the Ecole Normale — what became the Laboratoire Kastler Brossel (LKB). Their primary objective was to demonstrate optical pumping experimentally and to explore the possibilities it created. Excellent students from the Ecole Normale soon joined the group (Bernard Cagnac, Jacques Winter, Jacques Blamont and Jean-Pierre Barrat, among many others). This field of research proved to be a treasure trove of new physics. Optical pumping was demonstrated in 1952, and was followed by the observation of multiphoton resonances, where several photons, instead of a single one, are absorbed by the atoms at the same time — Brossel provided a physical interpretation of the selection rules for the polarization of the radio frequency in terms of photon angular momentum. Then, in work overseen by

Physicist who opened up new perspectives in quantum optics

Brossel and Kastler, came coherent radiation trapping and polarization transfer, the general distinction between diagonal and off-diagonal elements of the density matrix (populations and coherences) and the discovery of light shifts. After Kastler received the Nobel prize in 1966 for his work on optical methods for studying resonances of the atom, he often expressed his deep regret that Brossel had not shared it with him.

Brossel encouraged young scientists to pursue new directions of research in his laboratory. This research included work on atomic masers and magnetometers, parity-violation in atomic physics, cavity electrodynamics and Doppler-free two-photon spectroscopy. Perhaps the best-known application of optical pumping is in atomic clocks, and the work done at LKB, in particular on light shifts, was crucial to their development. Improvements in the optical pumping of rubidium atoms led to the creation in 1969 of a magnetometer that was sensitive to magnetic fields at the level of 10^{-9} gauss. In 1997, Brossel's colleague and former student Claude Cohen-Tannoudji shared the Nobel prize for his work on ultra-cold atoms and laser cooling.

Although Brossel was interested in the applications of his research, he was



sceptical about application-driven research in universities. He argued that technical breakthroughs are the fruit of fundamental research driven by pure scientific curiosity, and rarely of application-oriented programmes. A good example is atomic clocks, which sprang from fundamental studies in atomic physics rather than from a drive to improve on mechanical or quartz clocks. Another example is optical pumping in helium-3. First performed 20 years ago by King Walters and Laird Schearer in the United States, optical pumping in this isotope was refined at LKB, motivated by the study of quantum effects in optically pumped gases. Now optical pumping in helium-3 forms the basis of a tool for the medical imaging of lung cavities in asthma patients.

Jean Brossel was for many years the head of the physics department at the Ecole Normale, to which he attracted brilliant and active colleagues. Teaching was always important to him, in particular as a way of attracting the best students to physics. But even at the peak of his administrative responsibilities, he never abandoned 'hands-on' work in the laboratory. For instance, he continued to prepare glass cells containing atomic gases, sometimes with elaborate coatings to prevent wall relaxation — an art in which no one could match his skill. He will be remembered by his colleagues and former students with great admiration.

Franck Laloë

Franck Laloë is in the Laboratoire Kastler Brossel, Département de Physique de l'ENS, 24 rue Lhomond, 75005 Paris, France. e-mail: laloë@lkb.ens.fr

LABORATOIRE KASTLER BROSSEL