OBITUARY COMMENT

Simon van der Meer

(1925–2011)

Engineer whose invention enabled the discovery of the W and Z particles.

Simon van der Meer was one of the handful of truly exceptional people who contributed to making the European Organization for Nuclear Research (CERN) the world's premier laboratory in elementary particle physics. His invention of stochastic cooling offered a means to nudge protons and their antimatter equivalents into tightly focused beams, paving the way for the discovery of the W and Z particles — two fundamental constituents of matter.

Van der Meer, who died on 4 March, studied technical physics at the University of Technology in Delft, the Netherlands, from 1945, at a time when Dutch universities were still recovering after being closed under the German occupation. He eventually obtained his engineering degree in 1952. Following a short period in Eindhoven at the Philips Research Laboratory, he was among the first researchers to move to the recently founded CERN near Geneva, Switzerland. He arrived at the age of 31 in 1956, a year before the laboratory's first accelerator was built, and worked there for the rest of his life.

In the early 1970s, circumstantial evidence for the electroweak model was accumulating. This model unified electromagnetism and the weak nuclear force, two of the four fundamental forces of nature (gravity and the strong nuclear force being the other two) in a single mathematical framework. But no one would be convinced until physicists had actually observed the W and Z bosons — particles that supposedly carried the weak force.

Accelerators at the time could smash particles into a stationary object. But producing the heavy W and Z bosons would require much more energy — specifically, getting protons and antiprotons to collide head on in tightly packed beams.

Among van der Meer's many original and highly practical ideas, stochastic cooling was the most important. This was, in essence, a subtle and practical realization of the 'Maxwell's demon' thought experiment, which demonstrates how, under certain circumstances, the second law of thermodynamics (which states that differences in temperature, pressure and so on equilibrate over time) can be circumvented.

It is universally accepted among physicists that any beam of elementary particles should obey the theorem of the French mathematician Joseph Liouville, and behave like an incompressible fluid. In other words, if the beam is squashed at one end, the distribution of particles will bulge out somewhere else along its length. Beams of fast-moving electrons and positrons, their antiparticles, disobey this rule because they emit a form of radiation; in essence, the beams 'cool' naturally. But in the case of the more massive particle beams, the Liouville theorem kicks in. This presents a significant obstacle to producing an orderly, narrow beam.

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Van der Meer's idea was both simple and ingenious. The 'incompressible fluid' condition is strictly valid only when very large numbers of particles are present. When small numbers of particles circulate through an accelerator ring, small fluctuations from the average course taken by the particles are observed. In the 1970s, these fluctuations — called Schottky noise — could easily be detected using a device called a pick-up electrode. Because every particle in the beam has a specific individual energy, different amounts of fluctuation are detected each time the beam of particles courses through the ring.

Van der Meer's idea was to 'correct' the average position of the particles in a beam electronically with the help of a 'kicker': a magnetic device that continuously nudges the particles back on course. This very subtle form of compression of the beam does not violate the Liouville theorem. Indeed, through the synchronized use of a pick-up and a kicker, the very tiny elementary volumes around which a particle is present are simply moved away from those around which there are no particles. The density of particles seems to increase simply because the voids have been pushed to the side.

The approach was originally applied to beams of protons, where the stochastic cooling effect was visible but very small because the number of particles in the beams was very large. In the late 1970s, David Cline, Peter McIntyre and I used a magnetic field to steer head-on protons and antiprotons, colliding them many times every second. Provided that we ramped up the density of the antiprotons as much as a billion times, van der Meer's cooling process became prominent.

Stochastic antiproton cooling was an essential ingredient for the realization of the CERN ppbar collider and for the subsequent discovery of the W and Z particles — for which van der Meer and I shared a Nobel prize in 1984. The same technology has been key at the Tevatron collider at Fermilab in Batavia, Illinois, where the top quark, the last and heaviest of all elementary quarks, was discovered in 1995. Indeed, during the past 25 years or so, stochastic cooling has been a major tool for all the significant discoveries made from high-energy collisions.

It is very unusual for a clever idea of an engineer to deeply modify fundamental concepts in physics. Simon himself noted that his lack of formal training in physics (he never obtained a PhD) probably turned out to be an asset. Not knowing the rules of the game meant he came up with an unthinkable idea.

With Simon's departure, we will miss not only a remarkable, inventive mind and a giant in our field, but also a very kind and universally respected person. His friends used to say that he would never use two words where one would suffice, but that his one word would invariably be the right one. ■

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