# Gerald Guralnik

## (1936–2014)

### Physicist who helped to conceive the Higgs boson.

Gerald Guralnik is best known for his work on the Higgs mechanism, which confers mass on particles. Along with particle physicist Carl Hagen and myself, he wrote one of three key papers published in 1964 that each took different routes to solving a conundrum of how particles interact.

Guralnik died of a heart attack on 26 April, aged 77, shortly after finishing a lecture at Brown University in Providence, Rhode Island, where he had been a faculty member since 1967. He was born in Cedar Falls, Iowa, where his parents ran an accountancy firm. Guralnik attended the Massachusetts Institute of Technology (MIT) in Cambridge. He then went on to Harvard University, also in Cambridge, to study for a PhD under Walter Gilbert, who was working on the theory of elementary particles before embarking on his Nobel-prizewinning experiments for DNA sequencing.

In 1964, Guralnik completed his doctorate in quantum field theory, which models subatomic particles as physical fields that extend throughout space. That same year, he won a US National Science Foundation fellowship to a theoretical physics research group, founded by Gilbert's former adviser Abdus Salam, at Imperial College London.

In the years after the Second World War, the success of quantum electrodynamics, which describes the electromagnetic force that drives interactions between matter and light, had spurred work on similar theories of other interactions. A key goal was a unified theory of the electromagnetic force and the weak force, which is observed in radioactive β-decay and the Sun's core. The big problem was that to explain the short range of the weak forces, the bosons transmitting them had to have large masses. By contrast, the electromagnetic force is carried over vast distances by the massless photon.

When I met Guralnik in 1964 at Imperial, I was interested to learn that he, too, was concerned with the problem of boson mass. Hagen, his friend and former MIT classmate, also came to Imperial, and the three of us worked together to find a solution. We were constant lunch companions. Guralnik enjoyed the work but often complained about the food — especially Scotch eggs (hard-boiled eggs baked into a grainy coating of sausage meat and breadcrumbs).

Just as our paper was in its final draft, we discovered two earlier papers (one by François Englert and Robert Brout at the Université Libre de Bruxelles in Belgium, and the other by Peter Higgs at the University of Edinburgh, UK) that addressed the problem of giving mass to bosons from

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different perspectives. All three papers showed that the mechanism could successfully use spontaneous symmetry breaking, in which the underlying physics is symmetric but its realization is not. For example, a bowl of water is rotationally symmetric, until it freezes and the ice crystals break the symmetry. A particular contribution of our paper was to show how spontaneous symmetry breaking could occur consistently within the formal structure of the theory. The three papers reached essentially the same conclusions, and were later selected by *Physical Review Letters* (the journal in which they were published) as among the most significant of 1964.

The publications attracted few citations in their first three years. Guralnik toured Europe and gave talks to sceptical audiences. Werner Heisenberg, known for formulating the eponymous uncertainty principle, told him that he was talking nonsense. When Guralnik won a postdoc position at the University of Rochester in New York, the head of the group urged him to switch to a different field (later admitting that the advice was misguided).

Our proposal, now generally known as the Higgs mechanism, is the cornerstone of the well-established unified electroweak theory, which explains both the electromagnetic and weak interactions. Steven Weinberg and Salam married this mechanism with a preliminary unified model proposed earlier by Sheldon Glashow, thus resolving its inconsistencies. For this work, the three of them shared the 1979 Nobel Prize in Physics.

The validity of the Higgs mechanism was finally demonstrated in 2012, with the experimental discovery of the Higgs boson, which last year led to another Nobel Prize, for Englert and Higgs, the surviving authors of the first two papers putting forth the mechanism.

The 1979 prizewinners carefully cited all three of the 1964 papers on an equal footing, but others have not always done so. Guralnik came to feel that our early paper was often unfairly neglected. He gave talks and wrote papers pointing out our distinctive contribution, of which he was justifiably proud, and in which he was unquestionably the prime mover.

In the meantime, Guralnik had gone on to contribute much to the development of computational approaches to quantum field theory. From 1985 to 1987, as a staff member at Los Alamos National Laboratory in New Mexico, he used such approaches to make important contributions to quantum chromodynamics, the theory of strong interactions, which explains that quarks interact through a 'colour force'. Later, he worked on how chaos theory could be applied to particle physics. He also made significant contributions to string theory, some in collaboration with his son, Zachary Guralnik.

Gerry was always good company and had a great sense of humour. As well as being passionate about physics, he was enthusiastic about many things: fast cars, photography and state-of-the-art computers. Gerry was a member of Brown's Ersatz Brain Project, which aims to design a brain-like computer. He could be combative when others failed to live up to his exacting standards, but he was warm and generous.

Gerry once wrote that being able to work as a theoretical physicist was a privilege; his colleagues felt the privilege was theirs. ■

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