Prediction of the scalar boson by Robert Brout, François Englert, and Peter Higgs

There is great excitation at CERN about the announcement of a possible discovery, or at least a great step forward, in the particle physics world: it is concerned with the search for the particle that would give mass to all other elementary particles, the famous "scalar boson", often known as the "Brout-Englert-Higgs boson", or simply "Higgs boson".

This "missing piece" among the most fundamental constituents of nature was predicted 48 years ago by two physicists of the Université Libre de Bruxelles (ULB), Robert Brout and François Englert, and by Peter Higgs, from Edinburgh University.

At a time where Nature is about to speak about this fundamental particle, it may be useful to briefly revisit the chronology of its introduction.

The original papers

The article of Englert and Brout and the two articles of Higgs were published independently and nearly simultaneously in 1964. They establish the so-called "symmetry breaking" mechanism in Quantum Field Theory, the theory that describes all fundamental interactions of nature (except, as of today, for gravitation). The mechanism implies the existence of an auxiliary particle, a scalar boson.

Taken together, the works of Brout-Englert and Higgs provided the key element to build the Standard Model of particle physics. Later in the year 1964, G.S. Guralnik, C.R. Hagen, and T.W.B. Kibble came to the same questions. Their paper – which quotes both Englert-Brout and Higgs papers – discusses some more technical aspects.

The Standard Model is the most accurate and complete theory ever built for the understanding of fundamental interactions. As a part of the Standard Model, the symmetry breaking mechanism shows how very short-range interactions between elementary particles (like the weak force, responsible for radioactivity) and long-distance interactions (like electromagnetism, with infinite range) can be of the same origin. On basis of these ideas, theorists Sheldon Glashow, Abdus Salam, and Steven Weinberg built a theory unifying electromagnetic and weak interactions, for which they were awarded the Nobel Prize in 1979. The discovery at CERN in 1983 of the massive W and Z bosons predicted by this theory won next year's Nobel Prize to the experimentalists Carlo Rubbia and Simon van der Meer.

Chronology

Papers	Reception date	Publication date
F. Englert and R. Brout Phys. Rev. Letters 13 (1964) 321	26/06/1964	31/08/1964
P.W. Higgs Phys. Letters 12 (1964) 132	27/07/1964	15/09/1964
P.W. Higgs Phys. Rev. Letters 13 (1964) 508	31/08/1964	19/10/1964
G.S. Guralnik, C.R. Hagen and T.W.B. Kibble Phys. Rev. Letters 13 (1964) 585	12/10/1964	16/11/1964

International Recognition

The overwhelming and unique merits for modern particle physics of the works of Brout, Englert and Higgs have been recognized by their awarding of numerous prizes, among which the most prestigious prizes in physics – except as of today for the Nobel Prize:

- the European Physical Society High Energy and Particle Physics Prize was awarded to Brout, Englert and Higgs in 1997, "*for formulating for the first time a self-consistent theory of charged massive vector bosons which became the foundation of the electroweak theory of elementary particles*";

- the Wolf Foundation Prize in Physics was awarded to them in 2004 "*for pioneering work that has led to the insight of mass generation, whenever a local gauge symmetry is realized asymmetrically in the world of sub-atomic particles*".

It is also interesting to note that the unique merits of Brout, Englert, and Higgs are recognized by the Nobel Committee, in the review article "*Scientific Background on the Nobel Prize in Physics 2008*", published by the Royal Swedish Academy of Sciences. The 2008 Nobel Prize being awarded to Yoichiro Nambu, the Committee states: "*The same ideas (as by Nambu) were tried in 1964 for relativistic gauge theory by Robert Brout and François Englert and also by Peter Higgs. They found that a spontaneously broken gauge symmetry, as in the non-relativistic version of Nambu, does not produce a massless particle. Instead, this mechanism gives the vector field a mass and a scalar state, the still today hypothetical Higgs particle, which is also a characteristic feature of such a theory*".

In addition, the J.J. Sakurai Prize for Theoretical Physics of the American Physical Society was awarded in 2010 jointly to Brout, Englert, Guralnik, Hagen, Higgs, and Kibble "*for elucidation of the properties of spontaneous symmetry breaking in four-dimensional relativistic gauge theory and of the mechanism for the consistent generation of vector boson masses*". The awarding of this American prize to a wider list of authors, including Guralnik, Hagen, and Kibble, does by no means throw any doubt as to the forefront merits of Brout, Englert and Higgs.

A statement by Steven Weinberg

In a contribution released in May, 2012, on the site of the New York Review of books, Steven Weinberg, 1979 Nobel Prize, comes back to the history: "*In his recent book, The Infinity Puzzle (Basic Books, 2011), Frank Close points out that a mistake of mine was in part responsible for the term "Higgs boson." In my 1967 paper on the unification of weak and electromagnetic forces, I cited 1964 work by Peter Higgs and two other sets of theorists. (…) As to my responsibility for the name "Higgs boson," because of a mistake in reading the dates on these three earlier papers, I thought that the earliest was the one by Higgs, so in my 1967 paper I cited Higgs first, and have done so since then. Other physicists apparently have followed my lead. But as Close points out, the earliest paper of the three I cited was actually the one by Robert Brout and François Englert. In extenuation of my mistake, I should note that Higgs and Brout and Englert did their work independently and at about the same time, as also did the third group (Gerald Guralnik, C.R. Hagen, and Tom Kibble). But the name "Higgs boson" seems to have stuck.*" (As to the last sentence, let us recall, however, that Guralnik, Hagen, and Kibble do quote in their 1964 paper the works of Brout-Englert and Higgs).

In conclusion…

If and when the scalar boson will be observed at the LHC, this discovery will provide the verification of the visionary contributions of Robert Brout, François Englert, and Peter Higgs. It will also bring some sorrow, remembering that Robert Brout sadly passed in May, 2011.

Contacts :

Prof. Pierre Marage
Vice-recteur à la politique académique et à la recherche
Université libre de Bruxelles
Phone +32 2 650 45 00, Email : Pierre.Marage@ulb.ac.be

Prof. Jean-Marie Frère
Directeur, service de Physique théorique
Universite libre de Bruxelles

Phone +32 2 650 55 71, E mail : frere@ulb.ac.be

Press :

Communication Recherche, Département des relations extérieures

Nancy Dath, +32 (0)2 650 92 03, ndath@ulb.ac.be

Nathalie Gobbe, +32 (0)2 650 92 06, +32 (0)474 84 23 02, ngobbe@ulb.ac.be