62nd Lindau Nobel Laureate Meeting

PRESS RELEASE

Four Forces and a Puzzle Piece

- The standard model of particle physics is put to the test
- Higgs boson as key particle in the theoretical puzzle
- 27 Nobel Laureates provide the prospect of a new physics
- Panel discussion with live link-up with CERN during the meeting

Lindau, 20 June 2012. Particle physicists fit together the elementary building blocks and force fields of our world in an elegant model. Its theoretical architecture and experimental proof have been rewarded with many Nobel Prizes. This standard model leaves many questions unanswered, however: physicists have not yet been able to show how the particles obtain their mass. They do not know how to incorporate gravity into their construct. Moreover, it seems that their model only explains four percent of our universe. The remainder consists of mysterious dark matter and energy. A large part of the 62nd Lindau Nobel Laureate Meeting, which is dedicated to physics, will therefore be taken up with discussions relating to this issue. 27 Nobel Laureates and more than 580 young scientists from all over the world are expected. The discussions will also focus on the experiments in the LHC particle accelerator at the European Nuclear Research Centre (CERN) in Geneva, which could soon provide the standard model with more solid foundations and room for expansion. Nobel Laureates Carlo Rubbia, Martinus Veltman, George Smoot and David Gross will discuss the latest developments in this field in a panel discussion with representatives of CERN via live link-up with Geneva.

The Power of the Weak Interaction

The participating Nobel Laureates Carlo Rubbia, Martinus Veltman and David Gross have each made crucial contributions to the standard model of particle physics. Their discoveries relate to the strong and the weak

interactions within the atomic nucleus, two of the four fundamental forces of physics. The other two are gravitation and the electromagnetic force, which ensures, among other things, that the negatively charged electrons remain in a stable cloud around the positively charged atomic nucleus. Depending on the particular chemical element, the atomic nucleus contains a specific number of protons and neutrons, each of which is comprised of three quarks.

In order for simple hydrogen to form higher elements, protons must convert into neutrons. This also takes place during nuclear fusion in the sun. The weak interaction is responsible for this process. Our material world would not have formed from the original energy of the Big Bang without the weak interaction. The strong interaction in contrast keeps the components of the atomic nucleus together and counteracts the electric repulsion of like charges.

The four fundamental forces exert their effect with the help of specific exchange particles. The photons mediate the electromagnetic interaction, the gluons the strong one. The gravitons are believed to be the mediators of gravity, but have not yet been discovered. However, the W and Z bosons as mediators of the weak interaction have been detected by a team working with Carlo Rubbia and Simon van Meer at CERN. The mass of these bosons is 80 times the mass of a proton. Quarks and electrons, for example, are also not massless. But how can this be explained if the standard model mathematically allows only massless particles? The English physicist Higgs postulated there must be an interaction that gives the particles their mass, a force field through which they glide as if through syrup in order to become heavy. Otherwise all particles would only be able to move with the speed of light without ever forming stable matter. The exchange particle of this force field would be the Higgs boson, which has not yet been discovered, as this missing piece of the puzzle would only be formed at very high energies and decay again extremely rapidly. Only the LHC particle accelerator at CERN can generate these energies when protons collide, and can detect and analyse the fragments of these collisions.

The Hidden Charm of Supersymmetry

In his talk "The LHC at CERN and the Higgs", **Martinus Veltman** will outline the creation and development of the standard model and discuss the latest findings from CERN which indicate that the Higgs particle really exists. Veltman was awarded the Noble Prize in 1999 together with his former doctoral student Gerardus 't Hooft. Both were able to show mathematically that the weak and the electromagnetic interaction were originally unified in the so-called electroweak force, even if in our real world their forces in the atoms differ from each other by a factor of 100

billion. The explanation: the higher the energy becomes – that is, the closer the conditions get to those at the beginning of the universe - the stronger the weak force and the weaker the electromagnetic force become. The strong interaction also becomes weaker the more the energy increases. It exhibits a so-called asymptotic freedom. This discovery, for which **David Gross**, H. David Politzer and Frank Wilczek received the 2004 Nobel Prize in Physics, nurtures the hope that all four fundamental forces of physics can be derived from one primordial force that could be described in a theory of everything. This is because the exchange forces of the weak, strong and electromagnetic interactions have approximately the same strength in the energy range in which gravity also becomes large enough to be able to merge with them.

The premise for the unification of the four fundamental forces would be, however, that the Big Bang gave rise to a supersymmetric world initially, in which only later a symmetry break occurred from which the currently known elementary particles of the standard model developed. Each one of them would then have a supersymmetric partner in the universe which would have a mass, but would otherwise behave in a completely neutral way, and which would not be accessible for three of the four fundamental forces. Such supersymmetric particles could only be identified via their interactions with gravity. If they really exist, then it may be possible to detect them experimentally in the LHC at CERN. David Gross, whose talk "A century of quantum mechanics" will explain why he believes that the proof of supersymmetry will establish a new physics beyond the standard model, also expects this will happen.

The Mystery of Dark Matter

In physics, supersymmetric particles are considered promising candidates to explain dark matter, which holds the galaxies of the universe together like an invisible skeleton and amounts to around 23 percent of its total mass. This is because dark matter also exhibits neutral electromagnetic behaviour and only becomes noticeable via gravitation: it warps space and diverts light that reaches the earth from very distant objects. It could therefore be composed of supersymmetric particles. However, heavy neutrinos could also contribute to explaining dark matter, as Carlo Rubbia will explain in his talk "Neutrinos: a golden field for astroparticle physics."

Neutrinos are closely related to the weak interaction and are released together with electrons when neutrons are converted into protons during radioactive beta-decay. Why their mass is not zero, as was originally assumed, is one of the questions to which the standard model does not yet have an answer. Scientists are certain that all of the atoms we know are composed of two

different quarks, a type of electron and a type of neutrino. The standard model nevertheless describes two further families of four, which are composed of quite different types of quarks, electrons and neutrinos. They are stable for only tiny fractions of a second. They have been produced in particle accelerators and identified as elementary building blocks of the universe. What purpose do they serve? Why are there three particle families if all phenomena of life can be explained with the members of the first family?

It is possible that all problems of particle physics are interrelated, according to Martinus Veltman. "If we investigate the Higgs particles in great detail, we could possibly find a key to the solution of all other problems. This is the hope for the future." In order to fulfil it, this piece of the particle puzzle would first need to be found.

Nobel Laureates Carlo Rubbia, Martinus Veltman, George Smoot and David Gross will discuss the latest developments and progress at CERN in a panel discussion with representatives of CERN via a live link-up to Geneva during the Meeting of the Nobel Laureates. The panel discussion will take place on Wednesday, 4 July, between 3:00 and 4:30 p.m. in Lindau.

Further Information

The programme of the 62nd Lindau Nobel Laureate Meeting, background information regarding the participating Laureates, and abstracts/ summaries of their talks are available in the Lindau Mediatheque: www.mediatheque.lindau-nobel.org/#/Meeting?id=284. It also comprises audio recordings and videos of the lectures of Nobel Laureates from the more than 60 years of history of the Lindau Meetings. With supplementary background information, photos, links to related contents and didactically edited "mini lectures", the Lindau Mediatheque is interesting for researchers, those interested in science, journalists and teachers alike.

Topic cluster from all mediatheque content on the topic of subatomic particles:

http://www.mediatheque.lindau-nobel.org/#/TopicCluster?id=4

Profiles of the Nobel Laureates with background information in the Lindau Mediatheque:

Carlo Rubbia (Physics, 1984): http://www.mediatheque.lindau-nobel.org/#/Laureate?id=6928

Martinus Veltman (Physics, 1999): http://www.mediatheque.lindau-nobel.org/#/Laureate?id=6968

David Gross (Physics, 2004): http://www.mediatheque.lindau-nobel.org/#/Laureate?id=6826

Official Nobel Prize award reasoning for to the Laureates mentioned above:

Carlo Rubbia received the Noble Prize in Physics in 1984 together with Simon van der Meer

"for their decisive contribution to the large project that led to the discovery of the field

particles W and Z, communicators of weak interaction"

Martinus J. G. Veltman and Gerardus 't Hooft were awarded the Noble Prize in Physics in 1999

"for elucidating the quantum structure of electroweak interactions in physics"

David J. Gross was awarded the Noble Prize in Physics in 2004 jointly with H. David Politzer

and Frank Wilczek "for the discovery of asymptotic freedom in the theory of the strong

interaction"

The Lindau Nobel Laureate Meetings

27 Nobel Laureates and more than 580 young scientists from 69 countries will participate in the

62nd Lindau Nobel Laureate Meeting (Physics) from 1 to 6 July 2012. The topics include cosmology,

particle physics, the challenges of a sustainable energy supply and the climate issue. The Lindau

Nobel Laureate Meetings have been taking place every year since 1951. They are organised by the

Council for the Lindau Nobel Laureate Meetings e.V. established in 1954 and the Foundation

Lindau Nobelprizewinners Meetings at Lake Constance established in 2000. More than 250 Nobel

Laureates are Members of the Founders Assembly.

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