Tease Out the Strong Force

One of the fundamental challenges in nuclear physics is to predict the properties of subatomic matter from quantum chromodynamics (QCD)—the theory describing the strong force that confines quarks into protons and neutrons, and that binds protons and neutrons together. [12]

At very high energies, the collision of massive atomic nuclei in an accelerator generates hundreds or even thousands of particles that undergo numerous interactions. [11]

The first experimental result has been published from the newly upgraded Continuous Electron Beam Accelerator Facility (CEBAF) at the U.S. Department of Energy's Thomas Jefferson National Accelerator Facility. The result demonstrates the feasibility of detecting a potential new form of matter to study why quarks are never found in isolation. [10]

A team of scientists currently working at the Large Hadron Collider at the European Organization for Nuclear Research (CERN) announced that it has possibly discovered the existence of a particle integral to nature in a statement on Tuesday, Dec. 15, and again on Dec.16. [9]

In 2012, a proposed observation of the Higgs boson was reported at the Large Hadron Collider in CERN. The observation has puzzled the physics community, as the mass of the observed particle, 125 GeV, looks lighter than the expected energy scale, about 1 TeV. [8]

'In the new run, because of the highest-ever energies available at the LHC, we might finally create dark matter in the laboratory,' says Daniela. 'If dark matter is the lightest SUSY particle than we might discover many other SUSY particles, since SUSY predicts that every Standard Model particle has a SUSY counterpart.' [7]

The problem is that there are several things the Standard Model is unable to explain, for example the dark matter that makes up a large part of the universe. Many particle physicists are therefore working on the development of new, more comprehensive models. [6]

They might seem quite different, but both the Higgs boson and dark matter particles may have some similarities. The Higgs boson is thought to be the particle that gives matter its mass. And in the same vein, dark matter is thought to account for much of the 'missing mass' in galaxies in the universe. It may be that these mass-giving particles have more in common than was thought. [5]

The magnetic induction creates a negative electric field, causing an electromagnetic inertia responsible for the relativistic mass change; it is the mysterious Higgs Field giving mass to the particles. The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass rate by the diffraction patterns. The accelerating charges explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Relativistic Quantum Theories. The self maintained electric potential of the accelerating charges equivalent with the General Relativity space-time curvature, and since it is true on the quantum level also, gives the base of the Quantum Gravity.

Contents

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Preface

Popular questions about the Higgs Field:

1.) If the Higgs field is responsible for imbuing particles with mass, and mass is responsible for gravity, is it possible that the Higgs field will provide the missing link between general relativity and quantum mechanics i.e. could the Higgs field be the basis of a quantum theory of gravity?

2.) Can the theoretical Higgs Field be used as the "cause" of relativistic momentum or relativistic kinetic energy of a moving body?

3.) Does Einstein's General Relativity need to be adjusted for the Higgs field?

4.) Since the Higgs field gives most particles mass, and permeates all space, then GR needs the Higgs field to be a theory of space?

5.) So where GR is highly curved, the Higgs field is also curved? And does a highly curved Higgs field affect the way particles acquire mass? For that matter, a curved space-time would also curve electromagnetic field?

How can we answer these questions?

There is an explanation of the magnetic effect caused by the electric current from the observed effects of the accelerating electrons, causing naturally the experienced changes of the electric field potential along the electric wire. The charge distribution is lowering in the reference frame of the accelerating charges linearly: ds/dt = at (time coordinate), but in the reference frame of the current it is parabolic: $s = a/2\ t^2$ (geometric coordinate). The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories. [1]

One origin of the Quantum Physics is the Planck Distribution Law of the electromagnetic oscillators, giving equal intensity for 2 different wavelengths on any temperature. Any of these two wavelengths will give equal intensity diffraction patterns, building different asymmetric constructions, for example proton - electron structures (atoms), molecules, etc. Since the particles are centers of diffraction patterns they also have particle – wave duality as the electromagnetic waves have. The

Electroweak Interaction shows that the Weak Interaction is basically electromagnetic in nature. The arrow of time shows the entropy grows by changing the temperature dependent diffraction patterns of the electromagnetic oscillators. [2]

Viewpoint: Scattering Experiments Tease Out the Strong Force

One of the fundamental challenges in nuclear physics is to predict the properties of subatomic matter from quantum chromodynamics (QCD)—the theory describing the strong force that confines quarks into protons and neutrons, and that binds protons and neutrons together. In other words, can QCD explain why subatomic matter is stable, how it comes into being, evolves, and organizes itself, and what phenomena could emerge from it [1]? Improving our understanding of the strong force will be important, for example, in shedding light on the nucleosynthesis processes that create the elements present in the Universe and in illuminating the mechanisms that fuel stars and drive stellar explosions. Now, Amit Kumar of Saint Mary's University, Canada [2], and co-workers have shown that the scattering of protons by an isotope of carbon can be a sensitive probe of the strong force. Specifically, they have demonstrated that measurements of the scattering cross section are sensitive tests of strong-force models.

At the low energies relevant for most studies of nuclear structure and nuclear reactions, atomic nuclei can be described in terms of nucleons—neutrons and protons. The strong interactions between nucleons make nuclei extremely complex quantum many-body systems. Presently, the best theoretical approach for tackling this complexity is the so-called chiral effective field theory (EFT) [3, 4]. Chiral EFT, based on the intrinsic chiral symmetries of QCD, is an approximation of QCD that uses effective degrees of freedom such as nucleons, pions, and other hadrons. Using a pertubative approach, it provides a systematic framework to construct the two-, three-, and many-nucleon interactions necessary to solve nuclear many-body problems.

In the last decade, advances in chiral EFT, together with the development of powerful many-body computational methods [5] have dramatically pushed the frontiers of nuclear theory, allowing for the description of nuclei with increasingly larger mass numbers. Recently, Hagen et al. successfully used chiral EFT and advanced many-body methods to calculate the nuclear structure of nickel-78 [6]. The same group is now tackling nuclei near tin-100 [7]. Remarkably, computational progress has been so swift that the many-body calculations themselves are not the primary obstacles for computing nuclear properties in this medium-mass region. Theoretical limitations come instead from existing models of two- and three-nucleon (and many-nucleon) interactions [8]. Three-nucleon forces arise naturally in chiral EFT, mirroring the complicated multiquark interactions from QCD. Since EFT is an effective field theory that approximates QCD, the parameters describing these forces cannot be derived directly from QCD itself. Instead, they can be extracted from combining experiments with theoretical calculations. Constraining such parameters from data, however, is not easy, since many of them are not directly related to specific nuclear processes. The hope is that new types of experiments, guided by advanced theoretical calculations, will help us discern between models for two- and three-nucleon forces. This is the framework within which the new work finds its rationale.

To probe the nuclear force, Kumar and co-workers study the elastic scattering of protons from carbon-10 (10C10C). Rather than hitting a static carbon target with protons, the experiments were carried out in an “inverse kinematics” mode: a beam of 10C10C isotopes, accelerated by the ISAC rare-isotope beam facility at TRIUMF, Canada’s national laboratory for nuclear and particle physics, bombarded a solid hydrogen target with 10C10C nuclei at a rate of 2000 particles per second (see Fig. 1). Using position-sensitive detectors, the researchers determined the probability, or cross section, of a proton scattering from a carbon atom at a particular angle. This angular dependence serves as a “fingerprint” for the strong-force interactions within the nuclei.

The use of 10C10C entails two important advantages. First, it is a nucleus that lies exactly at a nuclear proton dripline—the boundary in the chart of nuclides beyond which nuclei lose stability. Adding one more proton to such a dripline nucleus results in an unstable nucleus that immediately decays radioactively. The neighbors of 10C10C in the nuclide chart (nitrogen-11, berylium-8, and boron-9) are unstable. Since the nuclear force determines the delicate balance between stability and instability, the sensitivity of nuclear structure to the strong force becomes more pronounced at the dripline. This makes dripline nuclei extremely interesting from both a theoretical and an experimental perspective.

The second advantage of 10C10C concerns the theoretical description of experiments of protons scattered from it. In a scattering event, one has to consider, in addition to a proton- 10C10C pair, a virtual intermediate state in which a proton is added to 10C10C to form nitrogen-11 (11N11N). Because 11N11N is unbound, only a few of its excited-state levels have to be considered at the energies relevant for the experiment, easing the theoretical analysis. Well-bound nuclei would exhibit a much larger level density, making their reactions more difficult to describe theoretically.

The authors analyze proton scattering from 10C10C using an ab initio model that accounts for the effects of both bound and unbound states [9]. This approach allows them to precisely describe both a system consisting of a proton separated from 10C10C and one with all nucleons close together (11N11N). Employing recent parametrizations for the three-nucleon force obtained through chiral EFT, Kumar et al. compared the experimentally determined cross section with theoretical predictions from three existing chiral EFT models for the strong force: one that includes two-nucleon forces only, called the NNNN model, and two that include different parametrizations of both two- and three-body interactions, called the NN+3N400NN+3N400 and N2LOsatN2LOsat models.

Their analysis showed that the angular distribution of low-energy elastically scattered protons is a sensitive observable for testing strong-force models, in particular for the three-nucleon force. The N2LOsatN2LOsat model (described in Ref. [10]) delivered the best agreement with the angle-dependence data. The reason for its success may lie in the fact that compared to the NN+3N400NN+3N400 model, the N2LOsatN2LOsat model is constructed by fitting the ground-state properties of a larger set of nuclei. The inclusion of more neutron-rich nuclei, in particular, likely gives better constraints for three-nucleon forces than those derived from light nuclei such as deuterium, tritium, helium-3, or helium-4. It is worth noting, however, that all models, including N2LOsatN2LOsat, failed to reproduce the magnitude of the scattering cross section.

The work of Kumar and colleagues illustrates a paradigmatic approach (see Fig. 2) to achieving a grand goal of nuclear physics: developing a predictive theory that is strongly grounded in QCD. Ideally, we would like to compute properties of nucleonic matter using QCD. Since this problem is too complex, it can be approximated first by using chiral EFT to construct nuclear interactions. Such interactions can in turn be used to solve nuclear few- and many-body problems. The success of such an approach relies on the theory-experiments synergy that is at the very heart of the scientific method. On the theoretical front, QCD approaches like lattice QCD, which formulates the theory on a discrete, as opposed to continuous, spacetime, will need to deliver EFT Hamiltonians that are more directly connected to the underlying theory for the strong force. At the experimental level, approaches like that of Kumar et al. will help researchers identify the most sensitive ways to test theoretical models in the lab. [12]

'Fire-streaks' are created in collisions of atomic nuclei

At very high energies, the collision of massive atomic nuclei in an accelerator generates hundreds or even thousands of particles that undergo numerous interactions. Physicists at the Institute of Nuclear Physics of the Polish Academy of Sciences in Cracow, Poland, have shown that the course of this complex process can be represented by a surprisingly simple model: Extremely hot matter moves away from the impact point, stretching along the original flight path in streaks, and the further the streak is from the plane of the collision, the greater its velocity.

When two massive atomic nuclei collide at high energies, the most exotic form of matter is formed—a quark-gluon plasma behaving like a perfect fluid. These theoretical considerations show that after impact, the plasma forms into streaks along the direction of impact, moving faster the further away it moves from the collision axis. The model, its predictions and the implications for hitherto experimental data are presented in the journal Physical Review C.

Collisions of atomic nuclei occur extremely rapidly and at distances of merely hundreds of femtometres (i.e. hundreds of millionths of one billionth of a metre). The physical conditions are exceptionally sophisticated, and direct observation of the phenomenon is not currently possible. In such situations, science copes by constructing theoretical models and comparing their predictions with the data collected in experiments. In the case of these collisions, however, a huge disadvantage is that the resulting conglomerate of particles is the quark-gluon plasma. Interactions between quarks and gluons are dominated by forces that are so strong and complex that modern physics is not capable of describing them precisely.

"Our group decided to focus on the electromagnetic phenomena occurring during the collision because they are much easier to express in the language of mathematics. As a result, our model proved to be simple enough for us to employ the principles of energy and momentum conservation without too much trouble. Later on, we found that despite the adopted simplifications, the model predictions remain at least 90 percent consistent with experimental data," says Dr. Andrzej Rybicki (IFJ PAN).

Massive atomic nuclei accelerated to high velocities, observed in the laboratory, are flattened in the direction of motion as a result of the effects of the theory of relativity. When two such proton-neutron 'pancakes' fly toward each other, the collision is generally not central—only some of the protons and neutrons of one nucleus reach the other, entering into violent interactions and forming the quark-gluon plasma. At the same time, some of the external fragments of the nuclear pancakes do not encounter any obstacles on their way, and continue their uninterrupted flight; in the jargon of physicists, they are called "spectators."

"Our work was inspired by data collected in earlier experiments with nuclear collisions, including these made at the SPS accelerator. The electromagnetic effects occurring in these collisions that we examined showed that the quark-gluon plasma moves at a higher velocity the closer it is to the spectators," says Dr. Rybicki.

In order to reproduce this course of the phenomenon, the physicists from IFJ PAN decided to divide the nuclei along the direction of movement into a series of strips—'bricks'. Each nucleus in cross section thus looked like a pile of stacked bricks (in the model, their height was one femtometre). Instead of considering the complex strong interactions and flows of momentum and energy between hundreds and thousands of particles, the model reduced the problem to several dozen parallel collisions, each occurring between two proton-neutron bricks.

The IFJ PAN scientists confronted the predictions of the model with data collected from collisions of massive nuclei measured by the NA49 experiment at the Super Proton Synchrotron (SPS). This accelerator is located at the CERN European Nuclear Research Organization near Geneva, where one of its most important tasks now is to accelerate particles shot into the LHC accelerator.

"Due to the scale of technical difficulties, the NA49 experiment's results are subject to specific measurement uncertainties that are difficult to completely reduce or eliminate. In reality, the accuracy of our model can even be greater than the already mentioned 90 percent. This entitles us to say that even if there were any additional, still not included, physical mechanisms in the collisions, they should no longer significantly affect the theoretical framework of the model," says doctoral student Miroslaw Kielbowicz (IFJ PAN).

After developing the model of collisions of 'brick stacks,' the IFJ PAN researchers discovered that a very similar theoretical structure, called the 'fire streak model,' had already been proposed by a group of physicists from the Lawrence Berkeley Laboratory (USA) and the Saclay Nuclear Research Centre in France in 1978.

"The previous model of fire streaks which, in fact, we mention in our publication, was built to describe other collisions occurring at lower energies. We have created our structure independently and for a different energy range," says Prof. Antoni Szczurek (IFJ PAN, University of Rzeszow) and emphasizes: "The existence of two independent models based on a similar physical idea and corresponding to measurements in different energy ranges of collisions increases the probability that the physical basis on which these models are built is correct."

The Cracow fire streak model provides new information on the expansion of quark-gluon plasma in high energy collisions of massive atomic nuclei. The study of these phenomena is being further extended in the framework of another international experiment, NA61/SHINE at the SPS accelerator. [11]

First result from upgraded CEBAF opens door to exploring universal glue

The first experimental result has been published from the newly upgraded Continuous Electron Beam Accelerator Facility (CEBAF) at the U.S. Department of Energy's Thomas Jefferson National

Accelerator Facility. The result demonstrates the feasibility of detecting a potential new form of matter to study why quarks are never found in isolation.

The 12 GeV CEBAF Upgrade is a $338 million, multi-year project to triple CEBAF's original operational energy for investigating the quark structure of the atom's nucleus. The majority of the upgrade is complete and will be finishing up in 2017.

Scientists have been rigorously commissioning the experimental equipment to prepare for a new era of nuclear physics experiments. These activities have already led to the first scientific result, which comes from the Gluonic Excitations Experiment. GlueX conducts studies of the strong force, which glues matter together, through searches for hybrid mesons.

According to Curtis Meyer, a professor of physics at Carnegie Mellon University and spokesperson for the GlueX experiment at Jefferson Lab, these hybrid mesons are built of the same stuff as ordinary protons and neutrons, which are quarks bound together by the "glue" of the strong force. But unlike ordinary mesons, the glue in hybrid mesons behaves differently.

"The basic idea is that a meson is a quark and antiquark bound together, and our understanding is that the glue holds those together. And that glue manifests itself as a field between the quarks. A hybrid meson is one with that strong gluonic field being excited," Meyer explains.

He says that producing these hybrid mesons allows nuclear physicists to study particles in which the strong gluonic field is contributing directly to their properties. The hybrid mesons may ultimately provide a window into how subatomic particles are built by the strong force, as well as "quark confinement" - why no quark has ever been found alone.

"We hope to show that this "excited" gluonic field is an important constituent of matter. That's something that has not been observed in anything that we've seen so far. So, in some sense, it's a new type of hadronic matter that has not been observed," he says.

In this first result, data were collected over a two-week period following equipment commissioning in the spring of 2016. The experiment produced two ordinary mesons called the neutral pion and the eta, and the production mechanisms of these two particles were carefully studied.

The experiment takes advantage of the full-energy, 12 GeV electron beam produced by the CEBAF accelerator and delivered into the new Experimental Hall D complex. There, the 12 GeV beam is converted into a first-of-its-kind 9 GeV photon beam.

"The photons go through our liquid hydrogen target. Some of them will interact with a proton in that target, something is exchanged between the photon and the proton, and something is kicked out - a meson," Meyer explains. "This publication looked at some of the simplest mesons you could kick out. But it's the same, basic production mechanism that most of our reactions will follow."

The result was published as a Rapid Communication in the April issue of Physical Review C. It demonstrated that the linear polarization of the photon beam provides important information by ruling out possible meson production mechanisms.

"It's not so much that the particles we created were interesting, but how they were produced: Learning what reactions were important in making them," Meyer says.

The next step for the collaboration is further analysis of data already collected and preparations for the next experimental run in the fall.

"I'm sure that we've produced hybrid mesons already, we just don't have enough data to start looking for them yet," Meyer says. "There are a number of steps that we're going through in terms of understanding the detector and our analysis. We're doing the groundwork now, so that we'll have confidence that we understand things well enough that we can validate results we'll be getting in the future."

"This new experimental facility - Hall D - was built by dedicated efforts of the Jefferson Lab staff and the GlueX collaboration," says Eugene Chudakov, Hall D group leader. "It is nice to see that all of the equipment, including complex particle detectors, is operating as planned, and the exciting scientific program has successfully begun."

The 12 GeV CEBAF Upgrade project is in its last phase of work and is scheduled for completion in September. Other major experimental thrusts for the upgraded CEBAF include research that will enable the first snapshots of the 3D structure of protons and neutrons, detailed explorations of the internal dynamics and quark-gluon structure of nuclei, and tests of fundamental theories of matter. [10]

Physicists Have Discovered Evidence Of A Gluino Particle, The Cousin Of The Higgs Boson

The two teams working in concert, named Atlas and CMS, presented their findings on the particle from the Large Hadron Collider's second run (LHC Run 2). The results were based on what the scientists observed during the particle collisions. The previously-hypothesized particle, named the gluino, is theoretically the supersymmetric partner of the gluon (or glue particle, which is comprised entirely of nuclear force). This would mean that the gluino could be pair-produced by colliders like the LHC, and would more or less be described as a heavier version of the Higgs boson, a particle that essentially helps us understand why other particles contain mass and was identified at the LHC at CERN in 2012.

Despite the promising findings, the scientists stressed that there was not enough data to pinpoint anything definitive about the existence of the possible — and possibly important — particle.

"I don't think there is anyone around who thinks this is conclusive," said Kyle Cranmer, one of the members of Atlas, in an interview with the New York Times.

"But it would be huge if true," added the NYU-based physicist.

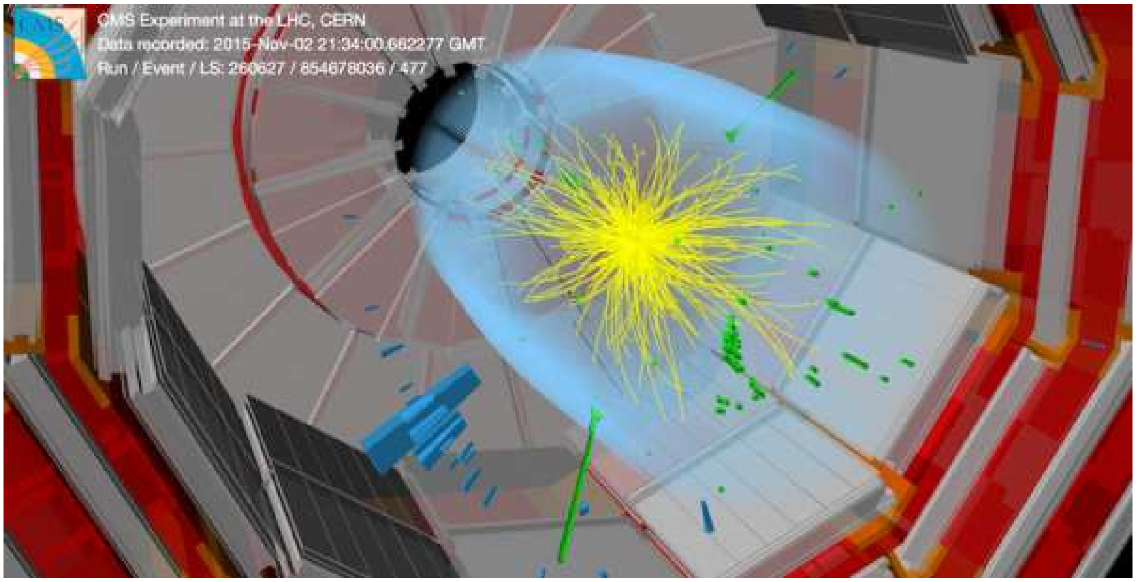


Image of a particle collision.

(Photo : CERN) Image of a particle collision.

The scientists first noticed data that would point to the existence of the gluino with extra gamma rays found within the collider. The gamma rays, which were congruent with the charge power of about 750 billion electron volts, were theorized to be the product of radioactive decay in a particle. This behavior would be symptomatic of a gluino.

"We are barely coming to terms with the power and the glory," another CERN team member, Maria Spiropulu, told the New York Times via text message, referring to the collider's expansive capabilities, among them the "ability to operate at 13 trillion electron volts."

"We are now entering the era of taking a shot in the dark!" the physicist concluded. [9]

Recent study predicts that Higgs particles are much heavier than earlier observation

Researchers at Aalto University in Finland now propose that there is more than one Higgs boson, and they are much heavier than the 2012 observation. The results were recently published in Nature Communications.

"Our recent ultra-low temperature experiments on superfluid helium (3He) suggest an explanation why the Higgs boson observed at CERN appears to be too light.

By using the superfluid helium analogy, we have predicted that there should be other Higgs bosons, which are much heavier (about 1 TeV) than previously observed," says Professor (emeritus) Grigory E. Volovik.

Prof. Volovik holds a position in the Low Temperature Laboratory at Aalto University and in Landau Institute, Moscow. He has received the international Simon Prize in 2004 for distinguished work in theoretical low temperature physics, and the Lars Onsager Prize in 2014 for outstanding research in theoretical statistical physics.

At the same time, the new CERN experiments have shown evidence of the second Higgs in just the suggested region (at 0.75 TeV). This evidence has immediately been commented and discussed in a large number of papers submitted to arXiv, an e-print service widely utilised by the physics community to distribute manuscripts of their unpublished work. [8]

Exploring the Higgs boson's dark side

Last month, after two years of preparation, the LHC began smashing its proton beams together at 13 Trillion electron Volts (TeV), close to double the energy achieved during its first run.

'We do not know what we will find next and that makes the new run even more exciting,' Daniela Bortoletto of Oxford University's Department of Physics, a member of the team running the LHC's ATLAS experiment, tells me. 'We hope to finally find some cracks in the Standard Model as there are many questions about our universe that it does not answer.'

One of the big questions concerns dark matter, the invisible 'stuff' that astrophysicists estimate makes up over 80% of the mass of the Universe. As yet nobody has identified particles of dark matter although physicists think it could be the lightest supersymmetric (SUSY) particle.

'In the new run, because of the highest-ever energies available at the LHC, we might finally create dark matter in the laboratory,' says Daniela. 'If dark matter is the lightest SUSY particle than we might discover many other SUSY particles, since SUSY predicts that every Standard Model particle has a SUSY counterpart.'

Then there's the puzzle of antimatter: in the early Universe matter and antimatter were created in equal quantities but now matter dominates the Universe.

'We still do not know what caused the emergence of this asymmetry,' Daniela explains. 'We have finally discovered the Higgs boson: this special particle, a particle that does not carry any spin, might decay to dark matter particles and may even explain why the Universe is matter dominated.'

Discovering the Higgs boson was a huge achievement but now the race is on to understand it: a prospect that Daniela is particularly excited about.

'This particle is truly fascinating,' she says. 'Spin explains the behaviour of elementary particles: matter particles like the electron have spin 1/2 while force particles

like the photon, which is responsible for the electromagnetic interaction, have spin 1. Spin 1/2 particles obey the Pauli principle that forbids electrons to be in the same quantum state.

'The Higgs is the first spin 0 particle, or as particle physicists would say the first 'scalar particle' we've found, so the Higgs is neither matter nor force.'

Because of its nature the Higgs could have an impact on cosmic inflation and the energy of a vacuum as well as explaining the mass of elementary particles.

Daniela tells me: 'Because of the Higgs the electron has mass, atoms can be formed, and we exist. But why do elementary particles have such difference masses?
The data of run 2 will enable us to study, with higher precision, the decays of the Higgs boson and directly measure the coupling of the Higgs to quarks. It will also enable us to search for other particles similar to the Higgs and determine if the Higgs decays to dark matter.'

Daniela is one of 13 academics at Oxford working on ATLAS supported by a team of postdoctoral fellows, postgraduate students and engineering, technical, and computing teams. The Oxford group plays a lead role in operating the SemiConductor Tracker (SCT), most of which was assembled in an Oxford lab. This provides information on the trajectories of the particles produced when the LHC's beams collide, which was crucial to the discovery of the Higgs boson.

Whilst the next few years will see the Oxford group busy with research that exploits the LHC's new high-energy run, the team are also looking ahead to 2025 when the intensity or 'luminosity' of the beams will be increased.

The LHC is filled with 1,380 bunches of protons each containing almost a billion protons and colliding 40 million times per second. This means that every time two bunches of protons cross they generate not one collision but many, an effect called 'pile-up'.

'After this luminosity upgrade the LHC will operate at collision rates five to ten times higher than it does at present,' Daniela explains. 'In run 1 of the LHC we had a maximum of 37 pile-up collisions per crossing but with the upgrade to the High Luminosity LHC, or 'HL-LHC', this will increase to an average of 140 pile-up events in each bunch crossing.'

With the HL-LHC generating many more collisions, the international Oxford-led team are designing and prototyping parts of a new semiconductor tracker that will be needed to help reconstruct particles from the complex web of decay trails they leave inside the machine.

As the LHC ramps up both its energy and luminosity it promises to give scientists working on experiments such as ATLAS answers to some of the biggest questions in physics. One thing is certain: this new physics will also lead to a whole set of new questions about the matter that makes up us and the Universe around us. [7]

The Higgs particle can disintegrate into particles of dark matter, according to new model

The problem is that there are several things the Standard Model is unable to explain, for example the dark matter that makes up a large part of the universe. Many particle physicists are therefore working on the development of new, more comprehensive models.

One of them is Christoffer Petersson, who carries out research in theoretical particle physics at Chalmers University of Technology in Sweden and the Université Libre in Belgium. Together with two research colleagues he has proposed a particle model based on what is known as supersymmetry.

This model contains more elementary particles than the Standard Model, including dark matter particles. In addition, the model gives the Higgs particle different properties than the Standard Model predicts. The model proposes that the Higgs particle can distintegrate into a photon (a particle of light) and particles of dark matter. However, these properties are quite difficult to discover – you have to look for them specifically to have a chance of finding them.

But Christoffer Petersson is fortunate – his model has met with a response at CERN. Two independent experimental stations – Atlas and CMS – at the Large Hadron Collider are now looking for the very properties of the Higgs particle his model predicts. If the properties are there, it is a clear indication that the model fits.

"It's a dream for a theorist in particle physics. LHC is the only place where the model can be tested. It's even nicer that two independent experiments are going to do it," says Christoffer Petersson.

In the first studies the volume of data was unfortunately too small for it to be possible to either confirm or reject Petersson's model.

A Higgs particle has been created in an LHC detector and has then disintegrated into four muons (the four red lines). According to Christoffer Petersson's model the Higgs particle can also disintegrate into a photon and particles of dark matter. Picture: CERN

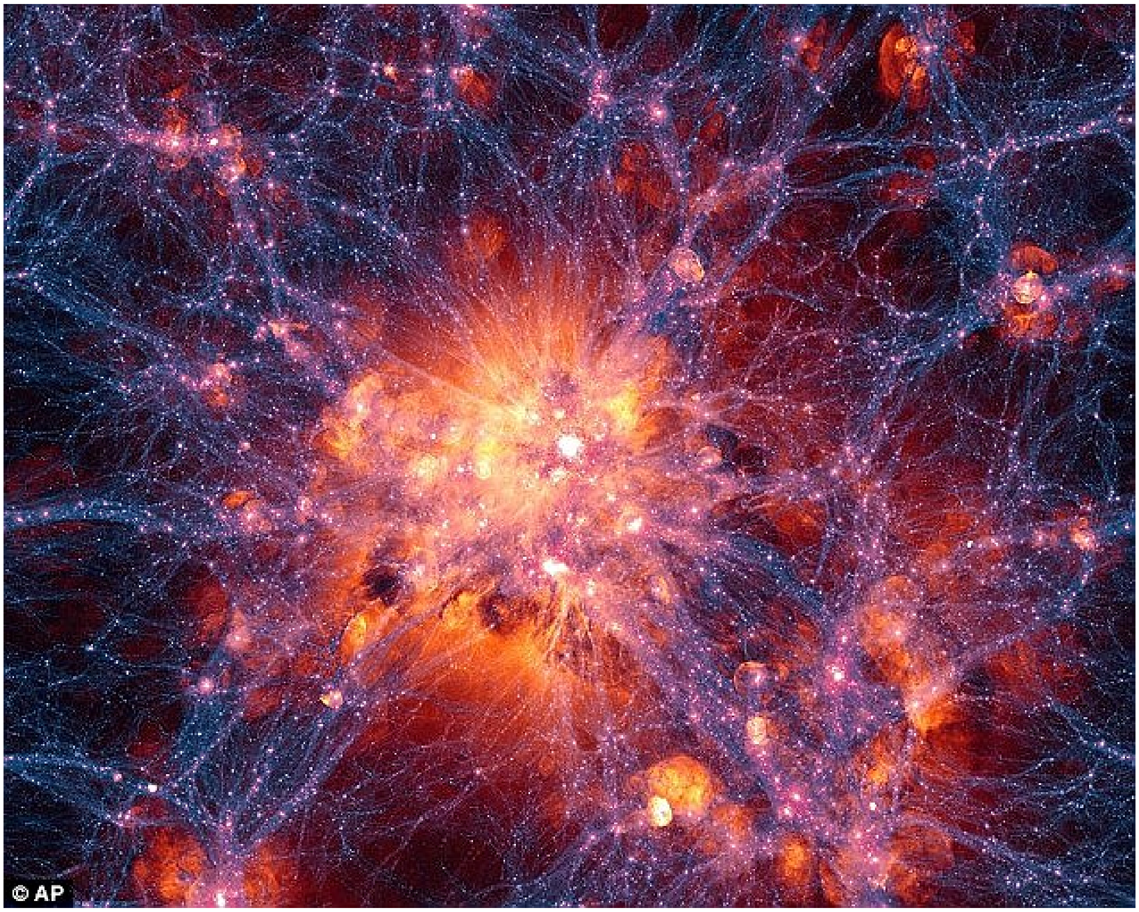
A Higgs particle has been created in an LHC detector and has then disintegrated into four muons (the four red lines). According to Christoffer Petersson's model the Higgs particle can also disintegrate into a photon and particles of dark matter.

"But we are already in full swing with new analyses in which we are testing his model in other ways and with more data. We congratulate Christoffer Petersson for having done an important job," says Zeynap Demiragli at the CMS experiment at CERN.

After being closed down for a time for an upgrade, LHC will start up again in the spring of 2015. With higher energies in the accelerator, the experiments will finally gather sufficient data to evaluate Petersson's model properly. He is on tenterhooks awaiting the results. [6]

Will the Large Hadron Collider find dark matter?

Atom smasher could soon solve one the universe's greatest mysteries, claims scientist. Dr Monica Dunford worked at Cern in Switzerland up until 2013. She was directly involved in the detection of the Higgs boson in 2012. Speaking to Mail Online she said of the time leading up to its discovery: 'I don't think there will be another time like that in my career for sure'. But she said that the Large Hadron Collider could find dark matter. And if it did it would be a 'bigger discovery' than the Higgs boson. In March 2015 the LHC will be restarted at double its previous power.



‘One of the things I’m most interested in is creating and discovering dark matter,’ Dr Dunford said. ‘We know from measurements of cosmology that 25 per cent of the universe is dark matter and we have absolutely no idea what that is.' An illustration of dark matter in the universe is shown.

When physicists study the dynamics of galaxies and the movement of stars, they are confronted with a mystery.

If they only take visible matter into account, their equations simply don't add up: the elements that can be observed are not sufficient to explain the rotation of objects and the existing gravitational forces. There is something missing.

From this they deduced that there must be an invisible kind of matter that does not interact with light, but does, as a whole, interact by means of the gravitational force. Called 'dark matter', this substance appears to make up at least 80 per cent of the universe. Finding the Higgs boson was one of the primary goals of the LHC - but perhaps the LHC’s most important moment is yet to come.

‘One of the things I’m most interested in is creating and discovering dark matter,’ Dr Dunford said. We know from measurements of cosmology that 25 per cent of the universe is dark matter and we have absolutely no idea what that is. For comparison, what we do know, electrons and protons, only count for four per cent. You have this huge chunk of a pie and no idea what it consists of.

One thing we could possibly produce would be a dark matter candidate via its decay products. Being able to produce it at the LHC would be a huge connection between our astronomical measurements and what we can produce in the laboratory. [5]

The Classical Relativistic effect

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field.
In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion. [1]

The Relativistic Quantum Mechanics

The same thing happens on the atomic scale giving a dp impulse difference and a dx way difference between the different part of the not point like particles.

Commonly accepted idea that the relativistic effect on the particle physics it is the fermions' spin - another unresolved problem in the classical concepts. If the electric charges can move only with accelerated motions in the self maintaining electromagnetic field, once upon a time they would reach the velocity of the electromagnetic field. The resolution of this problem is the spinning particle, constantly accelerating and not reaching the velocity of light because the acceleration is radial.

The Heisenberg Uncertainty Relation

I think that we have a simple bridge between the classical and quantum mechanics by understanding the Heisenberg Uncertainty Relations. It makes clear that the particles are not point like but have a dx and dp uncertainty.

The General Relativity - Electromagnetic inertia and mass

Electromagnetic Induction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

Relativistic change of mass

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

The frequency dependence of mass

Since $\boldsymbol{E = h\nu}$ and $\boldsymbol{E = mc^2}$, $\boldsymbol{m = h\nu / c^2}$ that is the ***m*** depends only on the $\boldsymbol{\nu}$ frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the $\boldsymbol{m_o}$ inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation. [2]

Electron – Proton mass rate

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. In the maximum intensity no diffraction patterns with equal intensity that is no fermions only bosons. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter. The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force.

In Quantum Field Theory (QFT), particles are described by excitations of a quantum field that satisfies the appropriate quantum mechanical field equations.
The excitations of the quantum field mean diffraction patterns in my theory. [2]

Higgs Field

The Higgs mechanism is a result of something called a field that extends throughout space, even where no particles are present. This notion is probably most familiar to you from a magnetic field. You feel a force between a magnet and your refrigerator even when “nothing” is there. A field can fill “empty” space. The Higgs field extends throughout space. Elementary particles acquire their masses by interacting with this field. It is kind of like space is charged and particles get mass through their interactions with this charge.

The Higgs boson is not directly responsible for mass. The Higgs field is. The boson is a particle that tells us our understanding of this mechanism is correct. It also is a big clue as to where that field came from in the first place. Its discovery tells us that what we expected to be true was indeed correct, and it gives us clues as to what else might underlie the Standard Model. [4]

The Higgs boson

By March 2013, the particle had been proven to behave, interact and decay in many of the expected ways predicted by the Standard Model, and was also tentatively confirmed to have + parity and zero spin, two fundamental criteria of a Higgs boson, making it also the first known scalar particle to be discovered in nature, although a number of other properties were not fully proven and some partial results do not yet precisely match those expected; in some cases data is also still awaited or being analyzed.

In my opinion, the best explanation of the Higgs mechanism for a lay audience is the one invented by David Miller. You can find it here: http://www.strings.ph.qmul.ac.uk/~jmc/epp/higgs3.html .
The field must come first. The boson is an excitation of the field. So no field, no excitation. On the other hand in quantum field theory it is difficult to separate the field and the excitations.
The Higgs field is what gives particles their mass.
There is a video that gives an idea as to the Higgs field and the boson. It is here: http://www.youtube.com/watch?v=RIg1Vh7uPyw . Note that this analogy isn't as good as the Miller one, but as is usually the case, if you look at all the analogies you'll get the best understanding of the situation.

What is the Spin?

So we know already that the new particle has spin zero or spin two and we could tell which one if we could detect the polarizations of the photons produced. Unfortunately this is difficult and neither ATLAS nor CMS are able to measure polarizations. The only direct and sure way to confirm that the particle is indeed a scalar is to plot the angular distribution of the photons in the rest frame of the centre of mass. A spin zero particles like the Higgs carries no directional information away from the original collision so the distribution will be even in all directions. This test will be possible when a much larger number of events have been observed. In the mean time we can settle for less certain indirect indicators.

The Weak Interaction

Since the Higgs boson is necessary to the W and Z bosons, the dipole change of the Weak interaction and the change in the magnetic effect caused gravitation must be conducted. The Wien law is also important to explain the Weak interaction, since it describes the T_{max} change and the diffraction patterns change. [2]

Higgs mechanism

The magnetic induction creates a negative electric field, causing an electromagnetic inertia. Probably it is the mysterious Higgs field giving mass to the charged particles? We can think about the photon as an electron-positron pair, they have mass. The neutral particles are built from negative and positive charges, for example the neutron, decaying to proton and electron. The wave – particle duality makes sure that the particles are oscillating and creating magnetic induction as an inertial mass, explaining also the relativistic mass change. Higher frequency creates stronger magnetic induction, smaller frequency results lesser magnetic induction. It seems to me that the magnetic induction is the secret of the Higgs field.

In particle physics, the Higgs mechanism is a kind of mass generation mechanism, a process that gives mass to elementary particles. According to this theory, particles gain mass by interacting with the Higgs field that permeates all space. More precisely, the Higgs mechanism endows gauge bosons in a gauge theory with mass through absorption of Nambu–Goldstone bosons arising in spontaneous symmetry breaking.

The simplest implementation of the mechanism adds an extra Higgs field to the gauge theory. The spontaneous symmetry breaking of the underlying local symmetry triggers conversion of components of this Higgs field to Goldstone bosons which interact with (at least some of) the other fields in the theory, so as to produce mass terms for (at least some of) the gauge bosons. This mechanism may also leave behind elementary scalar (spin-0) particles, known as Higgs bosons.

In the Standard Model, the phrase "Higgs mechanism" refers specifically to the generation of masses for the $W^{\pm}$, and Z weak gauge bosons through electroweak symmetry breaking. The Large Hadron Collider at CERN announced results consistent with the Higgs particle on July 4, 2012 but stressed that further testing is needed to confirm the Standard Model.

Gravity from the point of view of quantum physics

The Gravitational force

The gravitational attractive force is basically a magnetic force.

The same electric charges can attract one another by the magnetic force if they are moving parallel in the same direction. Since the electrically neutral matter is composed of negative and positive charges they need 2 photons to mediate this attractive force, one per charges. The Bing Bang caused parallel moving of the matter gives this magnetic force, experienced as gravitational force.

Since graviton is a tensor field, it has spin = 2, could be 2 photons with spin = 1 together.

You can think about photons as virtual electron – positron pairs, obtaining the necessary virtual mass for gravity.

The mass as seen before a result of the diffraction, for example the proton – electron mass rate Mp=1840 Me. In order to move one of these diffraction maximum (electron or proton) we need to intervene into the diffraction pattern with a force appropriate to the intensity of this diffraction maximum, means its intensity or mass.

The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles. The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces!?

The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.
There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

The Graviton

In physics, the graviton is a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory. If it exists, the graviton is expected to be massless (because the gravitational force appears to have unlimited range) and must be a spin-2 boson. The spin follows from the fact that the source of gravitation is the stress-energy tensor, a second-rank tensor (compared to electromagnetism's spin-1 photon, the source of which is the four-current, a first-rank tensor). Additionally, it can be shown that any massless spin-2 field would give rise to a force indistinguishable from gravitation, because a massless spin-2 field must couple to (interact with) the stress-energy tensor in the same way that the gravitational field does. This result suggests that, if a massless spin-2 particle is discovered, it must be the graviton, so that the only experimental verification needed for the graviton may simply be the discovery of a massless spin-2 particle. [3]

Conclusions

"If the model is found to fit, it would completely change our understanding of the fundamental building blocks of nature. If not, just the fact that they are willing to test my model at CERN is great," he says. [6]

On whether it would be the LHC's most important discovery to date, she said: 'Personally yes. It would be a bigger discovery than the Higgs boson. 'For the Higgs we had a very good concrete theoretical prediction; for dark matter we really have no idea what it would be.'

She added: 'There is no particle that we know of today that can explain dark matter, let alone what dark energy might be. So if we could directly produce dark matter particles at the LHC this would be a huge step forward in our understanding of the composition of the universe!' [5]

The electric currents causing self maintaining electric potential is the source of the special and general relativistic effects. The Higgs Field is the result of the electromagnetic induction. The Graviton is two photons together.

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