# UniverseNews

Excellence Cluster Universe | Issue 3/2013

South Pole station and IceCube Lab with drilled holes superimposed ©Haley Buffman & Jamie Yang/NSF

From the IceCube observatory

## First evidence of high-energy neutrinos

On the Nobel Prize for Physics 2013

## “What is missing, are new, brilliant theoretical ideas”

**Dear readers,**

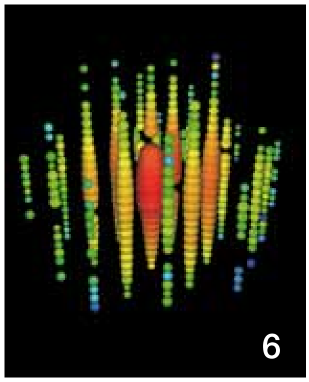
*This time the award of the Nobel Prize for Physics was not a surprise, but very satisfactory for us: A 50-year-old theory received its 'ennoblement' only after the experimental confirmation, with involvement of scientists from our cluster. In our interview, Prof. Dr. Dorothee Schaile and Prof. Dr. Siegfried Bethke explain why this Nobel Prize also honours the achievements of the ATLAS and CMS collaborations (page 3).*

*A publication in Science – this is a great experience for researchers. Our astroparticle physicist Prof. Dr. Elisa Resconi did succeed: she is one of the authors of the recent Science cover story about 28 neutrinos that raced from the reaches of the universe to the Earth (p. 6). And another joyous event: Dr. Martin Winkler and Dr. Oliver Pfuhl will receive the Universe PhD Awards 2013 for their outstanding dissertations (p. 14). Congratulations!*

*Petra Riedel, PR Manager*








# Review

*Photos: H. Schmidhofer, Amane/TUM, TUM*

## SPaRTa 2013

14. – 17.10.2013

Methods for the simulation of particle tracks and spins in electromagnetic fields were the focus of the workshop Sparta 2013 (Spin and Charged Particle Tracking in Magnetic Fields at Very Low Energies) in Seeon (photo). The scientists presented concepts for simulations from different fields and experiments and discussed approaches to exploit synergies for future developments.

## Open Day

19.10.2013

The joint program of the five Munich Excellence Clusters during the Open Day at the Campus Garching attracted a crowd. Speakers for the Universe Cluster were Dr. Andreas Müller ("Beam me up, Scotty – The Physics of Star Trek") and Dr. Marianne Göger-Neff ("Neutrinos: News from the ghost particles"). 500 visitors listened to Prof. Dr. Harald Lesch's talk on "Headlines from the edge of reality" (photo).

## ISM conference

21. – 25.10.2013

The formation of galaxies, stars and chemical elements is closely related to the physics of the Interstellar Medium (ISM). The 130 participants of the international conference in the framework of the DFG priority program "Physics of the Interstellar Medium" in Garching discussed how measurements, observations, simulations and models can be combined to a dynamic multi-phase model of the ISM.

*CERN, 4 July 2012: The ATLAS and CMS collaborations announce the discovery of the Higgs boson, François Englert (l.) and Peter Higgs are present. The two theorists have predicted the particle almost 50 years ago.*

Interview with Prof. Dr. Dorothee Schaile and Prof. Dr. Siegfried Bethke on this year's Nobel Prize in Physics

# "What is missing, are new, brilliant theoretical ideas"

**In 1964, the physicists François Englert, Robert Brout and Peter Higgs postulated a new mechanism that gives elementary particles their mass. Almost 50 years later, the theory has been confirmed at CERN with the discovery of the Higgs boson. On 10 December 2013, theorists Englert and Higgs – Brout died in 2011 – will receive the Nobel Prize in Stockholm. Following is an interview with Prof. Dr. Dorothee Schaile and Prof. Dr. Siegfried Bethke about the importance of the Nobel Prize, being deserving of the Prize as experimental physicists, and what other discoveries may be expected from CERN in the near future.** ***Interview: Petra Riedel***

**Did you anticipate this Nobel Prize?**

*Prof. Schaile:* To be honest, we sort of hoped for it. After all, the discovery of the Higgs boson is the culmination of years of research.

**Without the confirmation of the experiment, Englert and Higgs would not have received the prize. Is there an experimental physicist missing among the winners?**

*Prof. Bethke:* For me, it was no surprise that the award was limited to the two of them.

**Why?**

*Schaile:* Physics Nobel Prizes can only be awarded to individuals, unlike the Nobel Peace Prize. Between the two experimental collaborators ATLAS and CMS, which conducted the successful experiments at the Large Hadron Collider at CERN, a total of 6,000 people are involved.

**And there was no experimenter of particular importance?**

*Schaile:* Some scientists were very important for the experiments, some others for the data analyses. To select one or two laureates, would be very difficult. I would not know how to determine that.

*Bethke:* In 1984, two CERN particle physicists were awarded the Nobel Prize for the discovery of the $W^{\pm}$ and $Z^0$ bosons. Simon van der Meer had developed the technology of stochastic cooling for the Super Proton Synchrotron. At that time, no one else knew how to cool antiprotons. The second laureate, Carlo Rubbia, had launched the project and it was due to his enormous personal commitment that the detector was successful. At that time, there were two notably important experimentalists. However, for the Higgs discovery a group of 10 to 20 people was of importance. It would have caused a lot of bad feelings if only one of them would have been nominated for the Nobel Prize.

**Does this Nobel Prize rule need an up-to-date?**

*Schaile:* It could be reconsidered. Re-

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Robert Brout (1928 – 2011)


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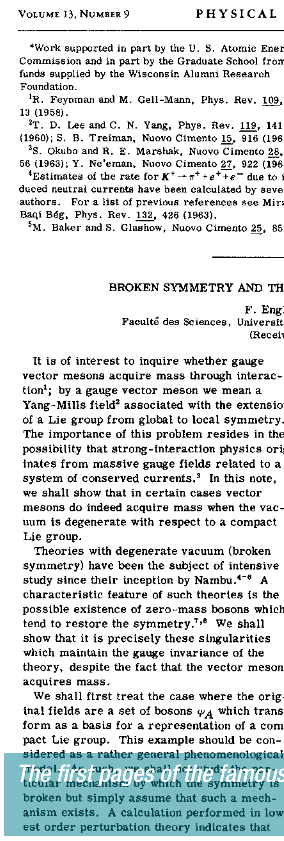
François Englert visiting the ATLAS experiment in 2007.



VOLUME 13, NUMBER 9 PHYSICAL

*Work supported in part by the U. S. Atomic Ener
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[2]T. D. Lee and C. N. Yang, Phys. Rev. 119, 141
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BROKEN SYMMETRY AND TH

F. Engl
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It is of interest to inquire whether gauge vector mesons acquire mass through interaction[1]; by a gauge vector meson we mean a Yang-Mills field[2] associated with the extensio of a Lie group from global to local symmetry. The importance of this problem resides in the possibility that strong-interaction physics ori inates from massive gauge fields related to a system of conserved currents.[3] In this note, we shall show that in certain cases vector mesons do indeed acquire mass when the vacuum is degenerate with respect to a compact Lie group.

Theories with degenerate vacuum (broken symmetry) have been the subject of intensive study since their inception by Nambu.[4-6] A characteristic feature of such theories is the possible existence of zero-mass bosons which tend to restore the symmetry.[7,8] We shall show that it is precisely these singularities which maintain the gauge invariance of the theory, despite the fact that the vector meson acquires mass.

We shall first treat the case where the orig inal fields are a set of bosons $\varphi_A$ which trans form as a basis for a representation of a com pact Lie group. This example should be considered as a rather general phenomenological model. As such, we shall not study the par ticular mechanism by which the symmetry is broken but simply assume that such a mechanism exists. A calculation performed in low est order perturbation theory indicates that

The first pages of the famous

search is becoming increasingly international and it gets more and more difficult to single out an individual.

*Bethke:* However, it has tremendous effects that the Nobel Prize distinguishes outstanding individuals and it should remain that way. One can meet and talk to Nobel Prize winners; young people can see them as a role models and say to themselves: One day, I want to win the Nobel Prize. A Nobel Prize shared by 6,000 shoulders might be realistic in terms of research achievements, but the effect would be wasted. Yet, the Nobel Prize Committee has found a very clever and elegant solution: It explicitly points out the successful discovery of the ATLAS and CMS experiments, and that seems to me quite unusual.

**This may be elegant. But is it fair?**

*Bethke:* Justice must be served. In this case, I was fully satisfied and happy without reservation. In particle physics, however, it is noticeable that the recent Nobel Prizes were awarded only to theoreticians. It is actually more difficult to select individuals from the experimental area, which could mean that there is no Nobel Prize in experimental particle physics. Of course, that would be a shame and a pity. But there are prizes that are also awarded to collaborations and they are of similar importance as the Nobel Prize within the scientific community – for example, the prize of the European Physical Society (EPS). Many EPS winners were later honoured with the Nobel Prize, including in 1997 Englert, Brout and Higgs.

**Last year, the CERN scientists only suspected to have found the Higgs boson. In March of this year, CERN announced: We are more confident. Why?**

*Schaile:* In July 2012, only parts of the data were available. Based on this data we were able to see that the particle is a new boson, and that it is within a mass range that we expected it to be for the Higgs particle. Meanwhile, more data were evaluated and further analyses were made. Now we can say that this boson is very likely to have the properties predicted for a Higgs boson.

**How confident are you?**

*Bethke:* We are now at a three sigma confidence level, thus a probability of 99.7 percent. In order to be firmly convinced we would need at least five sigma.

**The residual uncertainty was eliminated by the Nobel Committee?**

*Bethke (laughs ):* Yes, it was exalted to six sigma by the Nobel Committee, that is, to a 100 percent certainty. Theorists are only awarded the Nobel Prize when a signal has been established.

**Do you have doubts?**

*Bethke:* No, only in a sense that as a scientist I have to admit: It is never fully proven. Should it be something else, I would consider this even more interesting, because we would have clues to a deeper, more fundamental theory, such as supersymmetry. That would push open new doors.

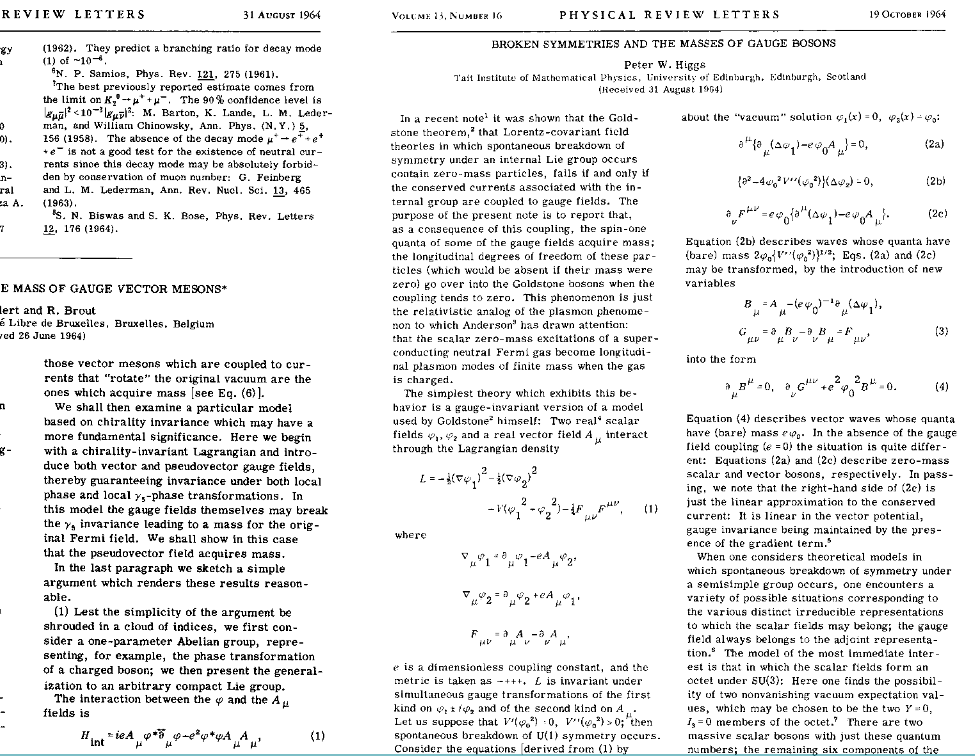
**Which kind of Higgs boson is it? The Standard Model Higgs or a supersymmetric Higgs boson?**

*Schaile:* If it is a Standard Model Higgs boson, it should not have an angular momentum, so have spin 0, and a fixed coupling to other particles. Everything points to that at the moment. However, the simplest of the postulated supersymmetric Higgs bosons may differ only very little from the standard model boson in terms of mass. We can only distinguish it when we would discover other supersymmetric particles. So far, we have not been successful.

**Is supersymmetry then finished?**

*Schaile:* No, not at all. The parameter space of supersymmetry is huge. In addition, there are ranges that we experimentally cannot reach with the current accelerators.

*Bethke:* And theorists can always fall back to that, thus, supersymmetry will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E MASS OF GAUGE VECTOR MESONS*

lert and R. Brout

é Libre de Bruxelles, Bruxelles, Belgium

ved 26 June 1964)

those vector mesons which are coupled to currents that "rotate" the original vacuum are the ones which acquire mass [see Eq. (6)].

We shall then examine a particular model based on chirality invariance which may have a more fundamental significance. Here we begin with a chirality-invariant Lagrangian and introduce both vector and pseudovector gauge fields, thereby guaranteeing invariance under both local phase and local $\gamma_5$-phase transformations. In this model the gauge fields themselves may break the $\gamma_5$ invariance leading to a mass for the original Fermi field. We shall show in this case that the pseudovector field acquires mass.

In the last paragraph we sketch a simple argument which renders these results reasonable.

(1) Lest the simplicity of the argument be shrouded in a cloud of indices, we first consider a one-parameter Abelian group, representing, for example, the phase transformation of a charged boson; we then present the generalization to an arbitrary compact Lie group.

The interaction between the $\varphi$ and the $A_\mu$ fields is

$$H_{\text{int}} = ieA_\mu \varphi^* \overleftrightarrow{\partial}_\mu \varphi - e^2 \varphi^* \varphi A_\mu A_\mu, \quad (1)$$

symmetry by fixing $\langle\varphi\rangle \neq 0$ in the vacuum, with the phase chosen for convenience such that $\langle\varphi\rangle = \langle\varphi^*\rangle = \langle\varphi_1\rangle/\sqrt{2}$.

We shall assume that the application of the

VOLUME 13, NUMBER 16 PHYSICAL REVIEW LETTERS 19 OCTOBER 1964

BROKEN SYMMETRIES AND THE MASSES OF GAUGE BOSONS

Peter W. Higgs

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(Received 31 August 1964)

In a recent note[1] it was shown that the Goldstone theorem,[2] that Lorentz-covariant field theories in which spontaneous breakdown of symmetry under an internal Lie group occurs contain zero-mass particles, fails if and only if the conserved currents associated with the internal group are coupled to gauge fields. The purpose of the present note is to report that, as a consequence of this coupling, the spin-one quanta of some of the gauge fields acquire mass; the longitudinal degrees of freedom of these particles (which would be absent if their mass were zero) go over into the Goldstone bosons when the coupling tends to zero. This phenomenon is just the relativistic analog of the plasmon phenomenon to which Anderson[3] has drawn attention: that the scalar zero-mass excitations of a superconducting neutral Fermi gas become longitudinal plasmon modes of finite mass when the gas is charged.

The simplest theory which exhibits this behavior is a gauge-invariant version of a model used by Goldstone[2] himself: Two real[4] scalar fields $\varphi_1, \varphi_2$ and a real vector field $A_\mu$ interact through the Lagrangian density

$$L = -\tfrac{1}{2}(\nabla\varphi_1)^2 - \tfrac{1}{2}(\nabla\varphi_2)^2 - V(\varphi_1^2 + \varphi_2^2) - \tfrac{1}{4}F_{\mu\nu}F^{\mu\nu}, \quad (1)$$

where

$$\nabla_\mu \varphi_1 = \partial_\mu \varphi_1 - eA_\mu \varphi_2,$$

$$\nabla_\mu \varphi_2 = \partial_\mu \varphi_2 + eA_\mu \varphi_1,$$

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu,$$

$e$ is a dimensionless coupling constant, and the metric is taken as $-+++$. $L$ is invariant under simultaneous gauge transformations of the first kind on $\varphi_1 \pm i\varphi_2$ and of the second kind on $A_\mu$. Let us suppose that $V'(\varphi_0^2) = 0$, $V''(\varphi_0^2) > 0$; then spontaneous breakdown of U(1) symmetry occurs. Consider the equations [derived from (1) by treating $\Delta\varphi_1$, $\Delta\varphi_2$, and $A_\mu$ as small quantities]

508

about the "vacuum" solution $\varphi_1(x) = 0$, $\varphi_2(x) = \varphi_0$:

$$\partial^\mu\{\partial_\mu(\Delta\varphi_1) - e\varphi_0 A_\mu\} = 0, \quad (2a)$$

$$\{\partial^2 - 4\varphi_0^2 V''(\varphi_0^2)\}(\Delta\varphi_2) = 0, \quad (2b)$$

$$\partial_\nu F^{\mu\nu} = e\varphi_0\{\partial^\mu(\Delta\varphi_1) - e\varphi_0 A_\mu\}. \quad (2c)$$

Equation (2b) describes waves whose quanta have (bare) mass $2\varphi_0\{V''(\varphi_0^2)\}^{1/2}$; Eqs. (2a) and (2c) may be transformed, by the introduction of new variables

$$B_\mu = A_\mu - (e\varphi_0)^{-1}\partial_\mu(\Delta\varphi_1),$$

$$G_{\mu\nu} = \partial_\mu B_\nu - \partial_\nu B_\mu = F_{\mu\nu}, \quad (3)$$

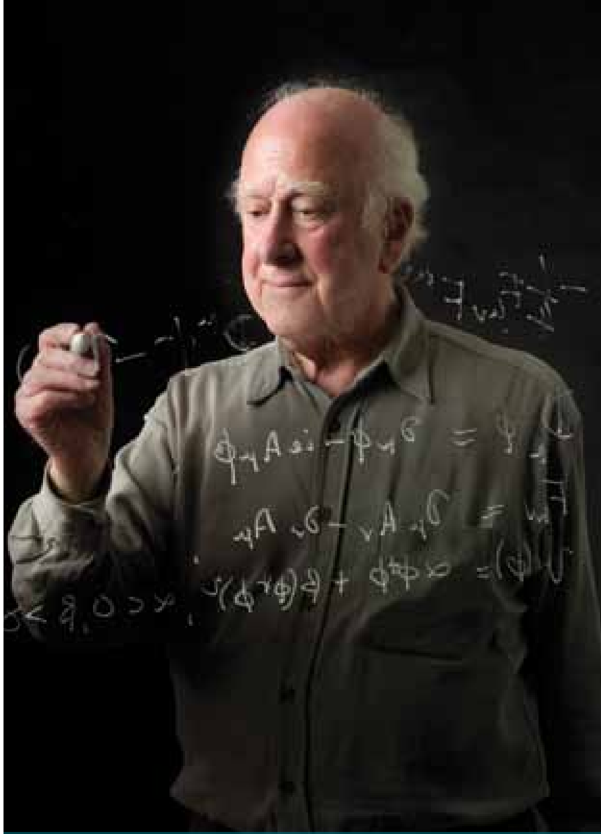
into the form

$$\partial_\mu B^\mu = 0, \quad \partial_\nu G^{\mu\nu} + e^2\varphi_0^2 B^\mu = 0. \quad (4)$$

Equation (4) describes vector waves whose quanta have (bare) mass $e\varphi_0$. In the absence of the gauge field coupling ($e = 0$) the situation is quite different: Equations (2a) and (2c) describe zero-mass scalar and vector bosons, respectively. In passing, we note that the right-hand side of (2c) is just the linear approximation to the conserved current: It is linear in the vector potential, gauge invariance being maintained by the presence of the gradient term.[5]

When one considers theoretical models in which spontaneous breakdown of symmetry under a semisimple group occurs, one encounters a variety of possible situations corresponding to the various distinct irreducible representations to which the scalar fields may belong; the gauge field always belongs to the adjoint representation.[6] The model of the most immediate interest is that in which the scalar fields form an octet under SU(3): Here one finds the possibility of two nonvanishing vacuum expectation values, which may be chosen to be the two $Y = 0$, $I_3 = 0$ members of the octet.[7] There are two massive scalar bosons with just these quantum numbers; the remaining six components of the scalar octet combine with the corresponding

s three pages publications of François Englert and Robert Brout (l.) as well as Peter Higgs.



Peter Higgs at his visit to CERN in 2008.

never be out of the game. Although some believe that the highest probability has a standard supersymmetry, which should eventually show itself. But there have been a lot of predictions like that in history. I just think of the theorists who predicted the existence of the top quark. In the 80s, they motivated us to do night shifts and long measurements at the DESY in Hamburg. If we would have known the extremely large mass this quark has, we would have gone home disappointed. The top quark was discovered at Fermilab in the US in 1995.

**The LHC is currently being upgraded. What expectations do you have for the new measurement phase from 2015 onwards?**

*Schaile:* We hope for signs of supersymmetry or higher dimensions. This would be as sensational as the discovery of the Higgs boson – and the fulfilment of what the LHC was actually built for: probing physics beyond the Standard Model.

*Bethke:* But I do not expect an early impact. For a great discovery, there should have already been a sign of something new on its way. It will take two or three more years until there is enough data to get significant information.

**You mentioned higher dimensions. Will we soon understand better, why the gravitational force does not fit the Standard Model and is much weaker than the other three fundamental forces of nature?**

*Bethke:* I am less hopeful. With our current capabilities, we will not be able to reach this range. We know that the Standard Model cannot be the mother of all things. What is missing, are new, brilliant theoretical ideas.

**And the Higgs boson?**

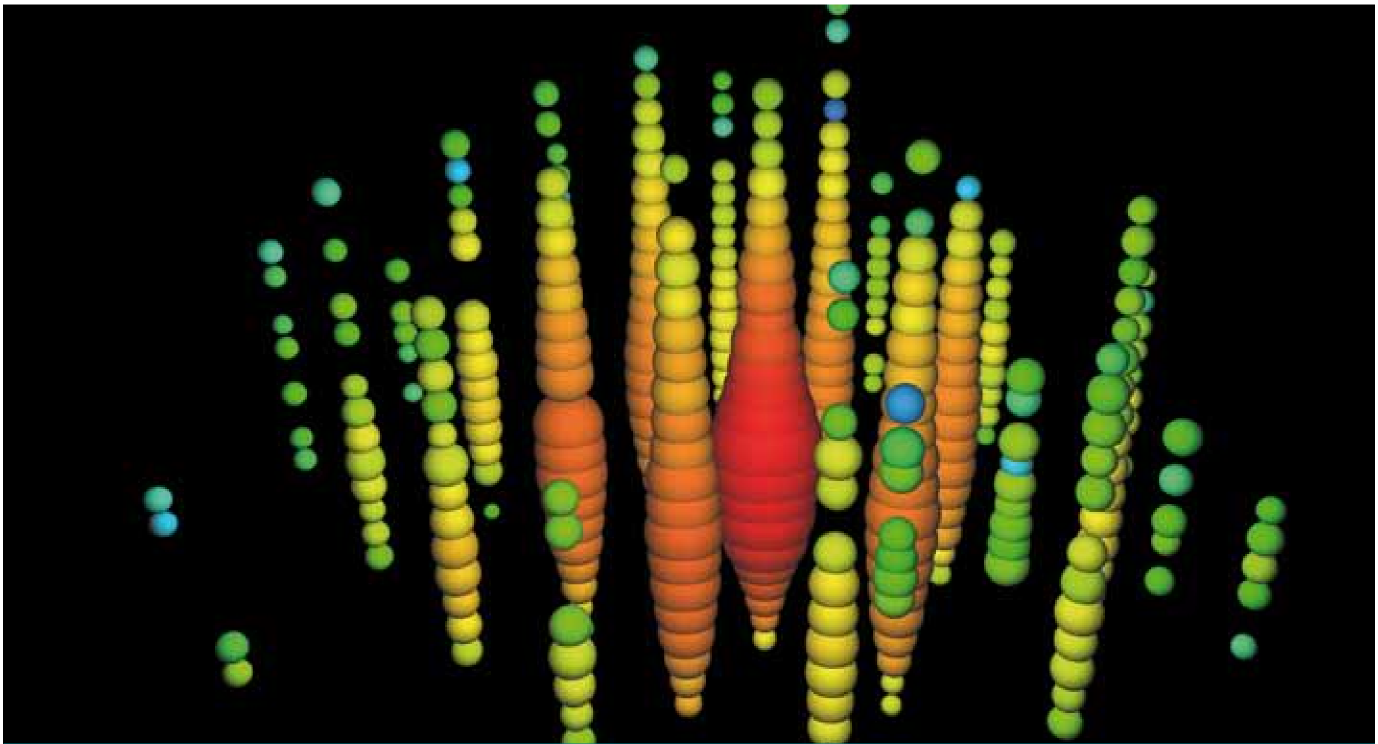
*Schaile:* We will know much more about its properties after the upgrade, because many more Higgs particles will be generated. I'm still fascinated that we were able to find the Higgs boson at all, as a manifestation of a fundamental mechanism of the universe that gives mass to elementary particles.

*Bethke:* The huge cluster of people at CERN and around the world works with an amazing professionalism. Accelerator and detectors are in excellent condition. The discovery of the Higgs boson could not necessarily have been expected at such an early stage. This success is a great incentive for all of us.


Prof. Dr. Dorothee Schaile is the Chair for Experimental Particle Physics at the Ludwig-Maximilians-Universität, Munich, and has decisively supported and promoted the ATLAS experiment from the beginning.


Prof. Dr. Siegfried Bethke is Director at the Max Planck Institute for Physics (MPP), an Honorary Professor at the Technische Universität München, Munich, and at the Max Planck Society responsible for the activities of the ATLAS experiment at CERN.

At the Excellence Cluster Universe, Prof. Schaile coordinates Research Area B „Symmetries of the early universe“; Prof. Bethke coordinates Research Area D „Phase transitions in the early universe“.



*Neutrino event with an energy of 1 PeV detected by the IceCube neutrino detector: There is a high probability that this neutrino stems from a supernova, a black hole or some other extreme phenomena*

South Pole observatory IceCube delivers first indications of neutrinos from cosmic accelerators

# Racing particles from space

**Nearly 25 years after the pioneering idea of detecting neutrinos with ice, there is first evidence of very high-energy neutrinos coming from outside our solar system. The IceCube experiment, a huge Neutrino detector frozen in the Antarctic ice, which is operated with the participation of the Technische Universität München, observed 28 neutrinos that are very likely to be ejected by cosmic objects such as supernovae, black holes, pulsars or other extreme extragalactic phenomena.**

*Prof. Dr. Elisa Resconi*

The Earth's atmosphere is constantly bombarded with different types of particles from the universe. Most of them, such as protons, electrons or helium nuclei have a certain mass and are electrically charged. If they collide with other particles or pass through the magnetic fields of the cosmos, the sun or the earth, they change their direction and their energy.

Unlike the uncharged and extremely light neutrinos: they rush through all matter almost undisturbed and reach the Earth practically unnoticed. In this way, billions of neutrinos pass through every square centimeter of the Earth every second. Most of them are produced in the Sun or the Earth's atmosphere by decay or transformation processes. But neutrinos are also generated on Earth: They are naturally produced in radioactive decays, as well as in man-made accelerator experiments and nuclear power plants.

Far rarer are neutrinos from the outer reaches of our galaxy or beyond, which have long been theorized by astrophysicists. Having its seeds in powerful cosmic objects such as supernovae, black holes, pulsars, active galactic nuclei and other extreme extragalactic phenomena, they should be extremely fast and thus have very high energies. Astrophysical neutrinos from such cosmic accelerators would therefore be messengers of violent and high-energy events in the universe. However, since neutrinos are very shy particles, such high-energy neutrinos have never been observed yet.

Now the scientists from the Antartic IceCube observatory report a first indication of neutrinos coming from outside our solar system. Between May 2010 and May 2012 they detected 28 very high-energy events that constitute the first solid evidence for astrophysical neutrinos from such cosmic accelerators like supernovae or black holes.

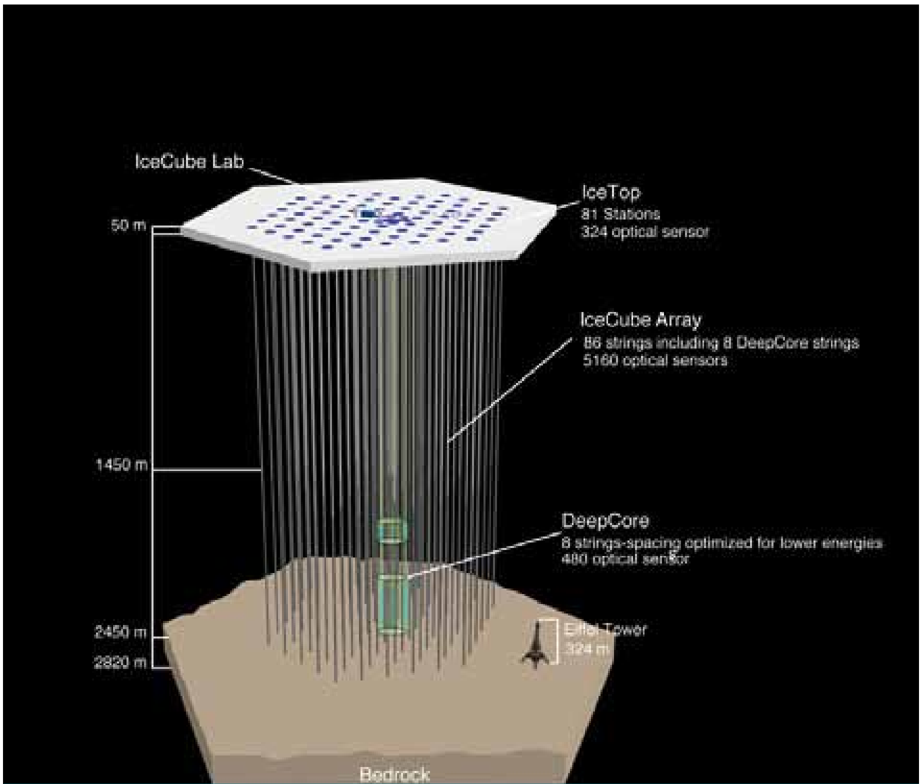
Last year, the IceCube scientists for the first time announced the detection of two neutrino events with more than 1 trillion electron volts (1 PeV, 1 PeV corresponds to 1000 TeV) – that is a thousand times more than ever achieved in a human-made accelerator experiment. "After hundreds of thousands of atmospheric neutrinos, these two events came as a complete surprise to all of us", says Prof. Dr. Elisa Resconi of the Technische Universität München, Munich, who is also a principal investigator at the Excellence Cluster Universe. Prof. Resconi is an expert in the field of high-energy neutrino research and member of the IceCube collaboration.

But that was only the beginning. Initially, the scientists had set a very high-energy threshold to reduce background from unwanted atmospheric neutrinos and other particles such as muons. Then, after the finding of the first two events, which were named 'Ernie' and 'Bert' by the IceCube scientists, the data from the entire measurement period since May 2010 was analyzed again with a slightly slower energy threshold. In this second round of investigation, the scientists could identify 26 more neutrino events with energies above 30 TeV.

*The IceCube laboratory at the Amundsen-Scott South Pole Station, in Antarctica, hosts the computers collecting raw data.*

"There is a very high likelihood that these neutrinos are coming from outside our solar system", says Prof. Resconi. Other origins or causes have been discarded by the scientists: "The events cannot be explained by other neutrino fluxes, such as those from atmospheric neutrinos, or by other high energy events, such as muons produced by the interaction of cosmic rays in the atmosphere."

The IceCube detector reconstructs the energy of the neutrinos by the Cherenkov light – tiny blue light flashes produced by the electrons or muons that result from an interaction of neutrinos with ice. To detect this light, 86 strings with a total of 5,160 digital optical modules are frozen into the South Pole ice at depths ranging from 1,450 to 2,450 meters. Events are recorded as a series of pulses in each sensor, where two basic neutrino event signatures are distinguished: a track-like pattern originating from neutrino-induced muons and a spherical light pattern produced by particle showers.




*The IceCube neutrino telescope is made up of 86 strings with a total of 5,160 digital optical modules that are used to sense and record neutrino events.*



The pioneering idea of detecting neutrinos in ice was born 25 years ago. IceCube was installed between 2004 and 2010 and is presently, with a size of one cubic kilometer, the largest neutrino observatory in the world. It is operated by an international collaboration led by the University of Wisconsin-Madison, USA, in which about 250 scientists and engineers, among others from the US, Germany, Switzerland and Japan are involved.

At this point, the IceCube scientists face the next challenge: "Now we need to clarify where 'Ernie' and 'Bert' and the 26 other high-energy neutrinos come from and how they were created. We are only at the very beginning of a new astronomy with neutrinos", says Prof. Resconi.

***IceCube collaboration/PR***

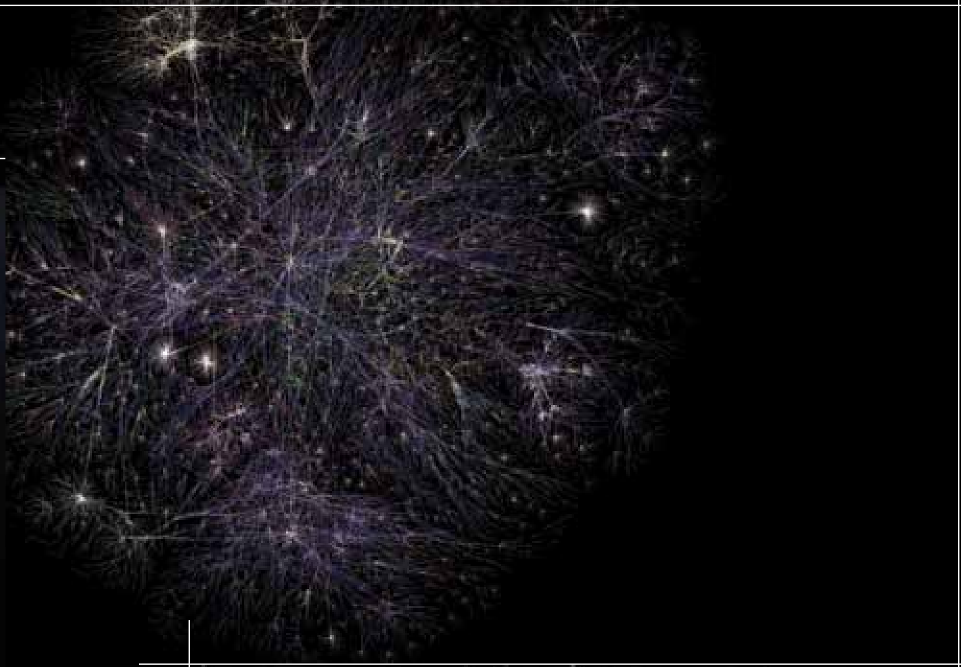
ArtScience on 9 October 2013
at Deutsches Museum

# Science or art?

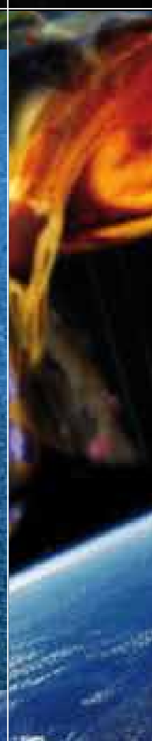
**The five pictures on these pages were composed by three scientists and two artists. Five works without any words: What do they represent? What is their meaning? Which picture is an image of reality, which one is pure imagination? Which picture is a piece of art and which one is created by a scientist?**

**At the ArtScience event on 9 October, these five images were displayed at the Deutsches Museum and the audience could have a first guess. The artists and scientists were present and explained their works subsequently. ArtScience, a joint event of the Excellence Cluster Universe and the Deutsches Museum, was organized by Prof. Dr. Elisa Resconi from the Technische Universität München, as part of the Munich IceCube meeting held in October 2013. On the next two pages you will find the answer to the question: Science or art?**

*@Wolfgang M. Heckl; Mark-David Hosale; P. Watson/J. Morris; http://opte.org; Pupa U.P.A. Gilbert and Christopher E. Killian*






ArtScience on 9 October 2013 at Deutsches Museum

# Science or art?



Prof. Dr. Wolfgang M. Heckl

“This sculpture is an artistic rendition of a recording with a scanning tunnelling microscope. It shows a layer of organic molecules arranged in a hexagon pattern because of the hydrogen bond, to be seen as yellow circles with the benzene rings in its cores. On this layer, nano-objects can blend in, in a periodic manner, shown here in the form of a buckminsterfullerene, a C-60 molecule, in the middle of this sculpture. The sculpture is magnified by a factor of one billion. In this way it enables visually impaired people to get a haptic impression of the nano-world by palpating the sculpture.” The physicist Prof. Dr. Wolfgang M. Heckl is Director General of the Deutsches Museum and helds the Oskar von Miller professorship of scientific communication at the Technische Universität München, Munich. In his spare time, Wolfgang M. Heckl is engaged as a painter, style: moleculism and nano-graffiti.


Dr. Christian Spiering

“I found the picture on the Internet and was fascinated by its filigree glitter network. Fireworks? Frost on a window, coloured by lights behind? A fay’s net from a children’s fairy tale? Or simply an abstract work of art? None of this, but at least as fantastic: The picture shows the global Internet traffic in 2006.”
Dr. Christian Spiering is a specialist in neutrino and astroparticle physics and worked for many years as a scientist at the Deutsches Elektronen-Synchrotron (DESY) in Zeuthen. Since 2000, Christian Spiering is engaged in the IceCube collaboration, whose spokesperson he was from 2005 to 2007.

*Protocols: Petra Riedel, Photos: Benjamin Eberhardt*

Prof. Dr. Francis Halzen

"In this picture, the biomineral crystals of a sea urchin tooth can be seen. Geological or synthetic mineral crystals usually have flat surfaces and sharp edges, while biomineral crystals can have strikingly unusual forms that have evolved to enhance function. The image was captured using scanning electron microscopy. Each colour highlights a continuous single-crystal of calcite, the colours are chosen so that one can clearly distinguish the different crystals. Together the crystals harden and sharpen the tooth so that it can even grind rock."
The theoretical physicist Prof. Dr. Francis Halzen is Hilldale and Gregory Breit professor at the University of Wisconsin-Madison, USA, studying topics related to the interface of particle physics, astrophysics and cosmology. Currently, he is the spokesperson of the IceCube collaboration.

Dr. Rachel Armstrong

"This picture entitled 'Flying City' depicts an ecology of systems and objects situated in Earth's orbit as a prototype 'synthetic world'. It is fashioned from space debris, fragments of asteroids and strategically transported materials brought into the system, where they are assembled to form an ecosystem of exchange. Consequently, this flying city is a dynamic space that responds to changes in its environment and grows and changes with time and according to the needs of its inhabitants. The fabric that constitutes this habitat can be thought of as a 'post-natural' fabric, an entanglement of technology, natural systems and human habitation with the potential to evolve."
Dr. Rachel Armstrong is Co-Director of AVATAR (Advanced Virtual and Technological Architectural Research) in Architecture & Synthetic Biology at The School of Architecture & Construction, University of Greenwich, London. Rachel Armstrong invents and designs sustainable solutions for our environment using advanced new technologies such as synthetic biology and smart chemistry. Her current project 'living architecture' investigates a new approach using building materials that give our buildings some of the properties of living systems.

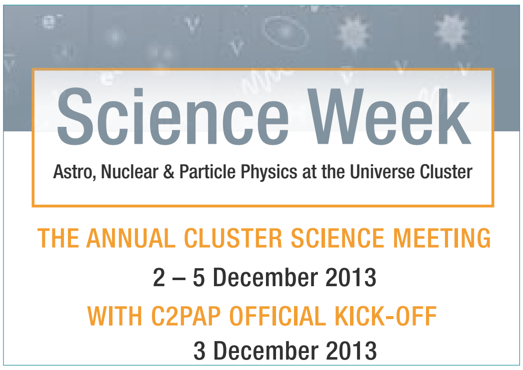
Dr. Mark-David Hosale

"The picture shows a close up of my architectural installation 'homunculus agora' with several dozen sculptural bodies, homunculi, which was displayed in September 2013 in a museum in Canada. Some of the homunculi are touch-sensitive and respond with emotional sound and light signals."
Dr. Mark-David Hosale is a media artist and composer. His works have been exhibited at international conferences, universities, and festivals. Currently, he holds a position as an assistant professor in Digital Media in the Fine Arts Faculty of York University, Toronto, Canada.

The Computational Center of the Excellence Cluster Universe

# The C2PAP team is complete

**In June of this year the computer cluster of the Computational Center for Particle and Astrophysics (C2PAP) started operation at the Leibniz-Rechenzentrum (LRZ). With astrophysicist and C2PAP archive scientist Dr. Marion Cadolle Bel, the fifth and last C2PAP member is now on board since October. The astrophysicist Dr. Margarita Petkova started in June, followed by the cluster administrator Dr. Aliaksei Krukau, who is located at the LRZ, and particle physicists Dr. Jovan Mitrevski and Dr. Frederik Beaujean. The C2PAP team supports the scientists of the Excellence Cluster to make the most of the possibilities offered by the cluster's dedicated Computational Center. An introduction.**




*Photos: Amane/TUM*

*The C2PAP coordinators: Prof. Dr. Joseph Mohr (l.) and Dr. Günter Duckeck*

| | | |
|---|---|---|
| **Name:** | Dr. Jovan Mitrevski | Dr. Frederik Beaujean |
| **Position/task:** | Particle event processing, data handling | Particle algorithms, statistics |
| **born in:** | Bitola, Macedonia | Hilden, Germany |
| **Graduated:** | 2007 (PhD), Columbia University | 2012 (PhD), Technische Universität München (TUM) |
| **PhD thesis:** | Measurement of Single Top Quark Production at D0 Using a Matrix Element Method | A Bayesian analysis of rare B decays with advanced Monte Carlo methods |
| **Natural Languages:** | Macedonian, English, French | German, English, Spanish, French, Romanian |
| **Programming languages:** | C++, Python, scheme, shell scripts, awk | C++, Python, Mathematica, Bash |
| **Computational expertise:** | computer architecture, ATLAS reconstruction software, large software projects | Monte Carlo methods, Bayesian statistics |
| **My favorite object in the Universe:** | Henry, my baby boy (14 months) | Planet Earth +/- 10° around the equator |
| **Problems I like to solve in my work:** | outline the plan for a physics analysis or a software project | computational problems: you program for weeks and then it runs on 1,000 cores - despite all the things that could go wrong |
| **If I am not a at my desk staring at the screen ...** | … I'm making sure that Henry doesn't get into any trouble | ... I'm out climbing, playing Tennis, snowboarding. |
| **If non-scientists ask, if I'd have liked to become an Astronaut, I answer …** | Not really, but I did consider going into astrophysics instead of particle physics. | No. As a little kid, I wanted to become an archeologist. |


*The C2PAP team members (from left):*
*Dr. Jovan Mitrevski, Dr. Frederik Beaujean, Dr. Margarita Petkova, Dr. Aliaksei Krukau, Dr. Marion Cadolle Bel*

Dr. Margarita Petkova

Astro algorithms, hydro codes

Sofia, Bulgaria

2011 (PhD), MPI for Astrophysics

Numerical radiative transfer and the Hydrogen reionization of the universe

Bulgarian, English, German

C, C++, Fortran, Basic

code parallelization, high performance computing, algorithm development

The Big Bang, if it can be considered an object. Amazing that it all started! there!

analyzing code for bugs or "issues" and eliminating them

... I am either cooking at home or jumping around somewhere

Yes! As I child I imagined that the big tree outside our apartment building had a space rocket inside.

Dr. Aliaksei Krukau

Chief admin C2PAP cluster at LRZ

Minsk, Belarus

2007 (PhD), MPI for Molecular Physiology and TU Dortmund

Molecular dynamic simulations of a small elastin-like peptide

Russian, Belorussian, English, German

Fortran, OriginC, bash, Python

molecular dynamics, Monte Carlo methods, large data sets analysis

Orion constellation

develop new methods for data analysis, storage and visualization

… I am reading, playing volleyball and chess, developing small educational apps

No.

Dr. Marion Cadolle Bel

Astro archiving, data handling

Saint-Germain-En-Laye, France

2006 (PhD), Universite of Paris VII & Observatoire de Paris/Meudon

The high-energy emission coming from stellar mass black holes

French, English, Spanish

Perl, Python, scripting, Java, IDL, SQL, C++

modeling, simulation, analysis software of several space missions, databases

Cygnus X-1, a black hole discovered by direct mass measurements

Learning how to collaborate with many scientists from different cultures and countries.

... I'm kite-surfing (summer) or skiing (winter) or dancing (all year)!

Yes sure! But I could have also hunted tornados (it looks as if I transferred the hunting passion to black holes)!

Universe PhD Awards 2013

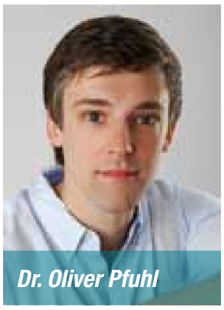
# Outstanding theses

**Dr. Martin Winkler and Dr. Oliver Pfuhl are presented with this year's Universe PhD Award for the best doctoral theses at the Excellence Cluster Universe in 2012/13. Martin Winkler graduated with a paper on dark matter at the Technische Universität München. Oliver Pfuhl developed in his doctoral thesis at the Max Planck Institute for Extraterrestrial Physics innovative components for the GRAVITY interferometer. The two young researchers will receive the Universe PhD Award endowed with 2,000 Euros during the Excellence Cluster Universe's Science Week 2013.**

**Laudatio for Dr. Oliver Pfuhl's dissertation by the selection committee (shortened version):**

"Astronomical observations with extremely high spatial resolution provide one of the scientifically most promising directions of present and future astrophysical research. The potential for new scientific detections in this arena with present day telescopes of the 8 meter class is already enormous but it will gain tremendously in the future with the advent of the next telescopes of the 30 meter class.

The dissertation by Dr. Oliver Pfuhl 'The GRAVITY interferometer and the Milky Way's nuclear star cluster' is a milestone in this new field of research. In its first part, Pfuhl develops two key-components for one of the most ambitious experiments in modern ground-based astronomy, the GRAVITY interferometer at the European Southern Observatory's (ESO) Very Large Telescope (VLT). GRAVITY will probe the physics of General Relativity by directly resolving the orbital motions of stars close to the event horizon of the central super massive black hole in our Milky Way. It will measure astrometric positions with a precision of micro arc seconds. The key components developed by Dr. Pfuhl are the fiber coupler and the guiding system. The fiber coupler provides all the functions necessary for the high precision control of the optical path; the guiding system provides the active compensation of tilt- and pupil errors along the 100 meter optical path.


*Dr. Oliver Pfuhl*

The second part of the thesis uses the SINFONI integral field spectrometer at the ESO VLT to investigate the star formation history of the star cluster around the central black hole in the Milky Way.

The analysis of more than 500 stars reveals that more than 80 percent of the stellar mass close to the black hole must have formed already more than five billion years ago. The spectacular conclusion in agreement with other observations is that the cluster must have formed at times when the mass of the black hole, and therefore its influence on surrounding star formation, was still small.

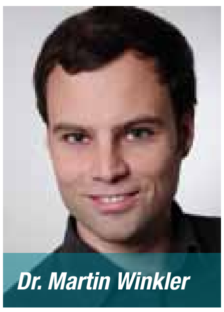
The dissertation by Dr. Oliver Pfuhl is an important advancement of astronomical science. The Excellence Cluster Universe recognizes this accomplishment by the PhD Award 2013."

**Laudatio for Dr. Martin Winkler's dissertation by the selection committee (shortened version):**

"Dark matter is the most challenging and the most exciting problem when it comes to the properties of matter nowadays. From the rotation curves of galaxies and the velocity distribution in clusters of galaxies we know that there must be a dark matter. There are experiments in search for it, but its nature is unknown. Since the understanding of dark matter surely requires an extension of the Standard Model, there are different ideas on where to look for it – unlike the other great mystery of the universe, the dark energy.

Given this situation, it is important to assess all aspects of the problem as well as possible solutions. The achievement of Martin Winkler is to elaborately, critically and concisely examine the problem in his dissertation 'Light dark matter in theory and experiment' in a very interesting way.

First, the paper discusses the evidence for dark matter particles from direct search experiments, of which some of them have seen possible signals (such as DAMA and CRESST), which refer to particles with masses of about 10 GeV, and some not (such as XENON). Furthermore, Winkler analyzes the experiments for the indirect search of dark matter via its possible decay products, such as neutrinos from gravitationally captured dark matter in the sun or antiprotons in cosmic rays produced in the halo of the galaxy. He comes to the conclusion that no evidence for dark matter can be drawn from the indirect search experiments, but a strict limit on the cross section of dark matter with ordinary matter may be derived.


*Dr. Martin Winkler*

Models for dark matter are also discussed in supersymmetric extensions of the Standard Model. Winkler, together with his supervisor Prof. Dr. Michael Ratz (TUM), proposes an original approach with an additional scalar field and a „Singlino" which fits within the observed limits. Additionally, he discusses ways to test the model.

The thesis of Martin Winkler is an excellently written, original and important contribution to this very current and exciting question. Therefore, Dr. Martin Winkler is awarded the Universe PhD Award 2013 for the best theoretical thesis."

ERC-Grants & new Fellows

# Personalia

Prof. Dr. Georgi Dvali, MPP and LMU as well as principal investigator of the Excellence Cluster Universe, was awarded the Advanced Investigator Grant from the European Research Council (ERC ), endowed with 1.2 million Euros, together with Prof. Cesar Gomez, Madrid. Dvali was honoured for his outstanding fundamental research on the structure of space and time and the nature of gravity. The grant will provide him with the freedom to pursue new innovative research projects.

PD Dr. Hans-Thomas Janka, scientist at the Max Planck Institute for Astrophysics and principal investigator of the Excellence Cluster Universe, received an ERC Advanced Grant for his project on the modelling of stellar collapse and explosions. The funding is awarded to independent and autonomous top researchers on the basis of academic excellence and will finance the work of Janka's research group for the years ahead.

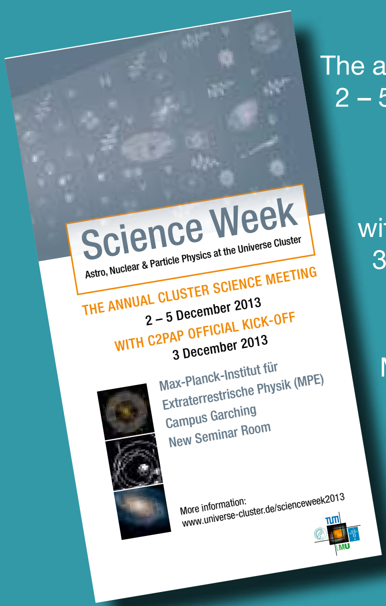
Dr. Patrick Vaudrevange is Fellow at the Excellence Cluster Universe since 1 October. After completing his PhD at the University of Bonn in 2008, he was first a Research Fellow in the group of Prof. Dr. Dieter Lüst at the LMU before he became a member of the theory group at the Deutsches Elektronen-Synchrotron (DESY), Hamburg. His interests lie in theoretical particle physics and string theory.

Since 1 November, Dr. Claudia Hagedorn is Fellow at the Excellence Cluster Universe. After receiving her PhD in 2008 at the TUM and the Max Planck Institute for Nuclear Physics in Heidelberg, she held several postdoc positions in Germany and Italy, most recently she was a Fellow at the Istituto Nazionale Fisica Nucleare, Section of Padua, Italy. The focus of her work is on theoretical particle physics.



## *Science Week 2013*

Astro-, Nuclear and Particle Physics at the Universe Cluster




The annual cluster science meeting
2 – 5 December 2013

with C2PAP official kick-off
3 December 2013, 9 a.m.

Max Planck Institute for
Extraterrestrial Physics (MPE),
new seminar room,
Giessenbachstr., Garching


## IMPRINT

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Scientific & Public Events

# Preview

**Within the next couple of months, the Excellence Cluster Universe will organize numerous scientific and public events. The conferences and workshops highlighted in blue are primarily addressing experts. All other events are aimed at the interested public.**

| | | |
|---|---|---|
| 02.12.2013, 14:15 | Seminar: "In medium modification of kaons in cold nuclear matter" | TUM Physics Department, James-Franck-Str. 1, Garching |
| 03.12.2013, 19:00 | Cafe & Kosmos: "Die Dunkle Energie - immer noch rätselhaft" with Prof. Dr. Gerhard Börner, MPA | Vereinsheim, Occamstr. 8, Munich |
| 02. - 05.12.2013 | Excellence Cluster Universe's Science Week 2013 www.universe-cluster.de/scienceweek2013 | MPI for Extraterrestrial Physics, Giessenbachstr., Garching |
| 11.12.2013, 16:30 | Universe Colloquium followed by wine & cheese Paola Popesso, TUM: "The $SF^2$ project: Linking the structure formation process to the evolution of the galaxy star formation activity" | Excellence Cluster Universe, Boltzmannstr. 2 (seminar room, basement), Garching |
| 12.12.2013, 12:30 - 13:00 | Fruits of the Universe A lunch talk with food for body and mind | Excellence Cluster Universe, Boltzmannstr. 2 (foyer, 1st floor), Garching |
| 18.12.2013, 16:30 | Universe Colloquium followed by wine & cheese Peter Ludwig, TUM: "Search for supernova debris in Earth's microfossil record" | Excellence Cluster Universe, Boltzmannstr. 2 (seminar room, basement), Garching |
| 13. - 17.01.2014 | Teacher training: Astronomie, Kosmologie & Relativität in cooperation with Lehrerakademie Dillingen and Kerschensteiner Kolleg http://fortbildung.schule.bayern.de | Kerschensteiner Kolleg, Deutsches Museum |
| 14.01.2014, 19:00 | Cafe & Kosmos for further events see www.cafe-und-kosmos.de | Vereinsheim, Occamstr. 8, Munich |
| 29.01.2014, 19:00 | Wissenschaft für jedermann Prof. Dr. Andrzej Buras/Prof. Dr. Stephan Paul, TUM: "Die Unterwelt der Elementarteilchen: Von den kleinsten Längenskalen des Universums und ihrer Bedeutung für unsere Existenz" | Deutsches Museum, Hall of Fame |
| 05.02.2014, 16:30 | Universe Colloquium followed by wine & cheese Esa Vilenius, MPE: "TNOs are cool - a Herschel survey of the trans-Neptunian region" | Excellence Cluster Universe, Boltzmannstr. 2 (seminar room, basement), Garching |
| 05.02.2014, 19:00 | Wissenschaft für jedermann Dr. Nadine Neumayer, ESO: "Giganten der Schwerkraft: Schwarze Löcher in den Zentren unserer Galaxien" | Deutsches Museum, Hall of Fame |
| 10. - 11.02.2014 | Interdisciplinary cluster workshop: Dark matter www.universe-cluster.de/darkmatter2014 | MPI for Extraterrestrial Physics, Giessenbachstr., Garching |
| 17. - 18.02.2014 | Interdisciplinary cluster workshop: Statistics www.universe-cluster.de/statistics2014 | MPI for Extraterrestrial Physics, Giessenbachstr., Garching |