

Dear Readers,

the second round of funding for the Excellence Cluster Universe is taking shape: Four new junior research group leaders will bring exciting new research topics to the Cluster by the end of the year. The hardware for the Cluster's own Computational Center for Particle and Astrophysics (C2PAP) has been delivered and is currently installed at the Leibniz-Rechenzentrum. At the beginning of June it will start operation with first simulations. The new science center Munich Institute for Astro- and Particle Physics (MIAPP) has opened registration for the first four workshops in 2014. For four weeks, scientists from around the world will have the opportunity to interchange with the local researchers and develop new ideas. Therefore we can expect fascinating new insights into the Big Bang and the universe in the second round - some projects are presented in this newsletter.

Petra Riedel  
PR Manager

## PICTURE OF THE MONTH

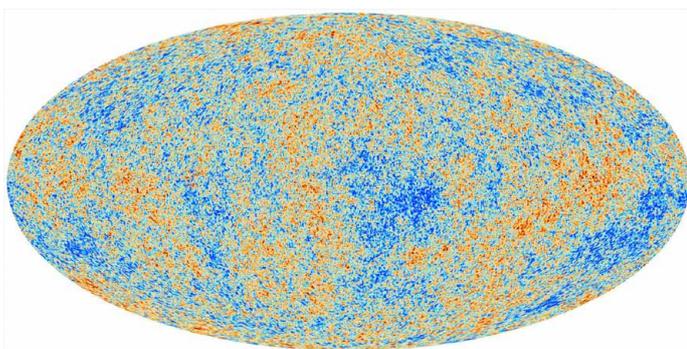


Great progress in the east hall of the FRM II: The magnetic shielding for the experiment for the measurement of the electric dipole moment of the neutron (EDM) is completed. For this high-precision experiment the research group of Prof. Dr. Peter Fierlinger will receive another 3.45 million euros by the Deutsche Forschungsgemeinschaft (DFG).

## HIGHLIGHT

### Planck data of the Universe: „The standard model is an almost perfect fit“

On 21 March 2013, the European Space Agency released the data of the satellite mission “Planck”. The space mission was launched in 2009 in order to map the cosmic background radiation over the entire sky. As astronomers now know, the cosmic background radiation was emitted some 380,000 years after the Big Bang from the then finely dispersed cosmic matter. For cosmologists the sky map with the radiation pattern of the cosmic microwave background is a “baby photo” of the 13.8 billion years old universe. With elaborate analyses scientists can learn more from the pattern. An interview with Dr. Torsten Enßlin from Max Planck Institute for Astrophysics (MPA), head of the German Planck group:



The new map of the cosmic microwave background as observed by the Planck satellite: The tiny temperature fluctuations correspond to regions of slightly different densities, representing the seeds of all future structure.

#### What surprised you most in the analysis of the Planck data?

That it confirms the standard model of cosmology so well: six parameters yield quite an accurate description of the essential characteristics of the universe. The universe as a whole appears to be homogeneous and uniform in all directions, and the structures we observe can be interpreted as the consequence of tiny fluctuations in density that occurred immediately after the Big Bang.

#### Is there no evidence, then, for other cosmological models?

Correct. The temperature fluctuations follow Gaussian statistics with high accuracy. This excludes models that predict strong non-Gaussianity, such as that of cyclic universes. But we found no indications that the Big Bang could have been the result of for instance a collision between two universes, as some theoreticians believe.

#### But there are a few things that don't fit into the perfect picture.

Yes, there seems to be a slight deficit of large structures in the universe, and this would not be expected according to the standard model. Observations on small and intermediate angle scales agree very well with the predictions, but the fluctuations on large angle scales are weaker than they should be. The other two peculiarities are things that we had already seen with the predecessor mission WMAP: The southern hemisphere has more pronounced structures than the northern hemisphere; and there is a “cold spot” on the southern sky with an unexpectedly low temperature.

### Could this be because of statistical effects in the measurements?

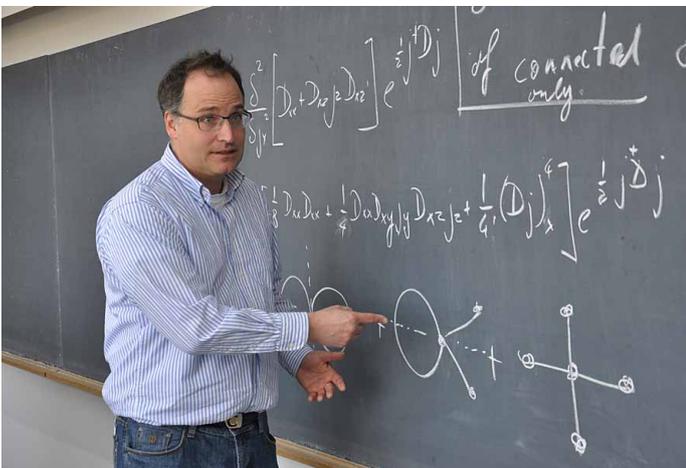
No. We see genuine effects in the sky for which we currently have no conclusive explanation. But even our standard model is statistical in nature; it only predicts the probability distribution of temperature structures in the microwave sky. We are, however, only observing a single realization of the structure of cosmic background radiation, in which aspects can deviate strongly from the statistical mean. So we ask ourselves: "If our best-fit standard model was right, how probable is it that we would see what we are now observing?"

### How can you find the answer to that?

Planck has also recorded the directions of oscillation of the microwave radiation, but the data are not analyzed yet. These so-called polarization data from Planck gives us a second chance for an objective look at the early universe. However, both temperature fluctuations and polarization have their origin in the gravitational potential of the early universe, and we can calculate the correlations between them. In this way, we can generate objective data to verify the observations. If one of the peculiarities is then confirmed, we can assume that they are cosmic in origin.

### What would that mean?

Well, if it were confirmed, for example, that large structures are slightly less pronounced, we could assume that the cosmos is more complicated on the largest observable scales than we had thought. In that case, we will need new physical explanations.



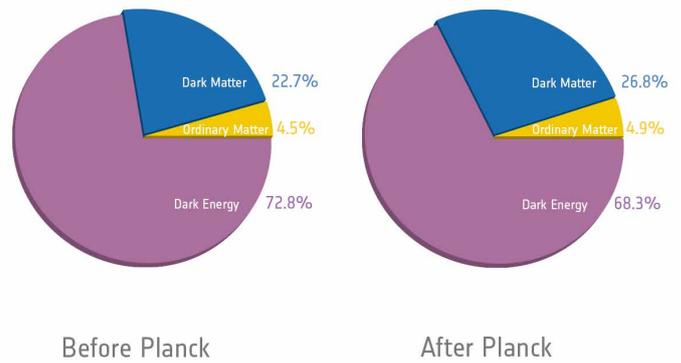
Dr. Torsten Enßlin from the Max Planck Institute for Astrophysics.

### To supplement the standard model?

Oh yes. Of course, there is already a whole range of candidates. But first we should see how far we get with the simplest model.

### The Planck data led to reframing of the Hubble constant, as well as other cosmological parameters. But the Planck value is significantly lower than other calculations. How do you explain this?

Within the error bars, there really is no overlap between the Hubble constant from the Planck data and that derived from supernova observations. There must be a systemic error somewhere - but where? The Planck value is based on a purely trigonometrical measurement of the temperature fluctuations. Supernovae,

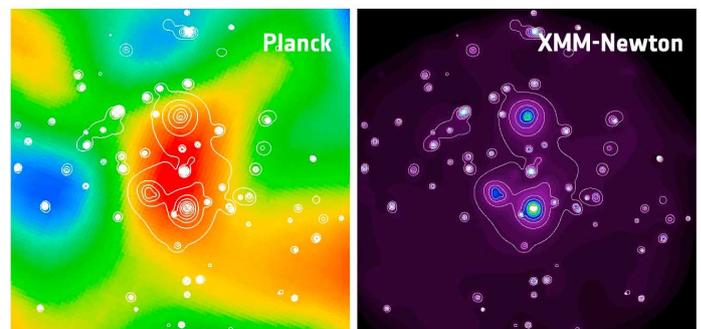


*Planck cosmic recipe: Planck's high-precision cosmic microwave background map has allowed scientists to extract the most refined values yet of the universe's ingredients ( $\Omega$ ). Normal matter that makes up stars and galaxies contributes just 4.9 % of the inventory. Dark matter, which is detected indirectly by its gravitational influence on nearby matter, occupies 26.8 %, while dark energy, a mysterious force thought to be responsible for accelerating the expansion of the universe, accounts for 68.3 %. The 'before Planck' figure is based on the predecessor mission WMAP by NASA (l.).*

on the other hand, are highly complex objects. I could imagine that certain simplifications might have implicitly entered there, despite careful calibration. For this reason, I tend to trust the Planck data more.

### Planck has measured the cosmos with unprecedented accuracy, even discovering new galaxy clusters, among other things. How does this work?

When the photons of cosmic background radiation pass a galaxy cluster on their way towards us, they can get a small energy boost from the electrons in the ionized part of the hot intergalactic medium. This Sunyaev-Zeldovich effect, as it is known, works as a characteristic signature of galaxy clusters in the cosmic background radiation. Identifying 1,227 otherwise unobservable galaxy clusters, Planck has generated the most extensive Sunyaev-Zeldovich catalog to date. A good half of them were already known, another 178 have been confirmed, and the remaining 366 are cluster candidates, yet to be verified. Planck has delivered so much new data that it will take many years to analyze it all. The polarization analyses will be released in 2014.

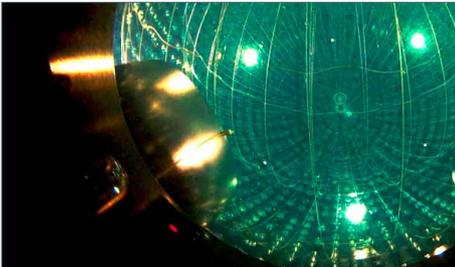


*Newly detected galaxy supercluster: This image shows one of the newly discovered superclusters of galaxies, detected by Planck (l.) and confirmed by XMM-Newton (r.). This is the first supercluster to be discovered through its Sunyaev-Zeldovich effect. The X-ray image reveals three galaxy clusters comprise this supercluster which is indicated as bright orange blob in the SZ-image. The X-ray contours are also superimposed on the Planck image.*

## ■ CLUSTER RESEARCH

### Scientists assess the radioactive signal of the Earth's mantle

**From a long-term measurement of geo-neutrinos at the neutrino detector Borexino, scientists have assessed the radioactive signal of the long-lived elements uranium and thorium in the Earth's mantle. The result contributes to a better understanding of the terrestrial heat.**



*Borexino: Inside view of the detector.*

Neutrinos are uncharged, weakly interacting elementary particles that carry a tiny mass. Within the Earth, they are produced in beta decays of long-lived radioactive elements, especially of thorium and uranium. They almost unattenuated pass through all layers of the Earth.

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To detect solar and geo-neutrinos, international scientists with extensive support from researchers from the Technische Universität München (TUM) have developed the instrument Borexino in the Italian Gran Sasso underground laboratory. During the data collection between December 2007 and August 2012, 14 geo-neutrinos have been identified. Taking into consideration the local geology and the models of the Earth's crust, the researchers were able to extract the radioactivity of uranium and thorium and their contribution to terrestrial heat.

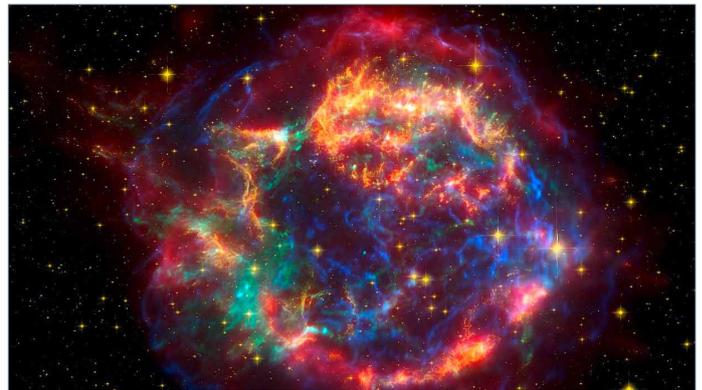
“For the first time, with Borexino in Italy and KamLAND in Japan two independent geo-neutrino detectors placed in different sites around the planet give the same constraints on radiogenic heat power of the Earth due to the decays of uranium and thorium, says Prof. Dr. Stefan Schönert from the TUM and Principal Investigator at Excellence Cluster Universe. “The new results from Borexino mark a breakthrough for the Earth Sciences and in particular for the comprehension of the origin and thermal evolution of the Earth.”

### First hints of supernova iron in bacteria microfossils

**In fossil remnants of iron-loving bacteria, researchers of the Excellence Cluster Universe at the Technische Universität München (TUM), found a radioactive iron isotope that they trace back to a supernova in our cosmic neighborhood. This is the first proven biological signature of a starburst on our Earth. The age determination of the deep-drill core from the Pacific Ocean showed that the supernova must have occurred about 2.2 million years ago.**

Most of the chemical elements have their origin in core collapse supernovae. When a star ends its life in a gigantic starburst, it throws most of its mass into space. The radioactive iron isotope Fe-60 is produced almost exclusively in such supernovae. Because its half-life of 2.62 million years is short compared to the age of our Solar System, no supernova iron should be present on Earth. Therefore, any discovery of Fe-60 on Earth would indicate a supernova in our cosmic neighborhood. In the year 2004 scientists at TUM discovered Fe-60 on Earth for the first time in a ferromanganese crust obtained from the floor of the equatorial Pacific Ocean. Its geological dating puts the event around 2.2 million years ago.

So-called magnetotactic bacteria live within the sediments of the Earth's oceans, close to the water-sediment interface. They make within their cells hundreds of tiny crystals of magnetite ( $\text{Fe}_3\text{O}_4$ ), each approximately 80 nanometers in diameter. The magnetotactic bacteria obtain the iron from atmospheric dust that enters the ocean. TUM nuclear astrophysicist Prof. Dr. Shawn Bishop conjectured, therefore, that Fe-60 should also reside within those magnetite crystals produced by magnetotactic bacteria extant at the time of the supernova interaction with our planet. These bacterially produced crystals, when found in sediments long after their host bacteria have died, are called “magnetofossils.”



*Cassiopeia A: Remnants of a supernova in the constellation Cassiopeia.*

Shawn Bishop and his colleagues analyzed parts of a Pacific Ocean sediment core obtained from the Ocean Drilling Program, dating between about 1.7 million and 3.3 million years ago. They took sediment samples corresponding to intervals of about 100,000 years and treated them chemically to selectively dissolve the magnetofossils – thereby extracting any Fe-60 they might contain.

Finally, using the ultra sensitive accelerator mass spectrometry system at the Maier-Leibnitz Laboratory in Garching, Munich, they found a tantalizing hint of Fe-60 atoms occurring around 2.2 million years ago, which matches the expected time from the ferromanganese study. “It seems reasonable to suppose that the apparent signal of Fe-60 could be remains of magnetite chains formed by bacteria on the sea floor as a starburst showered on them from the atmosphere”, Shawn Bishop says. He and his team are now preparing to analyze a second sediment drill core, containing upwards of 10 times the amount of material as the first drill core, to see if it also holds the Fe-60 signal and, if it does, to map out the shape of the signal as a function of time.



## New Science Center for Astro- and Particle Physics

In Fall 2012, the official starting signal sounded for the „Munich Institute for Astro- and Particle Physics“ (MIAPP). The institute is part of the Excellence Cluster Universe and beginning in 2014 will host four to six workshops per year on the most current and exciting topics from astrophysics, cosmology, nuclear- and particle physics.

The preparations are progressing at full speed: the future MIAPP building is being renovated, a poster has been distributed announcing the launch of MIAPP and the workshops are under preparation. The program will start at the end of May 2014 with four topics: the extragalactic distance scale, the role of neutrinos in astro- and particle physics, the challenges, innovations and developments in precision calculations for the Large Hadron Collider (LHC), as well as cosmology with the Planck Satellite. From 2015 on, there will be six workshops per year. Every fall, an international committee will select the topics from the proposal submitted by scientists from around the world.

### “We need a perfect start”

MIAPP is led by Professor Dr. Martin Beneke, head of the chair for theoretical particle physics at the Technische Universität München (TUM) and by Professor Dr. Rolf Kudritzki from the Institute for Astronomy at the University of Hawaii and the Ludwig-Maximilians-Universität München (LMU). Whereas Martin Beneke is on site, Rolf Kudritzki spends half of the year in Hawaii. Nevertheless, they still find the time to meet every week via videoconference. “The preparation phase is now very labor intense. In order to make MIAPP a success in the long run, we need a perfect start”, the two directors explain. After all, MIAPP should become a pillar for the Excellence Cluster Universe.

Examples for initiatives comparable with MIAPP are renowned institutes like the Aspen Center in Colorado and the „Kavli Institute for Theoretical Physics“ in Santa Barbara. The scientific environment of Munich and Garching with its local universities, the Max Planck Institutes and the European Southern Observatory (ESO) qualifies MIAPP as an unique place for scientific exchange and co-operation in astrophysics und particle physics.



MIAPP director Prof Rolf Kudritzki, University of Hawaii/LMU.



MIAPP director Prof Martin Beneke (TUM) presenting the model of the planned MIAPP building.

Each workshop will last for four weeks and will be organized by approximately four coordinators. One or two of them will come from the local science community to guarantee networking with Munich-based scientists. The coordinators will be supported by the MIAPP administration, which will take care of all non-scientific issues.

### Workshops and discussions

Up to 45 people can participate in the workshops. Roughly two thirds of the places will be reserved for international participants, the remaining made available for local scientists. Registration takes place on the MIAPP website and is now open for the 2014 workshop series. The coordinators will eventually provide the final list of participants. The main focus of each workshop lies on informal discussions and interactions between the participating scientists. Furthermore, there will be one or two talks per day with the possibility of a topical conference at the end of the program.

MIAPP will be located in a building at the IPP site, across the Universe Cluster. Each participant will receive a designated office and there will be in addition lounge areas to facilitate informal discussions. Since MIAPP will continue after the end of the Excellence Initiative 2017, a new building on the Research Campus has been planned. “There has never been an institute like MIAPP in Germany before. The feedback we have received so far is already overwhelming. We hope that MIAPP will become a center where new ideas for our research field are born”, Martin Beneke and Rolf Kudritzki explain.

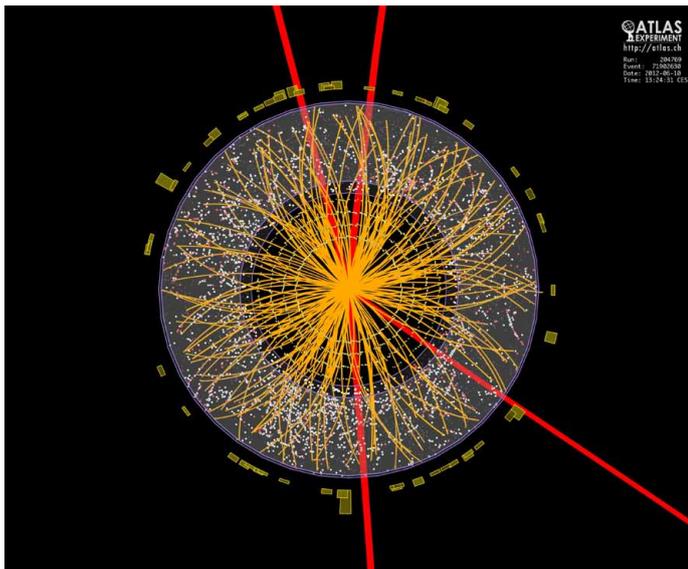
For more information on MIAPP, please see [www.munich-iapp.de](http://www.munich-iapp.de).

## ■ C2PAP

### The Excellence Cluster finds the Computational Center for Particle and Astrophysics

As part of its second round of funding, the Excellence Cluster Universe will establish the Computational Center for Particle and Astrophysics (C2PAP). It will provide the required computing and development capacities for particle and astrophysics. The hardware has been delivered and is currently installed at the Leibniz-Rechenzentrum. At the beginning of June it will start operation with first simulations.

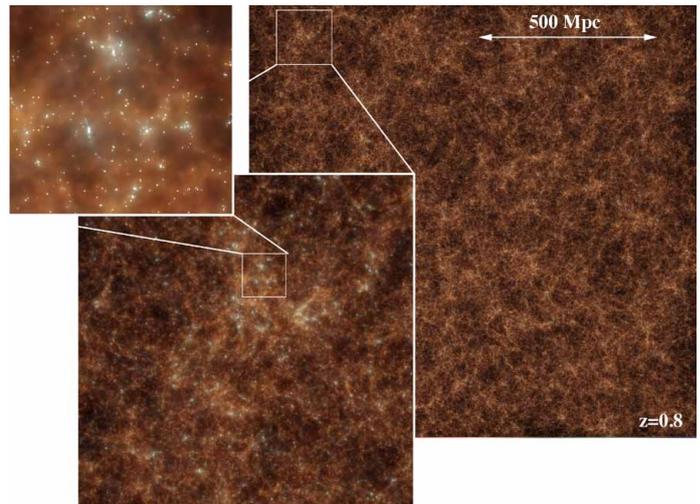
Scientists of the Excellence Cluster Universe have contributed to the development of a wide range of new important research instruments, which have made and promise to achieve more major breakthroughs in scientific research. For example, the Large Hadron Collider (LHC) at CERN offers the unique opportunity to study the fundamental constituents of matter and their interactions with unrivalled energies. At the ATLAS experiment, about a billion proton-proton collisions per second are generated in search for the Higgs boson and signs of supersymmetry. However, while the data analysis of the accelerator experiments is well organized within the "ATLAS Grid" global computer network,



Detection of a Higgs candidate on 10 Juni 2012 at the ATLAS detector at CERN. The masses of the lepton pairs correspond to 86,3 GeV and 31,6 GeV.

there is a growing need for computer capacity to run simulations. "Scientists want to find out which theoretical models can be used to reproduce the particle reactions found in the experiments," says Dr. Günter Duckeck from the Faculty of Physics of the Ludwig-Maximilians-Universität (LMU) and scientist at the Excellence Cluster Universe. To perform such complex simulations, extensive computing resources are required.

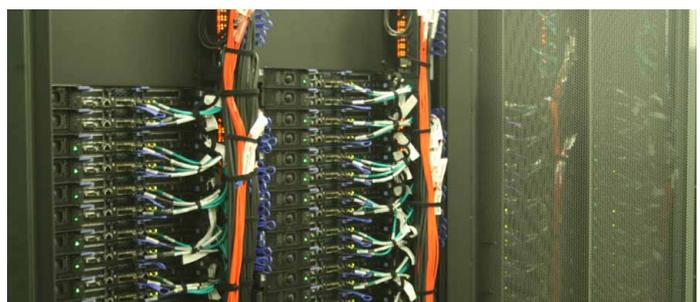
Likewise in astrophysics: A number of current or planned major projects, such as the Dark Energy Survey (DES), the South Pole Telescope (SPT), the Planck mission, eRosita, Euclid or LO-FAR will study the universe with an unprecedented accuracy. "In order to interpret these astronomical observations, theoretical predictions in the form of very complex hydrodynamic simulations based on cosmological models become more important,"



Cosmological, hydrodynamical simulation of a very large region of space at a redshift of  $z = 0.8$  (when the universe had half the age of today). The hot plasma filling the space between the galaxies and between the galaxy clusters is visualized in colours ranging from brown to light brown. The white dots represent the stars, which form galaxies within this simulation. The inlays show a sequence of zooms onto a super cluster structure formed in the simulation.

says Dr. Klaus Dolag, from the Universitäts-Sternwarte München within the Faculty of Physics at the LMU and scientist at the Excellence Cluster Universe. Until now, the astrophysicist and his colleagues have developed their own simulation programs and adapted them to the current supercomputers. However, for larger and more complex simulations on increasingly complex supercomputers, it is no longer that simple.

To provide the required computing and development capacities for particle and astrophysics, the Excellence Cluster Universe founded the Cluster's own Computational Center for Particle and Astrophysics (C2PAP). C2PAP consists of a dedicated computing cluster and staff to help with the development of new algorithms and the deployment of existing and new codes onto the dedicated cluster as well as other supercomputers. The dedicated cluster will be housed at the Leibniz-Rechenzentrum (LRZ) in Garching, Munich, close to the high-performance computer SuperMUC - and it will support the astro- as well as the particle physicists of the eight Cluster partner institutions in the rapid and efficient generation of new scientific knowledge.



A glimpse of the recently delivered Cluster's own C2PAP hardware located at the Leibniz-Rechenzentrum in Garching, Munich.



Prof. Dr. Joseph Mohr

The C2PAP dedicated cluster has over 2,000 cores with a computing power of about 2 % of the SuperMUC. Prof. Dr. Joseph Mohr, astrophysicist from the Faculty of Physics at the LMU, and Dr. Günter Duckeck will coordinate these efforts. Excellence Cluster scientists will be supported by five experts in the field of high performance computing.

These C2PAP staff members will be at the Excellence Cluster and also at LRZ. One of their main tasks will be to work on current development trends: Since the capacity of individual cores can hardly be improved

anymore, progress is being made primarily by placing more and more cores within one computing system. To fully exploit the computing power, the algorithms must be prepared so that as many computing processes as possible can run simultaneously. At the moment, this is not a problem. "But there are limits," says Dr. Günter Duckeck, "on a deeper level the processes can no longer be parallelized so easily."

However, as an interdisciplinary institution, the C2PAP primary goal is to provide an interface between the seven research areas of the Excellence Cluster Universe and foster cooperation and exchange among disciplines.

## Dr. Günter Duckeck

Already in his thesis in 1988 at the University of Heidelberg Günter Duckeck dealt with one of the four major particle physics experiments at the Electron-Positron Collider (LEP) at CERN, the detector OPAL (Omni Purpose Apparatus at LEP) which was still under construction at that time. After receiving his PhD in 1993 in Heidelberg with the work "Precision measurement of the hadronic and leptonic cross-section around the  $Z^0$  resonance and determination of the strong coupling constant" he was a Fellow at CERN for two years before he joined the chair of Prof. Dr. Dorothee Schaile in 1996 at LMU. Until 2000 he was mainly concerned with the analysis of OPAL data. For about ten years now, his focus is on the coordination of the ATLAS-D grid, the German participation within the global ATLAS computer network. As deputy coordinator of C2PAP Dr. Günter Duckeck will bring this experience to the new Cluster project.



## Dr. Klaus Dolag

Klaus Dolag received his PhD in 2000 in the field of simulation of magnetic fields in galaxy clusters at the Max Planck Institute for Astrophysics (MPA). Then he spent two years as Marie Curie Fellow at the Dipartimento di Astronomia the University of Padua and worked in the field of hydrodynamic cosmological simulations. After that he went back to the MPA dealing with, among other things, simulations of structure formation in different cosmologies. Since 2010, Dr. Klaus Dolag is researcher at the chair of Prof. Dr. Andreas Burkert at LMU. His focus is on magneto-hydrodynamic simulations of the formation of galaxies, clusters of galaxies and large-scale structures in the universe. These simulations serve as a theoretical counterpart to the observation programs that are supported in C2PAP. In 2012, Dr. Klaus Dolag habilitated with the work "Galaxy Clusters - Lighthouses of Cosmic Magnetisation."



## PEOPLE

### Four new Junior Research Groups

As a main part of the second funding period 2012 to 2017 the Excellence Cluster Universe proposed to found new junior research groups to stimulate new research activities. Therefore, the Cluster identified ten research topics in experimental as well as theoretical research, which shall be associated to a junior research group. Each group is endowed with a leader position, two PhD student positions, a start-up grant as well as funding for investments and general spendings. The Excellence Cluster Universe finances these groups until October 2017. Ten research group topics were advertised worldwide and many excellent young outstanding people applied last year. Now, the Cluster is happy to welcome four new junior research group leaders:

#### 1. Junior Research Group:

**"Studying the quark-gluon plasma via low-mass dilepton with ALICE" (experiment)**

Dr. Torsten Dahms (former affiliation: CERN, Ecole Polytechnique) works on quark-gluon plasma physics and the ALICE detector at the Large Hadron Collider (LHC) at CERN. He is going to start at the Cluster on 1<sup>st</sup> September 2013.

#### 2. Junior Research Group:

**"Strings and observables - connecting strings and black holes in particle physics and gravity" (theory)**

Dr. Mark Goodsell (former affiliation: CERN, Ecole Polytechnique) an expert on string theory and particle physics will start on 1<sup>st</sup> October 2013.

#### 3. Junior Research Group:

**"Formation and evolution of the cosmic large-scale structure" (observation)**

Dr. Paola Popesso (former affiliation: MPE) is an astronomer working on X-ray and infrared observations. She started on 1<sup>st</sup> May 2013.

#### 4. Junior Research Group:

**"Interplay between direct and indirect searches for new physics" (theory)**

Dr. David Straub (former affiliation: Universität Mainz) is a theorist working on particle physics, in particular flavour physics. He will start on 1<sup>st</sup> October 2013.

## EVENTS

### Universe Colloquium

All members of the Excellence Cluster Universe as well as the interested public are invited to the Universe Colloquium. In this year's summer semester it is held every Wednesday at 16:30 in

the Cluster's seminar room. There are exciting presentations on current research topics followed by wine and cheese and time to talk. Further information: [www.universe-cluster.de](http://www.universe-cluster.de)

### Workshop: Athos 2013

The 2<sup>nd</sup> Workshop on "Partial-Wave Analysis Tools for Hadron Spectroscopy" is being held at the Kloster Seeon in the Chiemgau region, southeast of Munich, from 21 to 24 May 2013. It is a follow-up workshop of ATHOS 2012, held near Genoa, Italy. At fixed-target experiments and colliders, ongoing precision studies concerning hadron spectroscopy and

CP-violation in heavy mesons using complex hadronic final states make it necessary to bring together expertise from different analysis groups and different experiments. The aim of the workshop is a constructive discussion about open issues, concerning both theoretical and practical problems. Further information: [www.athos2013.de](http://www.athos2013.de)

### Research Area Science Days

Each of the Cluster's Research Areas organize an annual science day. The following events have been scheduled:

10 June 2013, 10:00 - 16:00, Research Area I:  
C2PAP Kick off meeting

20 June 2013, 10:00 - 16:00, Research Area E:  
"Dark Matter and Dark Energy"

4 July 2013, 10:00 - 15:30, Research Area F:  
"Black holes, galaxy evolution, planet and star formation"

### New teacher training on Einstein's Relativity

Teachers in Bavaria teach one of the greatest theories in physics: Einstein's Relativity. The theory revolutionized our understanding of space, time, energy and mass. The details of Einstein's framework are mathematically quite complicated, nevertheless, it is possible to teach the foundations and main concepts of Relativity to students. The Cluster's Scientific Manager Dr. Andreas Müller is responsible for the teacher training programme of the Excellence Cluster Universe. Recently awarded with the Kepler Prize by the Verein zur Förderung des mathematischen und naturwissenschaftlichen Unterrichts e.V. (MNU), he developed concepts for teacher trainings and also acts as a trainer.

The new teacher training on Special and General Relativity is the third training format offered by the Cluster. The idea is to motivate students by bringing in the fascinating research examples of astronomy, cosmology, particle and nuclear physics where relativity comes into play, e.g. time dilation at high speeds and near black holes.



The Cluster's teacher training on Relativity is a half-day event and was held for the first time on 6 March 2013. The organizers were swamped by registrations: Nearly one hundred teachers applied for 20 places. Therefore, the Cluster decided to offer two more teacher trainings on Relativity on 18 June and 10 October 2013. Registration at <http://fortbildung.schule.bayern.de>

### Conference: The Physical Link between Galaxies and their Halos

Galaxies are surrounded by extended halos of stars, gas and dark matter. In our current paradigm for structure formation, the three kinds of halos play an important role in shaping the galaxies we see. From 24 to 28 June, observers and theorists meet in Garching to discuss the physical mechanisms governing these galaxy-halo connections. The internation-

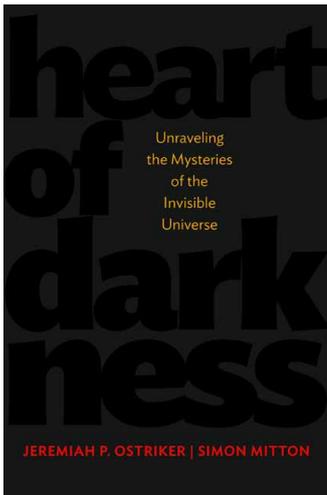
al conference is organised by the Max Planck Institute for Astrophysics (MPA) and for Extraterrestrial Physics (MPE), European Southern Observatory (ESO) and the Excellence Cluster Universe.

Further information: [www.mpa-garching.mpg.de/halo2013/](http://www.mpa-garching.mpg.de/halo2013/)

## BOOK

### A never-ending story

In their book “Heart of Darkness: Unraveling the Mysteries of the Invisible Universe”, astrophysics professor Jeremiah P. Ostriker and astronomer Simon Mitton recount the history of cosmology from Ancient Greece to the present day. In the 20th Century, it was generally accepted that there once was a Big Bang. Later physicists suggested the existence of a mysterious dark energy. Yet each new discovery raises new questions, but scientists are still unable to answer many of them.



“The heart of darkness: Unraveling the Mysteries of the Universe”

In mid-March, the Excellence Cluster Universe invited Jeremiah P. Ostriker to present his new book in Garching, Munich. Ostriker is known as one of the early proponents of “dark matter”. Born in New York City in 1937, Ostriker studied at Harvard, completed his doctorate in Chicago and then went on to Princeton, where he became professor. Later he held the Plumian Professorship in Cambridge, where his co-author Simon Mitton (b. 1946) is involved in researching the history of astronomy. Both of them witnessed important changes in the field of astrophysics.

The book begins with the Greek scholars and philosophers, who were concerned with the universe in ancient times. However, the authors also tell the story of the relegation in the significance of our Earth, beginning with Nicolaus Copernicus (1473 - 1543), who observed that the Earth circles round the sun.

In the first half of the 20th century, cosmologists have intensively focused on the question of how our universe might have arisen and how it will develop into the future. In the 1960s a major debate emerged: The “steady state” theory, which had been generally accepted until that time, and which maintains that although the universe is expanding, it doesn’t change its appearance at large scales over time, became increasingly challenged as a growing body of evidence emerged in favor of the competing Big Bang theory. The discovery of cosmic background radiation put an end to these discussions.

With the help of this radiation, it is possible to create a map of the universe from shortly after the Big Bang, from which the former structures are visible. Depending on how big they are, the galaxy formation can be explained. Simon Mitton recalls the reaction, when the measurement curve from COBE (Cosmic Background Explorer) satellite data was shown on 13 January 1990: “For a moment a hush descended, then there were murmurings. Next, people began to applaud. Then everybody stood up, clapping wild and enthusiastically.” The results confirmed the radiation law of a black body, discovered by Max Planck (1858 - 1947).



Jeremiah P. Ostriker presenting his book at Max Planck Institute for Extraterrestrial Physics in Garching on 15 March 2013.

And COBE detected small fluctuations in the background radiation, which would explain the structure of the universe if a kind of “dark matter” is postulated.

The “dark matter” also enabled other phenomena to be explained, including galaxy rotation curves. In fact, Ostriker, Jim Peebles and Amos Yahil had summarized all observations that pointed to the existence of a “dark matter” as far back as 1974. But also mysterious remains the “dark energy”, which was postulated to explain the accelerating expansion of the universe.

Ostriker and Mitton’s book also reveals much about how science works. The story of Fritz Zwicky (1898 - 1974), for example, shows that it can take a long time for the right ideas to be accepted. The Swiss physicist had posited a kind of “dark matter” as early as 1937, based on the observation of galaxies.

As much as we know about our universe - many more questions remain to be answered. In the author’s words: “We understand the minor components of the universe, the ordinary chemical elements and the fields of photons. But the dominant components – the dark matter and energy – remain totally mysterious to us. This is the heart of darkness at the center of our understanding of the cosmos.” There’s still plenty for young physicists to do.

Christiane Lorenz

#### IMPRINT

**Realisation:** Ulrike Ollinger & Katharina Fierlinger (Layout), Petra Riedel (Concept & Text)  
**Authors:** Petra Riedel, Alexandra Wolfelsperger, Dr. Andreas Müller  
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**Print:** flyeralarm GmbH, Alfred-Nobel-Str. 18, 97080 Würzburg  
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**Directors:** Prof. Dr. Stephan Paul (TUM), Prof. Dr. Andreas Burkert (LMU)  
 The Excellence Cluster Universe is supported by the German Excellence Initiative