NEWSLetter
Excellence Cluster Universe

Issue 4 December 2009

Dear Readers,

Just a few days are left in the year 2009, and we say farewell to the International Year of Astronomy (IYA2009) that boosted worldwide outreach activities. The Cluster took this great opportunity to engage in various cornerstone projects such as the 100 Hours of Astronomy, School Astronomy and Galilean Nights. Our highlight project in the IYA is an exhibition at the Deutsches Museum that translates the Cluster research on the "Origin and Structure of the Universe" into an attractive, easy-to-understand presentation for the public. The exhibition is a common project by ESO, the Max Planck Institutes for Physics, Astrophysics and extraterrestrial Physics as well as the Universe Cluster. "Evolution of the Universe", as the exhibition is called, has been open to the public since 9 December 2009 (p.3). So with the holiday season ahead, why not pay a visit to the Deutsches Museum?

Barbara Wankerl, PR Manager

PICTURE OF THE MONTH

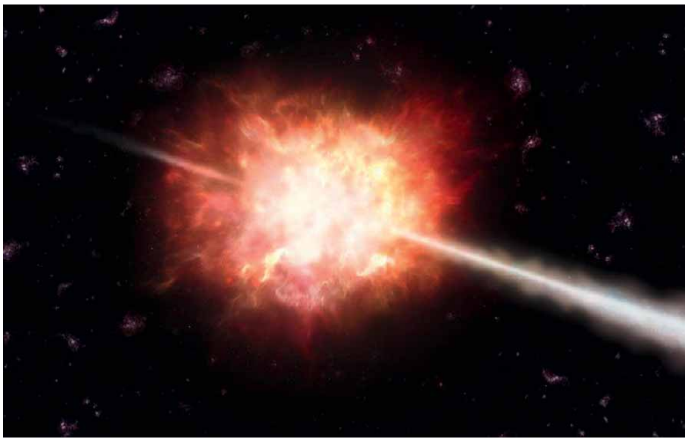
Re-start and Record

After taking up operations again on 23 November, CERN's Large Hadron Collider has now become the world's highest energy particle accelerator, having accelerated its twin beams of protons to an energy of 1.18 TeV. This promising result marks another important milestone on the road for the first physics at the LHC in 2010.

HIGHLIGHTS

Greetings from the Very Young Universe

In April 2009 scientists set a new record: They discovered the oldest object in the Universe so far, a gamma-ray burst (GRB) at a redshift of z=8.2. In terms of time this GRB leads back to a distant past when the Universe was about 700 million years old – an insignificant age compared to its existence of 13.7 billion years. The discovery resulted from a finely tuned orchestra of scientists and different astronomical instruments all over the world. The discovery of GRB090423 has been published just recently in the top scientific magazine "Nature". Co-authors of this article are Jochen Greiner and Thomas Krühler, scientists at the Max Planck-Institute for extraterrestrial Physics (MPE) and the Universe Cluster.



Artist's impression of a gamma ray burst: A highly focused, very bright beam emits from a supernova explosion or the fusion of two compact objects. GRBs are visible at distances over billions of lightyears.

GRBs are valuable objects for researchers. Both bursts and their afterglows come with an enormous luminosity making them a bright target for observing astronomers. Besides, their sources are well known: There is strong evidence that long lasting bursts can be traced back to supernova explosions, whereas short bursts (shorter than 2 seconds) probably stem from the merger of compact objects. With a burst of 10 seconds the newly found object probably belongs to the first group. "This finding provides us with an awesome insight", says Jochen Greiner, "There were stars at a very early stage of the Universe." The finding of such a rare object requires a smooth chain reaction of observations. The detection and identification of GRB090423 involved about a dozen observatories and instruments. The first to register the 10-second burst was the Swift gamma ray detector at 7:55 am UT on 23 April 2009. Follow-up observations with the Hawaii-based UKIRT infrared telescope and Gemini resulted in the finding of the afterglow in the near-infrared range.

Up to this point, GRB090423 could have been just another burst. However, it soon became evident that the object's light had traveled a really long distance. The first indication of a high redshift, the measure astronomers use for distance, came from the Gemini Northern Telescope about an hour later. This was confirmed first by the TNG telescope on La Palma and GROND, located at ESO's La Silla observatory in Chile at about 11 pm UT, setting the limits of the burst at a redshift between 6.8 and 8.5. Further observations from other telescopes, including the ESO Very Large Telescope in Chile later set the exact

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⇨ value to a redshift of z=8.2 just 24 hours after the burst. Thomas Krühler explains the role of the GROND (Gamma-Ray Burst Optical Near Infrared Detector) instrument in the finding and identification of GRB090423. “GROND is the only astronomical camera allowing simultaneous observations in seven spectral bands, i.e. in wavelengths from 400 to 2300 nanometers. This means we can detect a multitude of different signals to track down GRBs.”

GROND is a development of the MPE and the Thüringer Landessternwarte Tautenburg. Mounted at the 2.2-meter telescope on Mount La Silla in Chile, it has been delivering data since July 2007. “This record-breaking GRB is setting high expectations in future detections”, says Greiner. “With systematic searches for high redshift bursts using GROND, we hope to push the redshift for observations up to a limit of z=13.”

Half-life of Iron-60 Surprises Researchers

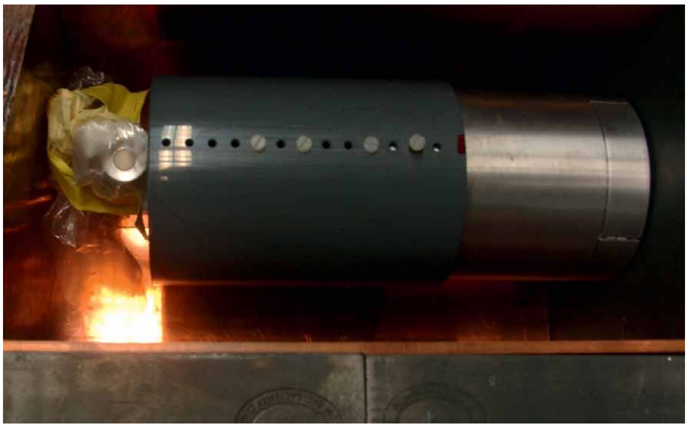
The decay of radioactive elements in the Universe provides astronomers with valuable findings on the chronological course of cosmic events. Recently, scientists from the TU München, the Excellence Cluster Universe and the Swiss Paul Scherrer Institut (PSI) have succeeded in determining the half-life of iron-60 more precisely than ever before. During their research they ran across a real surprise: The half-life of iron-60 of 2.6 million years clearly exceeds the hitherto known value of 1.5 million years (Physical Review Letters, Vol. 103, No. 7).

The rare, radioactive iron isotope iron-60, whose nucleus contains four neutrons more than the most frequent iron-56, interests scientist for many reasons. The radiation of its direct decay product cobalt-60 delivers information on the origin of heavy elements in high-mass stars of the Milky Way. The radioactive series of the iron isotope via cobalt-60 finally leads to the stable element nickel-60, whose frequency of occurrence in meteorites offers clues as to the earliest history of the solar system more than 4.5 billion years ago.

Astrophysicists reckon that in this phase, iron-60 could have acted along with other radioactive elements as a heat source inside the newly developing planets and asteroids and thus decisively influenced their composition. The presence of iron-60 in the developing solar system is explained by means of an external event, a nearby supernova for example, whose expelled material mixed with the gas of the developing solar system.

For a reliable interpretation of the measured data in all these contexts, an exact knowledge of the half-life of iron-60 is of decisive significance. The previous value of approximately 1.5 million years was adversely affected by an uncertainty of almost 20 percent – too much for the researchers as the interpretation and dating of these processes seriously depends on the half-life of iron-60.

In the new study, scientists investigated a few grams of material containing iron-60 – ten times more than in the last measurement



Exploring the half-time of iron-60: the container with the sample fluid.

in 1984. As it turned out, the half-life of 2.6 million years exceeds the previously accepted value by over 75 percent. This result means that previous examinations might have to be reassessed: For example, the origin of the chemical elements or the findings on past supernovae occurring close to the solar system.

Additional Project Funding at the Universe Cluster

As in the previous year, the Excellence Cluster called its principal investigators for additional project proposals. The preconditions for the proposals were clearly set: The suggested projects should have both an innovative and strongly interdisiplinary character improving the local infrastructure. On 26 August representatives of altogether 39 applications were given the opportunity to present their proposals to the Cluster community. Following several decision rounds, the Cluster’s Research Board decided to fund 20 projects with an amount close to 850,000 Euros.

The funded projects cover a wide range. In the field of astronomy the Cluster will co-finance a membership in the Dark Energy Survey (DES) collaboration, an investment several working groups will profit from. Further, a larger sum will flow into the modernisation of the Wendelstein Observatory.

In the field of particle physics the Excellence Cluster Universe will support the building of a Time Projection Chamber for the FOPI spectrometer at the GSI Helmholtzzentrum and detector devices for ultra-cold neutrons. Also innovative ideas presented by JRG’s were supported, allowing e.g to extend the Cluster’s activities in the field of neutrinoless double beta decay. Major project funding was dedicated to the experimental equipment, both at the Cluster’s laboratory and in the new Underground Laboratory at TUM, where scientists develop and test detectors for dark matter particles.

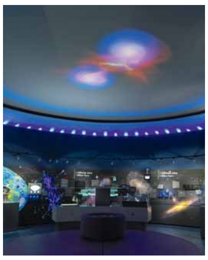
„Again we had to choose from a large number of very interesting project proposals“, says Cluster coordinator Stephan Paul. „Altogether the quality of proposals was high and we are glad to be able to finance or support more than half of them with substantial contributions.“

EVENTS

A Journey Through Time in the Deutsches Museum

A new exhibition at the Deutsches Museum allows visitors to experience cosmic history as never before. „Evolution of the Universe“, opened on 9 December 2009, is the result of a co-operation involving five local institutions: ESO, the Excellence Cluster Universe, and the Max Planck Institutes for Physics, Astrophysics, and Extraterrestrial Physics. Created as part of the International Year of Astronomy 2009, the exhibition will be open to all visitors of the Deutsches Museum, and is set for a two-year run.

This exhibition takes visitors back 13.7 billion years to the Big Bang. They will be able to follow the paths and byways of cosmic evolution, from the birth of space, time and matter to the formation of the network of filaments of galaxy clusters, that is, the Universe‘s large-scale structure. Back in the present, we explore the life cycles of stars, the structure and evolution of galaxies including the role played by those enigmatic objects, black holes before catching a glimpse of the future: What do scientists know about our universe‘s ultimate fate?



Weaving together astronomy, astrophysics, nuclear and particle physics, the exhibition offers a comprehensive view of cosmic history, which includes multimedia presentations of cutting-edge research. Hands-on experiments allow visitors to unravel the mysteries of the cosmic background radiation, the electromagnetic echo of the Big Bang, discover the crucial role of dark matter, and find out about the origin of elements we Earthlings take for granted, such as oxygen, iron and gold.

Covering an area of 100 square meters, the large circular hall that hosts „Cosmic Evolution“ is part of the museum‘s astronomy department on the 4th floor. Design and production of the exhibition were in the capable hands of „Die Werft“, a company whose portfolio includes the conception and realisation of several departments in the Deutsches Museum.

The exhibition is open daily from 9 am to 5 pm at Deutsches Museum, Museumsinsel 1, 80535 Munich.

Science Week 2009

From 12 to 15 Oktober 2009 the Excellence Cluster Universe held its annual Science Week, an interdisciplinary conference on particle, nuclear, and astrophysics in the auditorium at the Max-Planck Institute for Plasma Physics (IPP). Cluster scientists presented 36 talks covering subjects in all seven Research Areas. The Cluster was especially pleased to welcome Scott Tremaine (Institute for Advanced Studies, Princeton, USA) who reported about the centers of galaxies and black holes.

Another highlight was the presentation of the Universe PhD Awards, each endowed with 4,000 Euros. In 2009, three young and talented students received the prize: Michael Wurm (TUM; category: experiment) for his outstanding contributions in experimental neutrino physics with Borexino; Matthias Gritschneder (USM/LMU; category: theory) for his computer simulations of the birth of stars, and Monika Blanke (TUM; category: theory) for her brilliant theoretical contributions in particle physics by extending Randall-Sundrum models.

The first day of the Science Week closed with a reception, giving young Cluster researchers the opportunity to present and discuss their scientific work in a poster session. On Wednesday, 14 October, the Cluster members were invited to the General Assembly. At this meeting, the Cluster spokesman Prof. Stephan Paul (TUM) reported on the milestones the Cluster reached during the last year. The Cluster started in October 2006 and has grown to a substantial and internationally visible size with a scientific staff of about 200 people. Stephan Paul said that this good development was also due to a very mature guest and fellowship program met with high acceptance by the worldwide research community. Paul also gave an overview on current large infrastructural projects co-financed by the Cluster like the new telescope on the Wendelstein observatory, the ultra-cold neutron source and the new underground laboratory on the Garching Campus.

Traditionally, the Science Week’s Thursday is dedicated to the Research Area leaders’ presentations on the status-quo of the seven research areas A-G. It was impressive to see recent breakthroughs in research such as the detection of the most distant source in the sky, a gamma-ray burst detected by Cluster scientists in April 2009 or the preparations for the re-launch of the world’s most powerful particle accelerator, the Large Hadron Collider (LHC) at CERN, to which Cluster scientists significantly contributed. During the Science Week the Excellence Cluster Universe was honored by the visit of its Scientific Advisory Board. Its members took the opportunity to gain first-hand information and hold discussions with various representatives of both science and administration.

Sun, Science and Coffee: Open Day in Garching

It was a nice fall day, and about 10,000 people took the opportunity to take a look at "backstage" science: On 24 October, the Garching Campus again opened its doors to the public. In its program, the Universe Cluster linked together the microscopic and the macroscopic Universe: A three-dimensional virtual particle accelerator invited the visitors to simulate particle collisions. Another demontration took them to the world of strings: Scientists use these quantum "threads" to build a unified theory on matter and forces. Having made acquaintance with the tiniest structures people were

Full house: The Cluster program attracted a huge crowd, both outdoors at the dome and telescopes presented by Baader Planetarium and at the indoors talks, Science Café and demonstrations.

also able to look at the big objects in the Universe: The Worldwide Telescope provided an online journey through galaxies, nebulae and stars. Outside Baader Planetarium invited people to visit a real dome and take a closer look at the sun through the telescope.

Besides demonstrations, the Cluster also offered public talks on current research topics at the institutions - and the Science Café, a question-and-answer discussion on topics like the Big Bang, Dark Matter, Dark Energy, Black Holes and the role particles play in our lives. Again, these activities attracted a large audience - and resulted in a very lively exchange between scientists and visitors.

Classroom Astronomy

One of the last big events within the International Year of Astronomy 2009 was the "Week of School Astronomy" from 9 to 13 November. Thanks to the more than 20 Cluster Astronomers who agreed to visit elementary and secondary schools in and around Munich, the Excellence Cluster Universe was able to support this project actively.

The idea behind this venture was to inspire and boost interest in Astronomy and its related fields. Over the last few months, several activities for pupils and teachers took place: An "International Astronomical Youth Camp" in the Carpathians in Poland, an "Astro Class Competition" with great prizes, and several training lessons for teachers. Finally, the "Week of School Astronomy" brought Cluster researchers to the class room: They gave lectures at secondary schools and did interactive classes with the younger ones. The talks included a wide range of topics from the evolution of galaxies, our solar system to black holes and gravitational waves. At elementary schools, pupils learned about the planets and the stars by building models of the Solar System and star charts.

Even though all 174 elementary and secondary schools in Munich were contacted, ultimately, only ten schools took part in this project. The outcome was equally positive for the participating schools and the speakers. Some teachers and pupils wery quite enthusiastic and proposed to repeat the "Week of School Astronomy" in 2010.

PORTRAIT OF THE MONTH

What's the Matter with Matter?

After introducing Jochen Weller's group and "dark energy" in our last newsletter, we now take a big step from macrocosmos to microcosmos: The Junior Research Group (JRG) we present here deals with the "early" physics of the Universe – the understanding of the origin and the nature of matter. The JRG "Fundamental Physics with Neutrons" is led by Prof. Dr. Peter Fierlinger and looks at the innermost structures of particles.

In our everyday experience matter is something that is just there: matter forms our planet, the living and the inanimate nature on Earth, our solar system, all stars and galaxies in the cosmos. However, we cannot take the presence of matter for granted. "How matter came into existence is one of the major unsolved mysteries in the history of the Universe", explains Peter Fierlinger. There is evidence that shortly after the Big Bang there was an anti-material counterpart for each particle, e.g. the positron for the electron or the anti-neutron for the neutron. According to the laws

Bernd Taubenheim, Felix Rosenau, Peter Fierlinger and Florian Kuchler discuss the next steps in the Xenon experiment

of physics, particles and anti-particles cannot easily co-exist, as they destroy or annihilate each other when they meet, thereby releasing energy.

In this scenario neither matter nor anti-matter would have survived and our Universe today would consist of pure ⇨ next page

energy. "Our existence is the proof that somehow the symmetry of matter and anti-matter must have been disturbed", says Fierlinger. "At some point, there was a surplus of matter versus anti-matter that escaped annihilation." According to current knowledge there was one extra-matter particle in a number of one billion particles – today's matter-dominated Universe is the result of this tiny numerical difference.

Looking at the origin of matter one might consider it an accident that just happened. This of course is an unsatisfactory explanation. The starting point for Fierlinger's investigations is the research of Paul Dirac, who predicted the existence of mysterious anti-particles. These have the same weight as 'normal' particles and the same amount of charge but with opposite sign. After such particles were indeed found a few years later, Wolfgang Pauli stated that this similar behavior follows from fundamental symmetric properties of the universe: the reversal of charge (C), the reversal of the spatial coordinates (P) and the reversal of time (T). This relation is called the CPT symmetry. Although scientists assume that our Universe perfectly conserves these symmetries, some combinations of theses symmetries must have been violated to create the predominance of matter.

The setup in the experimental hall near the FRM II.

Peter Fierlinger explains how scientists deal with this riddle: "Today's research in this field focuses on finding examples of symmetry breaking in fundamental physical systems. Usually this is done at large accelerators, where under certain conditions particles and anti-particles are produced simultaneously. One major effort is to measure how long these particles and anti-particles live until they decay. It has indeed been observed that their lifetimes are different! However, this finding is by far not sufficient to explain our existence." A completely different route to find more broken symmetries is to look for electric dipole moments of fundamental systems: Due to mathematical calculations we know that a permanent electrical dipole moment (EDM) in a particle would hurt both the P and the T component in the CPT equilibrium. "Therefore, we search for an EDM in two different experimental settings", adds Fierlinger.

A very good candidate for EDM search is the neutron due to its relatively simple composition. Therefore, Fierlinger and his group are currently setting up experiments at the Excellence Cluster Universe and at the Paul Scherrer Institut (PSI) in Switzerland. Peter Fierlinger: "The neutron EDM experiment is based on trapped ultra-cold neutrons. These neutrons are cooled down to low energies and move with the velocity of a bicycle rider – allowing for much easier investigations than in 'normal', fast moving neutrons". However, Fierlinger's group has to be patient. The Maier-Leibnitz Neutron Source at TUM is building a new plant for ultra-cold neutrons that will start operations as late as 2011. In the meantime, the first runs will be performed at the PSI neutron source.

Fierlinger's group doesn't concentrate on neutrons exclusively. Another suited experimental system is based on an isoptope of the inert gas Xenon (129-Xe). "In contrast to the neutron EDM experiments that will use proven methods, we develop a completely novel measuring technique for Xenon". According to Peter Fierlinger, this approach opens new possibilities for investigating systematic effects in EDM experiments. When asked, what would happen to the neutron EDM experiment if there were promising results from Xenon, he says: "A measured EDM would be a spectacular indication of something unknown, but the observation of this effect in one system alone does not tell us enough about the underlying physics." Therefore it would make the neutron EDM measurement even more interesting. Xenon is also the connecting link to a different research topic Fierlinger is involved ⇨ next page

Junior Research Group: Fundamental Physics with Neutrons

The group has started in August 2008 and is led by Prof. Dr. Fierlinger (31). After completing his PhD studies at the University of Zürich, Peter Fierlinger spent two years as postdoc and fellow at Stanford University. His group consists of postdoc Guillaume Pignol, staff scientist Manfred Daum, Maximo Ave Pernas, a research fellow with the Cluster, as well as PhD students Florian Kuchler, Marlon Horras, Beatrice Franke and five diploma students.

Research Goals

- Experimental tests of fundamental symmetries in particle physics
- Time-reversal symmetry and CP Violation: search for the electrical dipole moment in the neutron and the 129-Xenon experimen
- Neutrino Physics: searching for the mass and nature of the neutrino

Collaborations

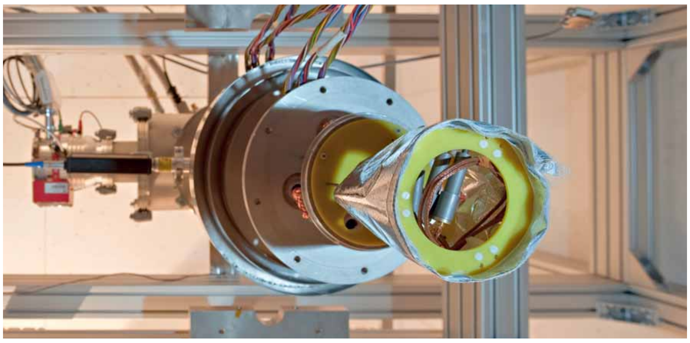
- Physikdepartment E18, TU München: cryogenics, experimental hardware
- FRM II, TU München: UCN source, experimental area, infrastructure
- Paul Scherrer Institut, Villigen, PSI UCN source: Ultra-cold neutron physics
- PTB Berlin: magnetic field testing, magnetometry, magnetic shielding
- Universitätsklinikum Jena: precision magnetometry
- Neutron EDM collaboration,
- EXO - the enriched Xenon observatory: neutrinoless double decay

Results so far

The group is in the process of setting up their experiments and so far has built a SQUID measuring setup, a magnetic field measuring robot, the most stable existing current source for low frequencies and a setup for spin-exchange optical pumping. The team has also developed a new approach to measure the EDM of 129-Xenon.

in: The hunt for the value of the neutrino mass, and whether the almost massless neutrino is its own antiparticle. “Like electrons, neutrinos are elementary particles known as leptons”, says Peter Fierlinger. “There are indications that the neutrino doesn’t have an explicit counterpart as is the case with electron and its antiparticle positron.” Using the isotope 136-Xenon, scientists are aiming at detecting neutrinoless double beta decay, a special case of radioactive decay. This is expected to be very rare, but it should answer the question of mass and nature of the neutrino. The experiment is currently built in an international collaboration based at Stanford University.

The JRG “Fundamental Physics with Neutrons” is situated in Garching with strong ties to PSI, PTB Berlin, Stanford University and Argonne National Lab. At the Universe Cluster Universe Peter Fierlinger’s group is settled within Research Area C “Particle Hierarchy” and closely co-operates with scientists at the FRM II and the E18 chair at the physics department of the TU München.



Interior of the cryostat for the Xenon EDM measurement

PEOPLE

Welcome to the Cluster!

The Excellence Cluster Universe welcomes five new research fellows: Lise Christensen, Kristina Giesel, Diego Guadagnoli, Aleksi Halkola and Minoru Nagai.

Before joining the Cluster, **Lise Christensen** worked as a postdoc at ESO for four years including three years as VIMOS instrument fellow in Chile. Her research in the past few years focused on the use of integral field spectroscopy. Christensen’s research projects will complement those currently being carried out in the Cluster’s research areas F and G centering on black holes and formation of heavy elements.

Kristina Giesel will join the Cluster as a research fellow in January 2010. Her last position was as a research fellow at the Nordic Institute of Theoretical Physics. At the Cluster she will further push her studies on Loop Quantum Gravity relating this approach to research issues in research areas A (Planck Scale Universe), E (Dark Universe) and F (Black Holes).

For the past four years **Diego Guadagnoli** worked as a postdoc at the TUM physics chair Theoretical Elementary Particle Physics. In this postion he became a member of research area C focusing on the origin of particle masses. His current research interests are concerned with phenomenology of physics beyond the Standard Model, and in particular supersymmetry.

Aleksi Halkola obtained his PhD in Astronomy from the Universitätssternwarte München. His main research interest focuses on dark matter and galaxy clusters and their study with gravitational lensing. He is now part of research area E which working on the decoding of the dark components of the Universe.

Minoru Nagai joined the Universe Cluster in October 2008 as a postdoc and a member of the Junior Research Group „New Physics beyond the Standard Model“. In his new position as a research fellow he will focus on flavor physics and CP violation relating these fields to current theoretical research issues like supersymmetry and the Grand Unified Theories (GUT).

New Chair for Cosmology

Joseph Mohr

This fall, the Excellence Cluster Universe has established a new chair for cosmology and structure formation at the Universitätssternwarte of LMU (USM). With this chair the Cluster completes an important field of research in its program. The Universe Cluster is pleased that Joseph (Joe) Mohr from the University of Illinois in Urbana has accepted this professorship. In his former position, Mohr was professor at the Department of Astronomy and the Department of Physics, and a Research Scientist at the National Center for Supercomputing Applications (NCSA). Even though Joe Mohr only arrived in Munich a couple of months ago, his group is almost complete and already engaged in research. Joe Mohr’s research within the Cluster will focus on the South Pole Telescope (SPT), the Dark Energy Survey (DES) and e-ROSITA.

“It’s really a pleasure and an honor to join the scientists at the Excellence Cluster Universe and more broadly here in Munich in their work on some of the fundamental physical questions facing us today”, says Joe Mohr. “The combination of scientific talent and research resources here in the Munich astrophysics community is only rivaled by one or two other research centers in the world. It’s really been great to join this effort, and I am quite confident that the road ahead will lead to many exciting new science results!”

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