NEWSLetter
Excellence Cluster Universe

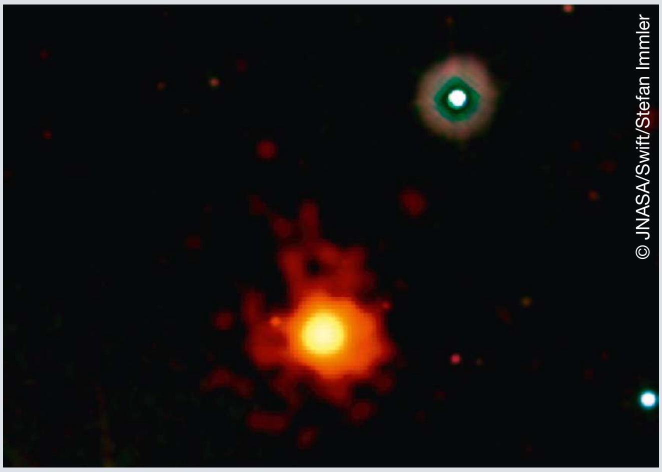
Issue 2 May 2009

Dear Readers,

"mission success" - these were the plain words on ESA's launch website after Ariane's start on 14 May. Backpacking both the Herschel and the Planck satellite, the rocket safely released two billion-Euro-worth telescopes that are now travelling to their final position at a distance of 1,5 million kilometers from Earth. From there, Planck will look back into the early Universe, studying the cosmic microwave background (CMB). Scientists hope to gain a better understanding of the energy fluctuations that can be traced back up to the Big Bang - and that formed the template for today's distribution of galaxies. Herschel's mission is to take images in the infrared spectral band to explore the mechanisms of star formation.
We would like to congratulate all parties involved in this huge project - especially our partner institutions MPA and MPE for their contributions to Planck and Herschel!

Barbara Wankerl, Public Outreach Coordinator

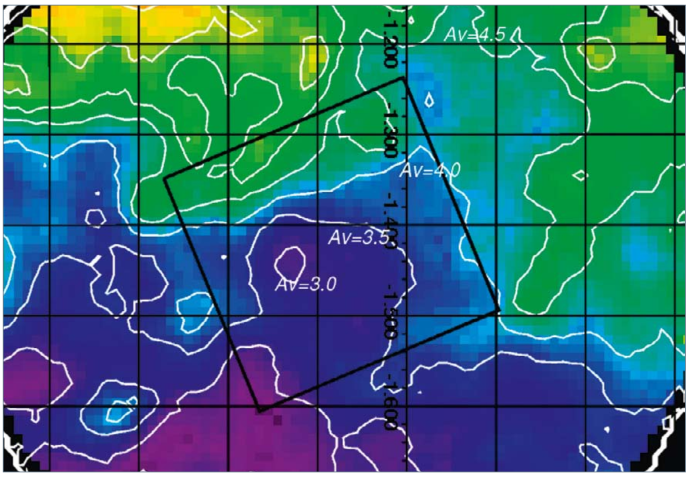
PICTURE OF THE MONTH



Greetings from the Universe's young days
This object is the most remote source ever observed in the Universe: It is a Gammy Ray Burst (GRB) that happened about 13 billion years ago, i. e. only 700 million years after the Big Bang. The GRB at a redshift of about 8.0 was first discovered by MPE-built GROND, an instrument of the 2.2-meter telescope mounted at the La Silla Observatory in Chile.

HIGHLIGHTS

Finding the sources of diffuse X-Ray emission in the Milky Way



The image shows the interstellar extinction – the observed field for the GRXE is marked with a square.

A mysterious X-ray glow in our galaxy, the Milky Way, has kept astronomers busy for more than 25 years. Now scientists have solved the riddle about the nature of this radiation: Mikhail Revnivtsev, a research fellow with the Excellence Cluster Universe and his colleagues in an international research team now have found direct evidence that the majority of the emission does not stem from one single diffuse X-ray-source. Obviously it is caused by discrete sources in our galaxy – very likely by accreting white dwarfs and active stars. The original research work was published in *Nature* on 30 April 2009 (Vol. 458, Nr. 7242).

In the universe, highly energetic electromagnetic X-rays usually are emitted by hot gas at a temperature of 10 to 100 million degrees. 25 years ago, astrophysicists found this kind of radiation along the disk of our galaxy - with no plausible explanation available: The so called "Galactic Ridge X-ray emission" (GRXE) might be characteristic for a very hot, optically thin plasma. However, an interstellar medium with these thermal properties would "fly away" from our galaxy immediately, causing a major energy loss that can not be replenished by the energy sources in the Milky Way.

In the past years observations from X-ray satellites RXTE (Rossi X-ray Timing Explorer) and Integral showed that the distribution of the GRXE follows the same pattern as the stars in the Milky Way. This led to the assumption that the bulk of the X-ray emission originates from stars, besides a small fraction being produced by hot, truly diffuse interstellar plasma, heated by stellar explosions (supernovae). These findings motivated the group around Mikhail Revnivtsev to perform more precise tests with the Chandra X-ray Observatory. The galactic test area they chose was a small field about half the moon's size near the center of the Milky Way. Explains Revnivtsev: "We chose a region of the Galactic plane that provided good conditions to perform our measurements: In this area we have a high GRXE intensity, which is essential to minimize the effects of X-radiation from extragalactic sources. On the other hand, there is a weak interstellar absorption of X-rays, crucial to maximize Chandra's sensitivity to discrete sources."

Indeed Revnivtsev and his team succeeded in finding discrete point sources for the GRXE focussing on a yet smaller "high resolution" circle in the test area. The scientists analysed

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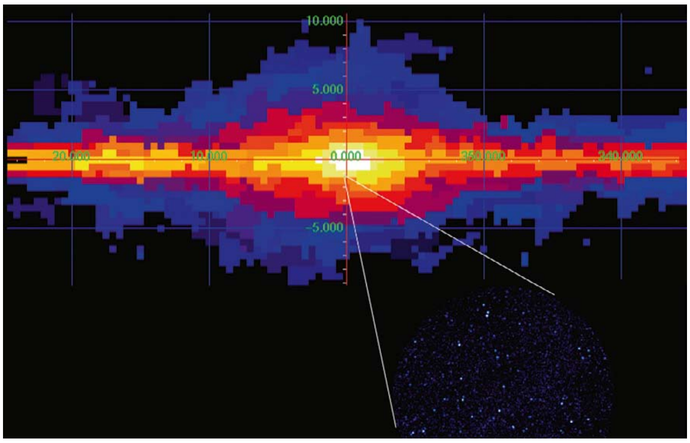
⇨ the telescope's images, finding 473 radiation peaks in a small circle of only ~2.6 arcminutes radius. In the next step the research team proved that the results of this limited area can be applied to the whole galaxy. They did so by scanning the same galactic area with another telescope. The Spitzer telescope operates at the near infrared (NIR) spectral band and is specialized to detect stellar mass distribution. Then they put this value into relation to the measured X-ray surface brightness and compared the result to the known GRXE/NIR intensity ratio of the whole Milky Way.

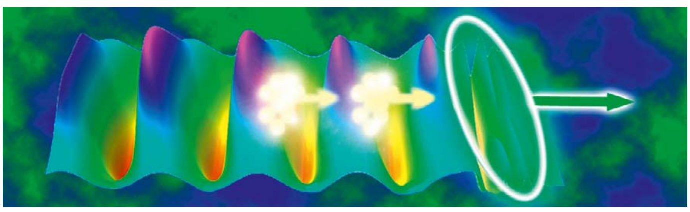
They found that the two values were in perfect agreement. "According to these results", says Revnivtsev, "we can regard our present study of just a tiny region of our galaxy as representative for the whole Milky Way." Most of the 473 X-ray sources detected are by all likelihood accreting white dwarfs and binary stars with a high activity in their coronae. White dwarfs are remnants of low-mass stars that accumulate matter from their partner-stars in a binary system. "Knowing the sources of GRXE we have solved a major energy problem in our Galaxy", resumes Revnivtsev.



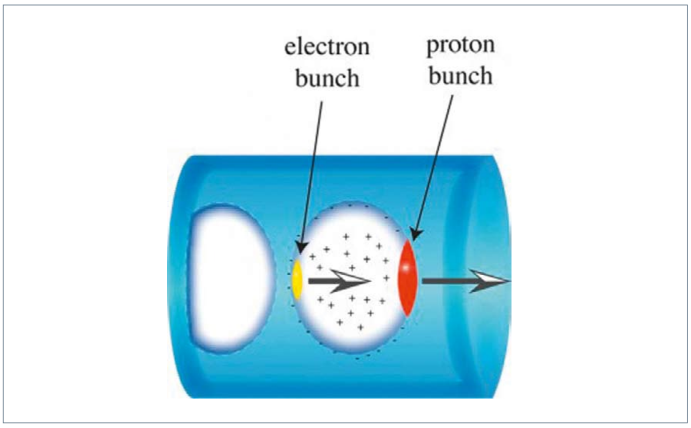
Picture of the GRXE

New technique for particle acceleration

Cluster members Allen Caldwell and Frank Simon of the Max-Planck-Institut für Physik together with a team of German and Russian physicists have developed a new technique for particle acceleration, called proton-driven-plasma-wakefield acceleration (PWFA). This new development may lead to much more compact – and therefore much cheaper – electron accelerators. Whereas the Large Hadron Collider (LHC) will cause protons to collide, the idea behind the PWFA is to accelerate electrons. In case this technique succeeds it may one day allow machines a fraction of the size of today's accelerators to create the highest-energy particles ever.



Laser-wakefield acceleration visualization



Plasma bubble created by the highly relativistic proton bunch (red), used to accelerate electrons (yellow).

In a conventional accelerator, particles are accelerated by the electric field in radio frequency resonators. The maximum field in these resonators is limited by breakdowns on the cavity walls due to the high fields. The radically new kind of acceleration skirts the electric field issue by using plasma – gas in which electrons have been ripped from their nuclei. This soup of ionized gas can handle electric fields about a thousand times stronger than can conventional accelerators, meaning the accelerators can potentially be a thousand times shorter. "The length of an accelerator is closely related to the overall cost of such a machine", explains Frank Simon, Junior Research Group Leader at the Excellence Cluster Universe. "So achieving higher acceleration gradients is a way of getting more bang for the buck", says Simon.

Electron acceleration by proton-driven PWFA is in its earliest theoretical stages and far from experimental verification. Using protons to drive the acceleration is an attractive new idea because extremely high energy proton beams already exist today at the Tevatron and the LHC. Using such beams could allow to accelerate electrons to energies in the TeV regime in one single acceleration stage, something not possible with other techniques of plasma acceleration currently under study. Perhaps the biggest issue is the proton bunch length, which must be very small to allow the electrons to overshoot and create the wakefield. Hadron colliders have bunches that are centimeters in length. But bunches are needed that are hundred micrometers in length.

Recently, spectacular success has been achieved in the study of plasma-based accelerators. Using electrons from the Stanford Linear Accelerator, a doubling of the energy of some of the electrons was achieved over a distance of less than one meter in 2007, an energy increase for which the conventional SLAC machine needs a length of 2 miles. The accelerating gradient was about 50 GV/m, more than a factor of 1000 more than the state-of-the art ILC acceleration structures achieve today.

The results of the simulation studies were published in Nature Physics (*Nature Physics, May 2009; DOI: 10.1038/NPHYS1248*).

For more information also see:

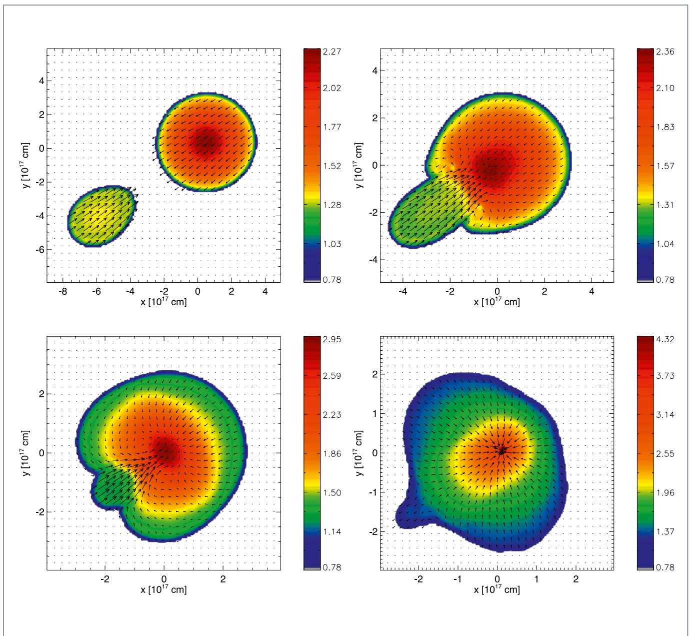
http://blog.wired.com/wiredscience/2009/04/tinyaccelerator.html and http://www.quantumdiaries.org/2009/04/16/future-accelerators-surfin-the-plasma-wave/

Gas cloud delivers new findings on the formation of stars

Astronomers have a rough idea of how stars form in the universe: Giant interstellar gas clouds travel through the Milky Way and other spiral galaxies. As they move they condense more and more due to the effect of their own gravitation until both density and temperature are high enough in certain areas to initiate nuclear fusion. Hundreds or thousands of stars thus form from a single huge cloud. However, are still many questions that remain unanswered on the formation of stars.

Andreas Burkert of the Excellence Cluster Universe and his colleague Joao Alves of the Spanish Calar Alto Observatory have gained new insight into the final collapse phase of a molecular cloud (*Astrophysical Journal, 695:1308-1314, 20 April 2009*). The researchers have discovered that the collision of two essentially stable gas clouds may be responsible for the decisive „kick" needed to trigger the final collapse. One of the closest star formation regions in our cosmic neighbourhood is the Pipe Nebula. The nebula represents a complex of numerous so-called Bok globules. These refer to spherical, cold gas clouds, whose masses are in the region of 0.1 to 10 times the mass of the sun. Astronomers have long considered such globules to be the direct precursors of young stars. One of them is the cloud Barnard 68 (B68).

Burkert und and Alves suggest that B68 is in fact in a very early state of instability and is just about to begin to collapse. The reason for this assumption is a small structure located in the southeast region of the cloud: Pictures of the cloud clearly show an independent globule which is approximately 10 times lighter and is evidently about to collide with B68. In order to prove their theory, both astrophysicists have now simulated the scenario with the help of a high-performance computer. They fed the computer with the coordinates of two spherical lumps which are 1 light year apart from each other with 2 and 0.2 solar masses respectively. They adjusted the inner structures of the



Snapshots of the simulation of a small globule merging with a big gas cloud

objects to the natural example of Barnard 68 and its neighbour. Then they followed the development of the system with the help of a numerical algorithm, which calculated the gas movement under the influence of gravitation in thousands of tiny steps in time.

As was expected, the smaller globule of the two changed its structure first to penetrate the larger globule after about 1.7 million years of „computer time" at a speed of 370 meters per second. In their model, the researchers also found the gas flow triggered by the impact pressure of the collapsing cloud, which they had observed flowing from the globule in the direction of the earthly observers. During the further course of the simulation, the previously stable system did in fact go out of balance and began to collapse and generated extremely high densities in its centre – the conditions for the formation of a star seem to be fulfilled. If the calculations of Burkert and Alves are correct, a new star similar to the sun will shine in our direct cosmic neighbourhood within the next 200,000 years, in whose vicinity planets could also form.

Collaboration in cosmological computational science

PRINCETON UNIVERSITY

The Excellence Cluster Universe and the University of Princeton are happy to announce a new joint research undertaking in cosmological computational science. For several years there has been collaborative research between scientists at Princeton and Munich in the area of galaxy formation. In recent years, scientists of the observatory of the Ludwig-Maximilians-Universität (LMU) and the Princeton University have made great progress in understanding the formation of galaxies, the basic building blocks of the Universe.

In the now formalized partnership scientists of both universities will employ supercomputers to run simulations. These will aid them in arriving at a better understanding of galaxy formation. The work will be centered at the Princeton Institute for Computational Science and Engineering (PICSciE) and the University Observatory Munich.

Partnership with Tokyo

The Excellence Cluster Universe and the Institute for the Physics and Mathematics of the Universe (IPMU) in Tokyo will intensify their scientific relationship. In a recently signed Memorandum of Understanding the two institutions agree to work together on the questions related to the formation and evolution of the Universe. The partnership includes collaboration in scientific projects as well as the organisation of conferences, workshops and schools.

New TUM Underground Laboratory Currently Under Construction

Digging a hole for the new Underground Laboratory

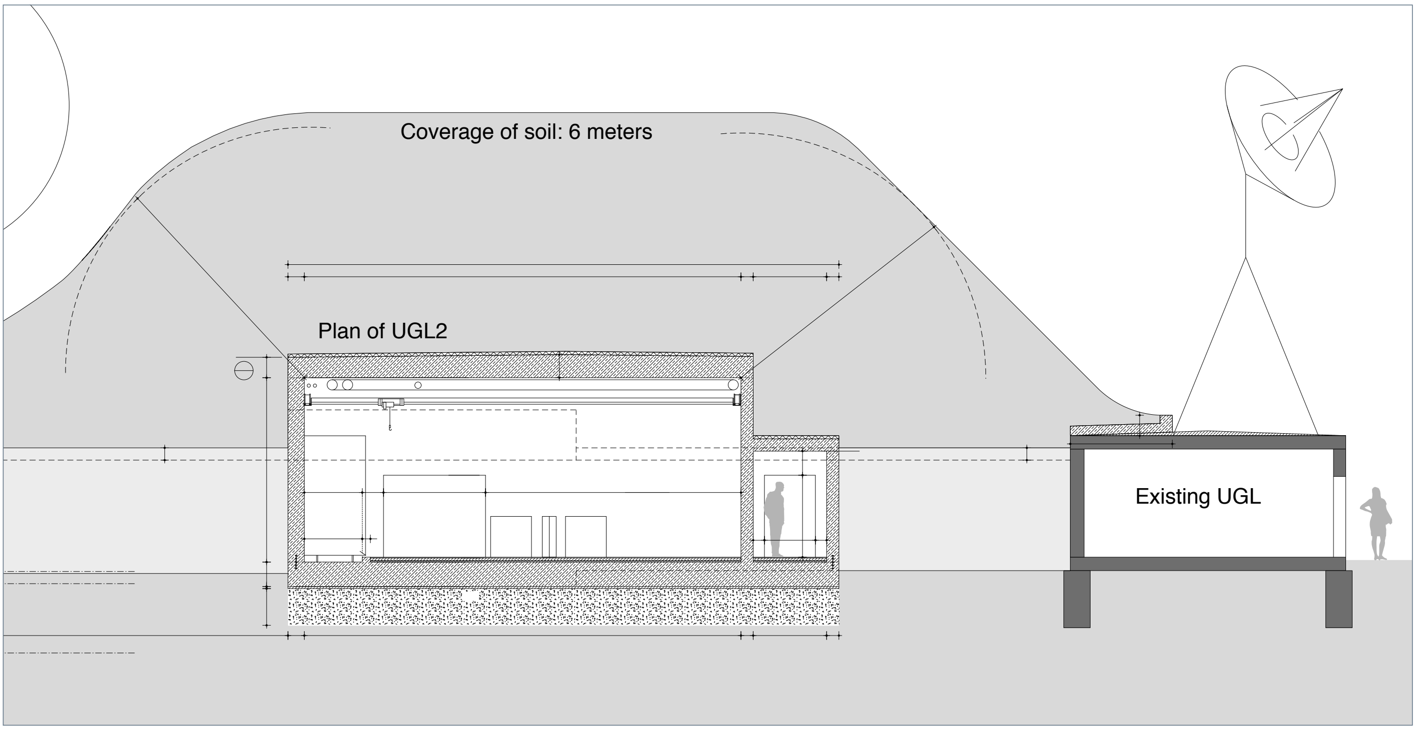
Over the past few weeks construction has been taking place: The excavation work for the new underground laboratory (UGL2) in Garching began mid-March. The Technische Universität München and the Excellence Cluster „Universe" are making an important contribution to astroparticle physics in Germany with the new laboratory. The newly constructed UGL comprises over 130 square metres of usable laboratory area and will be open to other European work groups within the framework of future major projects in astroparticle physics. Completion of the laboratory is planned for the end of 2009.

A core topic of astroparticle physics is neutrino research. Neutrinos are generated during fusion reactions inside stars and during stellar explosions, but were also formed during the dawn of the universe. Another core topic is dark matter: Hitherto unknown particles also come into consideration as possible candidates for this form of matter, which makes up approximately 80 percent of the total matter of the universe. The UGL2 serves as a development and test station for detection equipment, with which these particles can be detected. The detectors are used in large-scale research projects throughout Europe. These include international collaborations such as the experiment to build a search for dark matter CRESST, the future EURECA experiment, Double Chooz in France, and a future 50kt detector for neutrino astronomy.

An apparatus for the testing of low-temperature detectors is planned for the new UGL which can be operated at one hundredth of a degree above absolute zero, for example for the detection of dark matter particles. An additional main focus of the work in the UGL is the development and testing of liquid scintillators which emit light signals as soon as they detect a sought-after particle. In the already existing UGL scientists are working on the development and testing of such detectors.

Neutrinos occur extremely frequently on the earth, nevertheless they are extremely difficult to verify as they are neutral and rarely interact with their environment. The detectors must therefore be highly sensitive and react specifically to the sought-after particles. Furthermore, interfering background occurrences caused by muons must be suppressed. These particles are generated when cosmic rays strike the atmosphere.

This is why the development of new detection methods takes place in a protected environment. The UGL2 will be installed with 6 metres of protection underground: This corresponds to an equivalent of 15 metres underwater: This makes it possible to reduce the number of muons per square metre per second by approximately one third. Other components of the interfering cosmic radiation are blocked virtually completely.



More space for astroparticle physics at the Technische Universität München - cross section of the new Underground Laboratory

EVENTS

Day of Astronomy in the Deutsches Museum

This year's special day of Astronomy follows the motto of the International Year of Astronomy: "The Universe – yours to discover!" On **24 May 2009 the Deutsches Museum** and its partners offer a wide range of activities: At 11 am, the TUMLab opens its doors for live-observations of the night sky from an Hawaiian telescope – including the possibility to take images from celestial objects. Further, visitors are invited to build telescopes and to learn how to calculate the orbits of comets and asteroids.

Scientists of the Universe Cluster invite the visitors to guided tours on a variety of astronomical themes: "An expedition to our solar system", "Galaxies and black holes", "A journey to outer space", "Telescopes: From Galilei to Hubble". Each tour will take place twice that day. The tours are held in German, interested visitors are asked to register at the central hall of the museum.

The complete program and detailed scheduled are available at http://www.tumlab.de/astronomietag

Physics Spring in München

From 9 to 13 March 2009 the Ludwig-Maximilians-Universität hosted the spring congress of the DPG (German Physical Society). The congress was directed by Prof. Dr. Dorothee Schaile, who coordinates Cluster's Research Area B "Is there symmetry between matter and forces?". More than 1,300 experts joined this year's meeting that covered several priority topics as particle and gravity research, cosmology and radiation protection. The participants had the choice between more than 1,000 expert contributions.

Regarding the aim of the German Federal Government to reduce the emission of greenhouse gas CO_2 by 40 percent until the year 2020 (as compared to 1990), DPG president Prof. Dr. Gerd Litfin pleaded for enhanced efforts in energy research. This measure should be accompanied by prolonged running times of German nuclear power plants. Another key issue addressed by the DPG were the dramatic changes of physics education at German schools. Due to the substantial lack of physics teachers in Germany more and more teachers with other professional backgrounds are recruited. According to the DPG the "side-entry" initiatives hide risks regarding the quality of school lessons. At the same time, young people ready to study physics for a teaching profession might be demotivated. To provide high educational standards nevertheless, the DPG demands a German wide qualification program for side-entry teachers.

100 Hours of Astronomy at the Odeonsplatz

After endless months of grey and cold weather spring arrived just in time: Conditions for our „100 Hours of Astronomy“ event in the heart of Munich were almost perfect. From 3 to 5 Apri- about 5.000 people took the chance to visit a real observatory dome and to look through one of the many telescopes to watch the sun during daytime and the ascending moon and the Saturn in the evening.

The event was organised by the Universe Cluster and its industry partners Baader Planetarium and USM/Redshift. A main issue of the 100 hours of Astronomy was to make visitors aware about light pollution in the city - the reason why usually we cannot see many objects in the sky. The information panels of the Universe Clusters sparked off many discussion with scientists of ESO and the Universitätssternwarte München who answered the visitors' questions from „What happened before the Big Bang“ to „What will the future hold for our planet?“

The 100 Hours of Astronomy event was a global project within the framework of the International Year of Astronomy 2009 (IYA2009). It involved more than 100 countries with more than a million spectators who joined star gazing events and a 24-hour-online tour to 80 professional telescopes. The unprecedented ⇨ next page

success of these activities motivated the IYA's organisers to start a second edition in fall – called „Galilean Nights". On the weekend of 23 and 24 October 2009 amateur and professional astronomers will take to the streets and sidewalks again and point their telescopes to different targets: In that time of the year gas giant Jupiter will play the prominent part in the celestial theater.

http://www.100hoursofastronomy.org/photo-galleries/category/76-100
http://www.100hoursofastronomy.org/

PEOPLE

Start of New Research Group


Stefan Hofmann

"Particle Physics and the Early Universe" - that is the subject of the new Junior Research Group at the Universe Cluster . The group is led by Prof. Dr. Stefan Hofmann and will focus on research aspects related to particle physics in the early Universe, investigating the nature of dark matter and dark energy in particular.

The two dark components account for close to 95 per cent of the energy budget in the Universe and are subject to intense research. Both dark matter and dark energy are exciting aspects beyond the standard models of particle physics and cosmology. At the Universe Cluster, Stefan Hofmann's research will focus on cosmological challenges for fundamental theories.

Before joining the Excellence Cluster Universe, Stefan Hofmann was an assistant professor with the renowned Nordic Institute for Theoretical Physics and the Royal Institute of Technology in Stockholm, Sweden. Prior to that he was a research fellow in cosmology, particle and and string theory at the Perimeter Institute for Theoretical Physics in Ontario, Canada and at the Stockholm University.

LINKS

On Stuff ...

The name of the website speaks for itself: howstuffwork.com covers thousands of subjects from car engines to search engines, from cell phones to stem cells. The website tells you why you should be stressed in an earthquake and how to survive in the wilderness. The site claims that "there is no topic too big or too small for our expert editorial staff to unmask ... or for you to understand". So check it out - my favorite for the barbecue season: The top-5-tips for amateur beer brewers.

http://www.howstuffworks.com/

... and books

Books on the run: If you happen to find a book lying around on a park bench or a slightly more unusual place like the diving platform of a swimming pool, it may be a "released" book. That's how the makers of "bookcrossing.com" call it. The idea is to register books by special ID numbers and leave them in whatever places. By the ID the finder of a book can check who released it and leave a message on its new whereabouts - and put into the bookcrossing cycle again. You see: Books have more than just one story to tell!

http://www.bookcrossing.com/

Welcome to the Cluster!

Guests: Dr. Arunima Banerjee (Indian Institute of Science, Bangalore, 01 May 2009 - 25 May 2009 ++ Prof. Dr. Hector Rubinstein (COPS, Stockholm, Sweden, spring 2009) ++ Prof. Dr. Avraham Gal (Hebrew University of Jerusalem, Israel, 01 May - 31 July 2009) ++ Prof. Dr. Ikaros Bigi (University of Notre Dame, USA, 01 June - 30 June 2009) ++ Dr. Peter Petreczky (Broohaven Natl. Lab, Upton, USA, 29 June - 12 July 2009) ++ Prof. Dr. Julian Krolik (Johns Hopkins University, USA, 14 June - 26 June 2009) ++ Alan Chen (McMaster University, Canada, 01 July 2009 - 31 June 2010) ++ Prof. Dr. Neda Sadooghi (Sharif University, Teheran, Iran, 11 July - 25 July 2009) ++ Dr. Ekaterina Filippova, (Space Research Institute, Moscow, Russia, 1 June 2009 - 31 July 2009) ++ Dr. Bruce Elmegreen (IBM, USA, 21 June 2009 - 27 June 2009)
Postdocs: Dr. Guillaume Pignol (from 1 June 2009)

Shinya Wanajo – A new long-term guest at the Cluster


Shinya Wanajo

The Excellence Cluster Universe has a new long-term guest: Dr. Shinya Wanajo from the University of Tokyo. Arrived in the beginning of March he will stay for two years and support the group of Thomas Janka at the Max-Planck-Institut für Astrophysik. His research focuses mainly on the origin of elements that are synthesized in supernovae. Within this field he has been working on the nucleosynthesis of r-process species (gold, platinum, uranium, etc.) in core-collapse supernovae. Within the Cluster's research areas, Wanajo will be affiliated with RA G, which is engaged to answer the question how the universe was enriched with heavy elements.

Shinya Wanajo received his PhD in Astrophysics from the University of Tokyo and later worked there as a Postdoctoral Researcher at the Institute for the Physics and Mathematics of the Universe. Now, Wanajo is looking forward to be part of the Universe Cluster at Campus Garching.

Realisation: Ulrike Ollinger (Layout) · Barbara Wankerl (Conception & Text)

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Technische Universität München, Boltzmannstr. 2, D-85748 Garching, Fon: +49.89.35831-7100, Fax: +49.89.3299-4002, E-mail: info@universe-cluster.de, www.universe-cluster.de
Directors: Prof. Dr. Stephan Paul (TUM), Prof. Dr. Andreas Burkert (LMU)

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