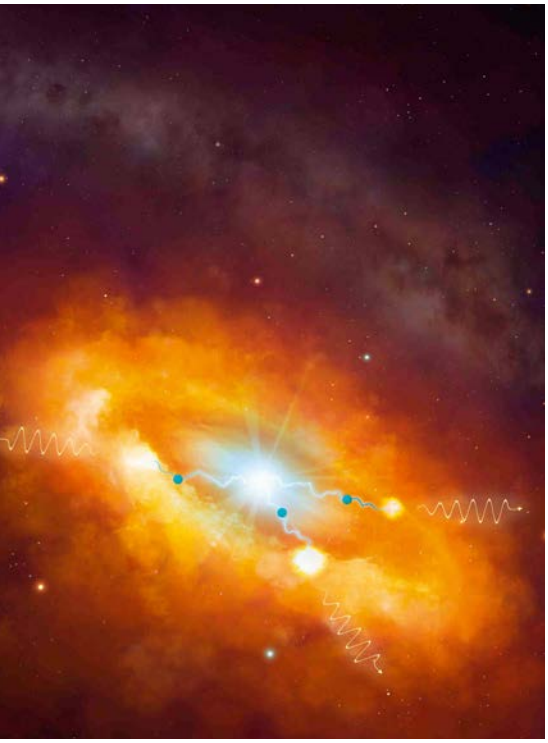
Extreme Energy Source at the Heart of the Milky Way

H.E.S.S. telescopes observe cosmic radiation accelerated by giant black hole



The Earth is constantly bombarded with high-energy particles from space. The particles in question are protons, electrons and atomic nuclei, and are referred to as cosmic radiation. Energy-rich gamma light is generated when the particles are accelerated. This process also takes place in the central area of our Milky Way. With the help of the H.E.S.S. telescopes in Namibia, researchers – including scientists from the Max Planck Institute for Nuclear Physics – have been observing the gamma rays transmitted in this way for a decade. They had already detected a highly compact point source and extended band of diffuse gamma radiation with energy levels in the teraelectron volt range (TeV = 10^{12} eV) some years ago, but now they have identified for the first time a source capable of radiating energy in the petaelectron volt range (PeV = 10^{15} eV). The scientists suspect that what is involved here is the Sagittarius A*, a supermassive black hole at the heart of the galaxy; this monster mass would be identical to the compact point source in the teraelectron volt range. Moreover, its gamma rays could interact with molecular clouds and thus also generate the diffuse band of gamma rays. The astronomers have eliminated other objects, such as a supernova remnant, a pulsar wind nebula and a compact cluster of massive stars, as possible energy sources in the petaelectron volt range. (www.mpg.de/10390310)

Extraterrestrial particle accelerator: This artist's depiction illustrates the processes that contribute to the formation of the high-energy gamma radiation. Protons (blue spheres), which are accelerated by the Sagittarius A* black hole (bright source in the center), interact with molecular clouds in the surroundings. This generates pions, among other things, which almost immediately disintegrate into gamma radiation photons (yellow waves). An image of the Milky Way in visible light is shown in the background.

Blood Test for Tuberculosis

Biomarkers may one day be able to predict the risk of developing tuberculosis. Between 1.5 and 2 million people die of tuberculosis every year, making it one of the infectious diseases with the highest global mortality rate. However, not everyone infected with tuberculosis becomes ill: fewer than 10 percent of those infected with the pathogen actually contract the disease. Up to now, it has not been possible to identify which of those infected would develop the disease. An international team of scientists, including researchers from the Max Planck Institute for Infection Biology in Berlin, have now developed a tuberculosis test that can predict with a reliability rate of around 75 percent whether an infected individual will go on to develop the disease. The results show that certain genes are active in the immune cells in the blood of those infected with tuberculosis who then later develop the disease. The blood test is expected to detect the activity pattern typical of potential tuberculosis patients, and could predict the onset of the disease as early as over a year before it develops. The researchers now plan to carry out clinical trials to test whether, once predicted, the onset of the disease can be prevented with the help of targeted treatment. (www.mpg.de/10377384)

Early prognosis: It is hoped that molecules in the blood will one day indicate to doctors whether a patient will develop tuberculosis.

Photos: Dr. Mark A. Garlick/H.E.S.S. Collaboration (top), Jonas Steengaard (bottom)

Compass in the Eye

Some mammals may be able to use the Earth's magnetic field for orientation, similar to birds

Foxes are more successful at catching mice if they pounce on their prey in a northeasterly direction. Scientists from the Max Planck Institute for Brain Research may have found an explanation for this extraordinary observation. They discovered light-sensitive molecules in the retinas of several mammalian species that can also register changes in the Earth's magnetic field. Dogs, wolves, bears, foxes and badgers have the molecule cryptochrome 1, while feline predators, such as cats, lions and tigers, do not. In primates, the molecule is found in the eyes of orangutans and some macaque species, for example. The researchers presume that, like some bird species, the animals in question use the cryptochrome 1 to sense the Earth's magnetic field. Migratory birds also have cryptochrome molecules in their eyes, allowing them to perceive the inclination of the magnetic field lines relative to the Earth's surface. However, the molecules react to the magnetic field only if they are simultaneously excited by light. In addition, birds also have microscopic ferrous magnetic particles in their cells to enable them to orient themselves based on the magnetic field. This kind of magnetite-based magnetic sense is also found in some mammals, such as *Fukomys*, a genus of common mole rats. (www.mpg.de/10319591)

Telltale magnetic field: Foxes may be able to locate their prey based on minute changes in the Earth's magnetic field.

Extortioners at the Negotiating Table

Participants in major political conferences could write a book about it: negotiations consistently fail due to the uncooperative and selfish behavior of individual participants. This can be observed in the often fruitless attempts to reach an international climate agreement over the years, as well as the current difficulties in getting the EU countries to agree on quotas for the acceptance of refugees. According to scientists from the Max Planck Institutes for Meteorology in Hamburg and for Evolutionary Biology in Plön, this is due to the fact that people prefer to have representatives who use extortion as a negotiating strategy. Such representatives keep their own contribution to the attainment of a collective target to a minimum, force others to compensate for any deficits through steadfast stonewalling and ultimately benefit most when the collective target is reached. The researchers discovered this with the help of a climate game and a model derived from game theory. In the experiment, 40 percent of the participants resorted to extortion. The findings give grounds for cautious optimism: extortion ultimately leads to a successful outcome in negotiations. All of the parties involved benefit when the objective of the negotiations is reached – the extortioners a great deal and their victims only marginally, but still. Despite the Machiavellian nature of this strategy, it could help in mitigating climate change. (www.mpg.de/10347602)

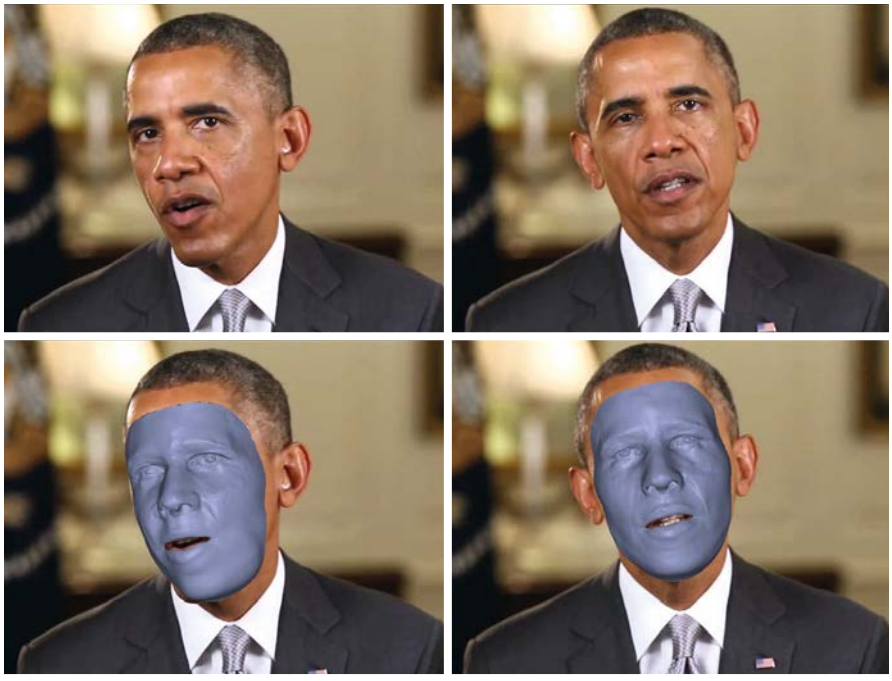
Political conferences are often the scene of fierce negotiations, with agreement often reached only at the last minute.

Photos: David Havel/shutterstock (top), dpa-picture alliance (bottom)

Animation Made Easy

Computer scientists in Saarbrücken produce realistic face models for films from video recordings

Today's film industry no longer relies solely on the skills of actors – when shooting has finished, the images of their faces are often edited on a computer. Such computer animation requires three-dimensional facial models known as face rigs, which, up to now, have been created using complex measuring techniques and manually inserted into the film scenes. Together with his team, Christian Theobalt, Leader of the "Graphics, Vision and Video" Research Group at the Max Planck Institute in Saarbrücken, has developed a new method that speeds this process up considerably. All the team needs are recordings from a standard video camera. The researchers use mathematical models to estimate the required parameters, such as facial geometry, reflection characteristics and scene lighting. Based on this, they can reconstruct an individual face on the computer so faithfully that it works like a complete face rig. With mathematical processes alone, the computer scientists can then give the actors different facial expressions. (www.mpg.de/10364192)

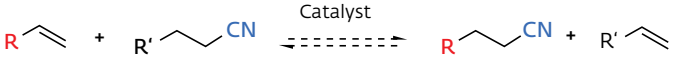


Suitable expressions: Based on ordinary video recordings like these images of US President Barack Obama, researchers at the Max Planck Institute for Informatics can create realistic facial models for computer animation and avatars. With the help of the models, they can also make the faces express emotions that were not shown in the original video.

A Hammer for Molecule Swapping

Chemists develop a versatile tool using a safe variant of hydrocyanation

Chemistry is like a toolbox. To synthesize drugs, plastics and dyes, chemists reach for various reagents in the same way that tradespeople reach for their tools. Scientists from the Max-Planck-Institut für Kohlenforschung (Coal Research) now present a new chemical tool that facilitates an important step in the synthesis process – hydrocyanation – and is less dangerous than the current standard method. What they have done is akin to inventing a hammer that can't hit the user's thumb. With the help of a suitable catalyst, the researchers succeeded in transferring one cyanide group – a functional group that creates numerous possibilities for the further processing of a substance – from one molecule to another. The donor molecule receives a double bond from its partner in the reaction. Up to now, this step in the synthesis process, which arises in the production of nylon, for example, required the use of toxic prussic acid (hydrogen cyanide). The new reaction is also easily reversible. The new hammer in the chemical toolbox not only prevents bruised thumbs, it also doubles as a pair of pliers. (www.mpg.de/10325265)



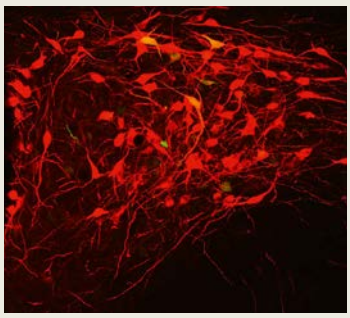
Molecular swap: Chemists from the Max-Planck-Institut für Kohlenforschung (Coal Research) have found a safe way to transfer the cyanide group (CN) from one molecule (R') to another (R). The donor molecule receives a double bond (=) from its partner in the reaction.

Photos: MPI for Informatics

Cuddle Hormone Relieves Pain

The name of the hormone oxytocin, which is derived from the Greek for quick birth, reflects one of its important functions: during childbirth, oxytocin triggers the contraction of the uterine muscles and initiates labor. Because oxytocin also plays a role in the regulation of social bonds, it is generally referred to as the cuddle hormone. The hormone is formed exclusively in the hypothalamus in the brain and is released into the bloodstream via the pituitary gland. Researchers from the Max Planck Institute for Medical Research in Heidelberg have now discovered, in the hypothalamus of rats, a small group of around 30 neurons that coordinate the release of oxytocin into the blood and also stimulate cells in the spinal cord. The nerve endings of the cells extend into the spinal cord, where they release oxytocin as a neurotransmitter. As the scientists have now established, the hormone reduces the sensation of pain in this way. They assume that these cells also exist in the human brain. The human oxytocin system, however, probably consists of more cells. (www.mpg.de/10353789)

Targeted release of hormones: A small group of oxytocin-producing neurons (red) coordinate the release of oxytocin into the blood and spinal cord.

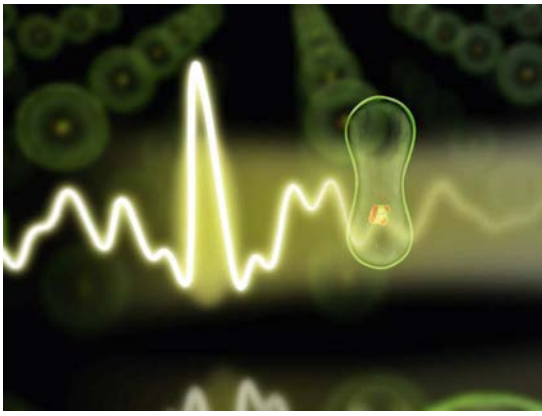


Photos: Christian Hackenberger (top), Eliava et al., 2016 (bottom)

Testing the Response Time of Electrons

Visible attosecond pulses can be used to measure the delayed reaction of electrons to light

Light could be the driving force that soon makes electronic components operate even faster. Physicists are therefore aiming to control electric currents in circuits in time with the light frequency. Insights gained by Eleftherios Goulielmakis and his research team at the Max Planck Institute of Quantum Optics may soon make it possible to control electrons more accurately using light. As the scientists discovered, electrons don't follow the electromagnetic forces of light immediately, but with a delay of 100 attoseconds. They determined this response time by exciting electrons in krypton atoms using attosecond pulses of visible light. By taking this delay into account, it may be possible to develop even more precise optical-electrical components. (www.mpg.de/9978880)



Electronic response time: Attosecond-long flashes of light make it possible to measure the delay with which electrons respond to the stimulating light due to their inertia. The characteristic form of the light wave arises because the attosecond pulse is formed from light of different wavelengths.

Immune Genes from Neanderthals

Early humans boosted the immunity of *Homo sapiens*

People who travel in foreign countries often find themselves fighting infections. This is because the immune system encounters pathogens there that are still unknown to it. The same principle applied to modern humans when they migrated from Africa to Europe around 50,000 years ago. The migrants clearly benefited from the local inhabitants who had lived there long before them: they mixed with the Neanderthals who had already been living in Europe for 200,000 years and adopted from them gene variants that gave them greater resistance to the local pathogens. Genetic analyses carried out by researchers from the Max Planck Institute for Evolutionary Anthropology in Leipzig have shown that people living outside Africa today inherited three immunoproteins from other early humans: two from Neanderthals and one from Denisovans, another early human species. The immunoproteins in question are known as toll-like receptors, which are expressed on the surface of immune cells and can detect components of bacteria, fungi and parasites. The gene variants of early humans reacted particularly sensitively to contact with pathogens. As a result, the migrants' descendants benefited from better protection against infection. However, the genetic legacy of early humans also makes us more susceptible to allergies today. (www.mpg.de/9819763)

Dark Taiga Lightens Up

Researchers predict that more deciduous trees will grow in boreal forests due to global warming

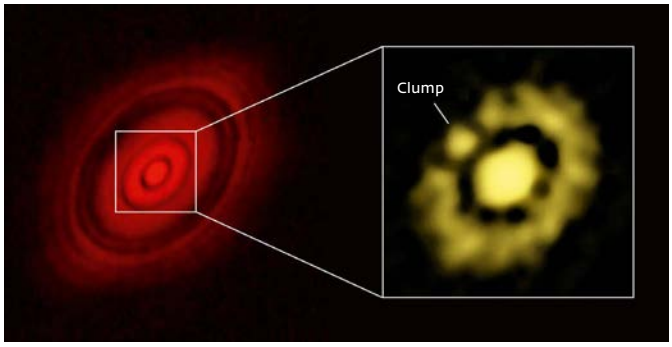
An international team headed by Susanne Tautenhahn from the Max Planck Institute of Biogeochemistry examined how boreal forests are changing as a result of global warming. "Due to climate change, fires caused by lightning, for example, are becoming more common and severe, and natural regeneration processes are being thrown off balance," explains Tautenhahn, who now works at the University of Jena. This sets a chain of events in motion: After a fire, it is difficult for coniferous trees to recolonize, as their relatively large seeds are limited in their capacity to disperse. Deciduous trees, in contrast, have relatively small seeds that are easily dispersed by the wind. This means that they can recolonize burn zones after large-scale fires considerably faster and, over the long term, become the dominant species in these areas. The reduction of the typical conifers, which store high levels of moisture at ground level, in turn further increases the likelihood of forest fires – a self-perpetuating cycle that results in lasting change in the ecosystem. (www.mpg.de/10315240)

The taiga transforms: Forest fires in boreal coniferous forests are set to increase due to global warming. Deciduous trees, which are currently found there only as pioneer species, could dominate in the long term.

Speedy Birth of a Planet

Astronomers observe a clump of dust in the disk around star HL Tauri

Planets form in disks of gas and dust. Images recorded using the VLA radio telescope array in New Mexico show the innermost parts of a planetary birthplace around the young star HL Tauri in unprecedented detail. A gigantic clump of dust with three to eight times the solar mass of the star is clearly visible. In the opinion of researchers from the Max Planck Institute for Astronomy, the existence of this clump of dust provides an answer to a fundamental question: How can planets form in the relatively limited period of time available for their growth? The new images point to a considerably faster birth process, as regions with a particularly high density of dust arise from certain flow patterns of the disk gas. Thus, planetary formation can unfold much faster there than in a homogeneous disk. The dense dust rings in which fragments like the aforementioned clumps can form are external indicators of this process. (www.mpg.de/10400125)



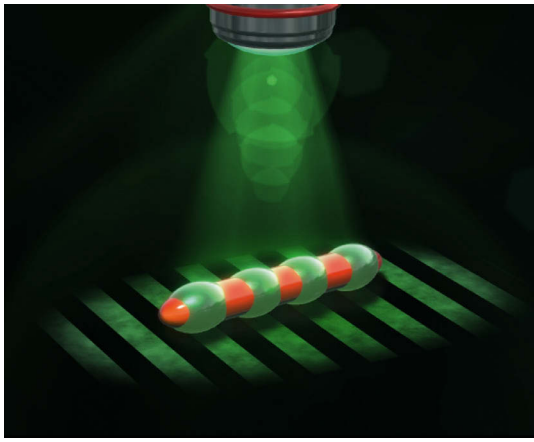
Cosmic delivery room: The protoplanetary dust disk around the young star HL Tauri. Left: earlier observations with the ALMA Observatory, which showed bright areas separated by gaps. Right: the new VLA images, in which additional structures of the inner rings are visible. The object marked as a clump is probably a region in which a planet is currently forming.

Photos: S. Tautenhahn/MPI of Biogeochemistry (top), Carrasco-Gonzalez et al.; Bill Saxton, NRAO/AUI/NSF (bottom)

Ciliates as Models

Swimming microrobots move through water like single-celled organisms

Ciliates can do amazing things: Because they are so tiny, the water in which they live appears to have the consistency of thick honey to them. Despite this, they are able to propel themselves through water thanks to the synchronized movement of thousands of extremely fine filaments, called cilia, on their outer skin. Researchers from the Max Planck Institute for Intelligent Systems in Stuttgart have now developed minute robots that, like the organisms on which they are based, are barely visible to the naked eye and can move through liquids in a similar way. In constructing their swimming microrobots, the scientists working with Peer Fischer used liquid crystal elastomers that expand when exposed to green light: a peristaltic movement results that propels the artificial ciliate when slivers of green light move over it. Although a mini-submarine that can navigate autonomously through the human body and detect and treat diseases may still be the stuff of science fiction, the use of a more developed version of these robots as tiny medical assistants at the end of an endoscope is entirely conceivable. (www.mpg.de/10327369)



Light-driven microswimmers: The material used in the nearly one-millimeter-long swimming body was specifically chosen for its ability to expand when exposed to light. This causes wave-shaped protrusions to form along the microswimmer and drive it in the opposite direction when green slivers of light move over its surface.

Hardship Linked to More Risk-Taking in Old Age

In most Western countries, people's propensity to take physical, social, legal or financial risks decreases with age. In countries like Nigeria, Mali and Pakistan, in contrast, risk behavior remains constant into old age. This is the finding of research carried out by scientists from the University of Basel and the Max Planck Institute for Human Development in Berlin. A comparison of data from 77 countries revealed a clear correlation between risk behavior and such factors as low per-capita income, greater income inequality and a high murder rate. The researchers suspect that this is because people in countries where resources are scarce have to compete more fiercely with each other than people in wealthy countries and countries with good social welfare provisions. (www.mpg.de/9818736)

Graphic: Alejandro Posada (top); photo: N. Hafer/MPI for Evolutionary Biology

Fighting for the Host

With the exception of the intrepid Jerry in the "Tom and Jerry" cartoons, no mouse would ever dream of voluntarily remaining in the immediate vicinity of a cat. Some mice, however, do just that, and even appear to be drawn to cats. Behind this strange behavior lies a parasitic protozoan called *Toxoplasma gondii*, which alters the mouse's behavior to its own ends: foolhardy mice are more likely to fall victim to predators, and this boosts the spread of the parasite. Other parasites also manipulate the behavior of their host. But what happens when parasites at different stages of development, or even different species of parasites with competing objectives, infect a single host? Scientists from the Max Planck Institute for Evolutionary Biology in Plön have discovered that parasites sabotage each other and disable the other's manipulation programs – even if they originate from different species. According to the researchers, in the case of conflicts of interest, the parasite that is in the infectious state and needs to change hosts has the upper hand. The researchers discovered this by studying parasitic tapeworms and threadworms, which first infect copepods and then fish. This behavior could also have medical consequences, for instance if parasites circumvent the manipulation programs of pathogens, thus hindering their spread. (www.mpg.de/9958046)

Conflicting goals: Several parasites often infect one and the same host, as shown here in a copepod, which is infected with the tapeworm *Schistocephalus solidus* (green) and the threadworm *Camallanus lacustris* (blue). If the parasites are at different stages in their development, they try to influence the behavior of the crustacean in opposing ways.