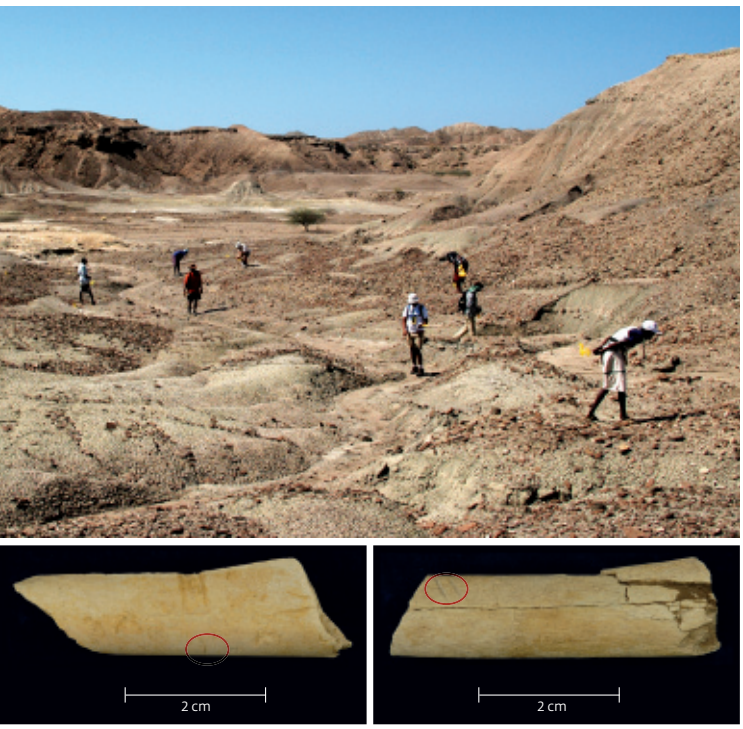
What Makes Humans Human?

Human ancestors were already using stone tools to cut up meat 3.4 million years ago



Photos: Dikika research project

Eating with a knife and fork is not merely an indicator of good behavior. Paleoanthropologists regard the crafting of tools to cut up meat as a criterion that distinguishes human beings, and ascribe it exclusively to the genus *Homo*. It appears, however, that the human ancestor *Australopithecus afarensis* was already using tools to eat. Shannon McPherron from the Max Planck Institute for Evolutionary Anthropology in Leipzig and an international team of researchers discovered 3.4-million-year-old bones in the Afar region in Ethiopia that bear unambiguous cut and percussion marks.

At that time, the only inhabitants of the area were representatives of the *Australopithecus afarensis* species, which also includes the famous "Lucy." The researchers, however, have not found any tools and therefore do not yet know whether *Australopithecus afarensis* actually made tools or only collected and used sharp-edged stones. The oldest stone tools discovered to date are 2.5 to 2.6 million years old and were probably worked by early humans of the species *Homo habilis*. (Nature, August 12, 2010)

The remains of a feast: Cut, scrape and percussion marks (red marking) on fragments of the thigh bone of possibly a goat (left) and the rib of a cow-sized hoofed animal (right).

Carbon in a New Balance

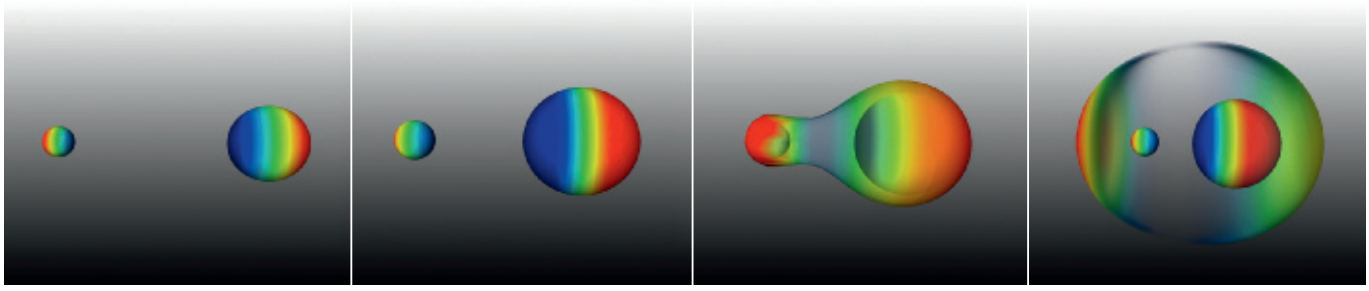
Climate forecasts might become more precise and more reliable in the future thanks to new findings on the role of terrestrial ecosystems in the global carbon cycle. International teams of researchers headed by the Max Planck Institute for Biogeochemistry in Jena have presented two wide-ranging analyses of measurements from 60 stations distributed across the world. The results are precise assessments of how ecosystems might react to climate change. For example, the rate at which plants photosynthesize – that is, fix carbon dioxide from the atmosphere – hardly varies with temperature fluctuations in most ecosystems. On the other hand, on 40 percent of the Earth's vegetated surface, photosynthesis reacts very sensitively to the amount of precipitation. Transpiration, whereby flora and fauna release carbon dioxide, increases less than previously assumed when the temperature rises. Furthermore, its dependence on temperature remains similar throughout the world, even in such diverse ecosystems as the tropical savanna and the pine forests of Finland. (Science Express, July 5, 2010)

Numerous measuring stations (red) around the world record the exchange of carbon dioxide and water in different ecosystems.

Graphic: Ulrich Weber – Max Planck Institute for Biogeochemistry

Kicks for Black Holes

Researchers are using a simple physical model to explain why the speed of these exotic objects slows down after they collide

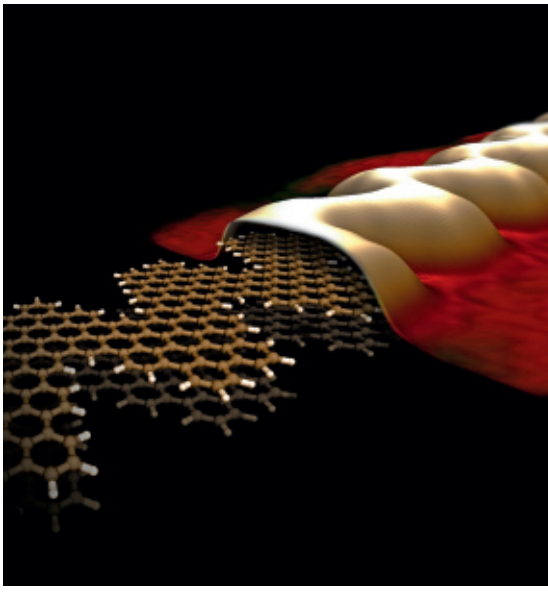


A kick-about in space: Researchers have simulated the collision of black holes on a computer and shown that the newly formed black hole is initially deformed. A bigger impulse is delivered to compensate for this asymmetry and to achieve an energetically more favorable spherical shape. This "anti-kick" slows the black hole down somewhat, causing it to move forward at a lower speed than previously.

Kicking is not restricted to football: When black holes collide and merge, the resulting black hole shoots on through space at speeds of up to several thousand kilometers per second. Sometimes, however, the speed decreases. Researchers working with Luciano Rezzolla from the Max Planck Institute for Gravitational Physics explain this using the gravitational waves that are radiated in the merging process. They simulated a frontal collision between two black holes, one fast-moving and small, the other slow-moving and large. Both radiated gravitational waves in the direction in which they were moving. As the larger black hole provides the stronger impulse, the merged black hole moves in its direction after the collision – which is the "kick". The black hole thereby created is initially not completely round, however, but has a "bump" where the smaller black hole was submerged into the larger. A pulsing movement smoothes this asymmetry, while more gravitational waves radiate toward the bump than away from it. The gravitational waves exert an additional impulse which creates a recoil. This "anti-kick" causes the resulting black hole to slow down slightly. (Physical Review Letters, June 3, 2010)

Carbon Ribbons

Carbon could emerge as the silicon of the future. It might be possible to create very small and powerful microchips from this material if it were to take on the properties of a semiconductor. A team working with scientists from the Max Planck Institute for Polymer Research and Empa, the Swiss Federal Laboratories for Materials Science and Technology, have now achieved this. The researchers used a simple chemical method to create narrow ribbons of graphene – single layers of carbon atoms – on a metallic substrate. For this purpose, they manufactured molecules from which they fabricated the graphene ribbons. As these are no more than a few nanometers in width, they take on semiconducting properties, which makes them promising candidates for future applications in electronics, particularly since their properties – according to width and edge-type – can be manipulated in a targeted manner. (Nature, July 22, 2010)



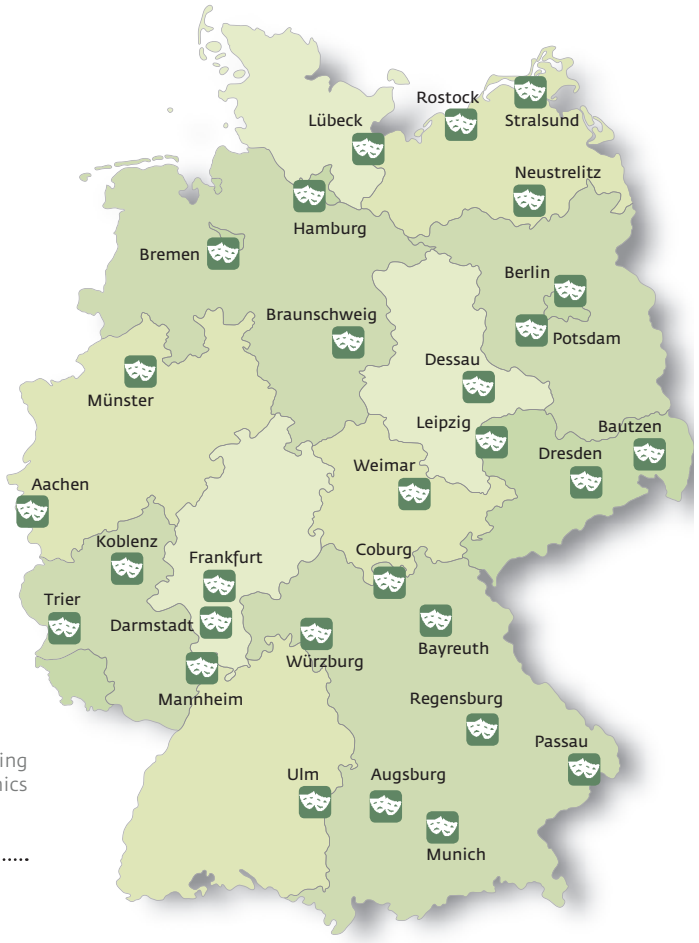
A material for nanoelectronics: Graphene ribbons are easily fabricated on metallic surfaces. Thanks to their semiconducting properties, it might soon be possible to make nanotransistors for electronic applications.

Graphics: MPI for Gravitational Physics (top), Empa (bottom)

The Phenomenon of the Opera

Cultural programs improve economic growth

When budgets are limited, authorities are quick to economize on cultural amenities. This might turn out to be counterproductive. A group of researchers at the Max Planck Institute for Economics in Jena has found that cultural events make cities and regions more interesting for highly qualified individuals – and thereby encourage economic growth in the area. The researchers evaluated regional data from Germany and determined that the number of highly qualified employees (defined as those with a university education) rose with the region's proximity to a baroque opera house. These highly qualified people, in turn, are largely responsible for the stronger economic growth these areas experience.

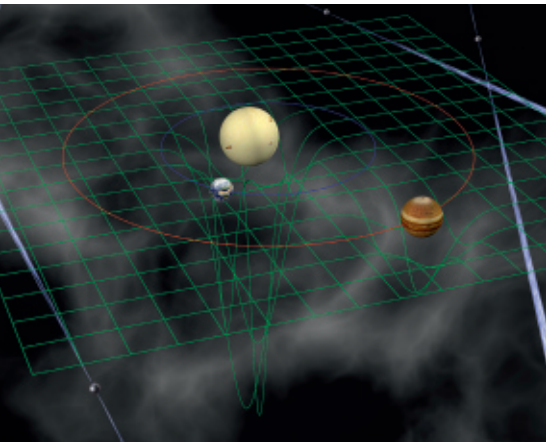


The locations of the 29 baroque opera houses that formed the starting point for the study conducted by the Max Planck Institute for Economics

Map: Heblich et al. (top), graphic: David Champion

Pulsars for Weighing Planets

Even high school students learn how to weigh planets. They apply Newtonian mechanics and determine the masses from the orbits of the planets' moons. Now, an international team led by David Champion from the Max Planck Institute for Radio Astronomy in Bonn has used a completely different method, which is not only accurate to 0.003 percent of the Earth's mass, but also allows the planets to be weighed together with their rings and moons. Astonishingly, the technology uses pulsars – dead stars that rotate extremely rapidly around their axes while transmitting very regular radio pulses. As the Earth moves around the Sun, the rhythm of the radio signals is distorted on Earth. The researchers calculate from this when the signals arrive at the barycenter of the solar system. The sequence of signals is completely regular only if the researchers know the exact location of the barycenter. This, in turn, depends on the masses of the planets. In an iterative process, the researchers adjust the planet masses until their calculations yield a regular rhythm at the barycenter. The procedure could supply important data for future space travel missions. (Astrophysical Journal, August 23, 2010)



The Sun and the planets are embedded in a time-space grid. Researchers can now determine their mass with pulsar signals (blue rays).

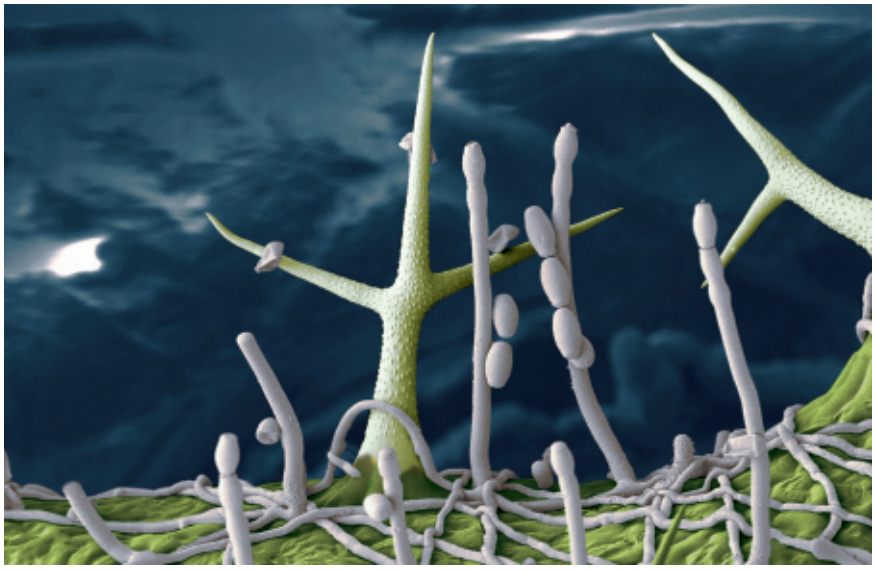
Today Paris, Tomorrow Tokyo

Frequent fliers know all about it: When the internal clock is upset, the whole body is affected. This is because we have not just one inner clock, but an entire network of clocks in our organs. This network coordinates physiological processes in the body such as heartbeat, temperature, sleep requirements and hormone levels. Jetlag disrupts the rhythm of the whole mechanism. The inner clocks in the organs adapt to changes in the external environment at different speeds. According to scientists at the Max Planck Institute for Biophysical Chemistry in Göttingen, the inner

Expensive Defense

Plants must always pay a high price for resistance to disease

Every amateur gardener is familiar with the dilemma: The largest and most beautiful roses are the most susceptible. The small and insignificant ones, on the other hand, are more resistant to pests. The high cost of self-defense is the reason for this. Scientists working with Detlef Weigel at the Max Planck Institute for Developmental Biology in Tübingen have discovered a variant of the ADC6 gene with which mouse-ear cress, *Arabidopsis thaliana*, defends itself against bacteria, fungi and insects. The gene makes the plants resistant to different pests, but it also interferes with the growth of leaves and seeds. In nature, only some 20 percent of the *Arabidopsis* plants carry the variety of the gene that provides a defense against pests. In years or habitats in which enemies are rife, these plants have an advantage over fellow members of their species, but conversely, when there are few pests, most of the other individuals grow and reproduce faster. (Nature, June 3, 2010)



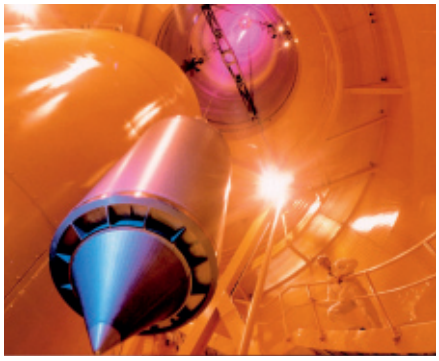
Arabidopsis with powdery mildew. The web of fungal hyphae forms rod-like reproductive organs with spores that are distributed by the wind. The plant's immune system defends it against the powdery mildew. The purpose of the spines on the surface of the leaves is to protect it from insects.

Photos: MPI for Developmental Biology – Jürgen Berger (top); ZARM – University of Bremen (bottom)

clock of the adrenal glands plays a key role in the adjustment to a new circadian rhythm. Depending on the time of day, the adrenal gland secretes corticosterone (cortisol in humans) which helps the body to adapt more quickly to jetlag. When mice, for example, were administered the active agent metyrapone, the release of corticosterone was delayed and the rodents adapted more quickly to the disturbed circadian rhythm. Whether taking metyrapone actually helps with jet lag and is free of side-effects, however, must first be substantiated in field trials and in sleep laboratory tests. (Journal of Clinical Investigation, June 23, 2010)

Quantum Gas in Free Fall

A sensitive measuring device must not be dropped – because this usually puts an end to its precision. However, that is exactly what a team of researchers, which included scientists from the Max Planck Institute for Quantum Optics, did. Surprisingly, their intention was to make the instrument more sensitive. The team working with physicists from the University of Hanover allowed a device, in which they generated a weightless Bose-Einstein condensate (BEC), to plummet down a drop tower at the University of Bremen. The particles in a BEC lose their individuality and can be regarded as super particles. The researchers want to use such an ultra-cold quantum gas at zero gravity to construct a very sensitive device with which to measure the Earth's gravitational field – in order to detect mineral deposits, for example. They could also use the procedure to test the equivalence principle. While every student is taught that it is irrefutable, proof has not been presented to date. According to the equivalence principle, gravitational mass corresponds to inertial mass, so that all objects in a vacuum fall at the same speed. (Science, June 18, 2010)

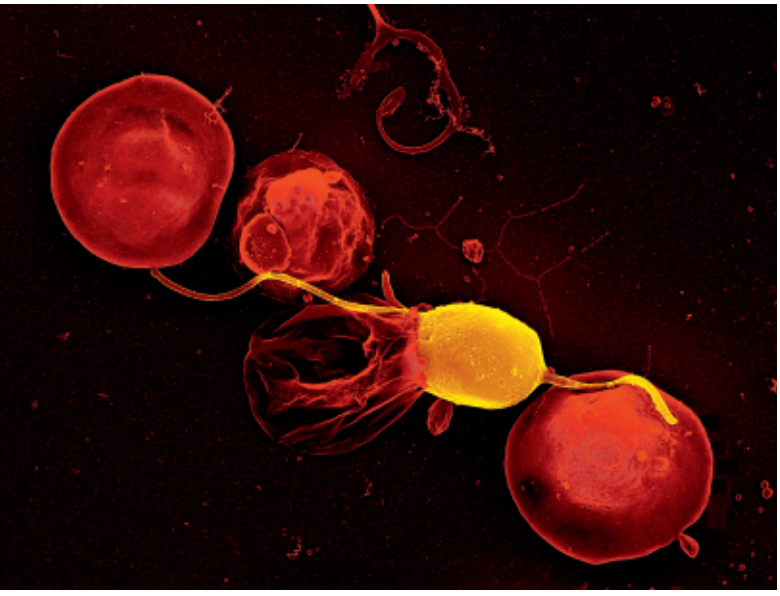


Fall height experiment: The capsule for the Bose-Einstein condensate

Immunity to Malaria

Antibiotics protect mice from malaria

An antibiotic against a non-bacterial pathogen – initially baffling, but it actually works. According to researchers at the Max Planck Institute for Infection Biology in Berlin and at the University Hospital in Heidelberg, antibiotics in tablet form could one day act as a vaccine against malaria. They have discovered that no disease-causing malaria pathogens appeared in the blood of mice which had been given the antibiotics clindamycin or azithromycin for three days. And there's more: They also develop a lasting immunity to subsequent infection.



The infectious stages of the malaria pathogen are transmitted by a bite from an infected mosquito. The vermiform sporozoites attack liver cells.

The scientists suspect that the active agents could work on humans in the same way. The antibiotics block an organelle of bacterial origin in the parasites, the apicoplast, which allows the pathogens to enter the cells. Although the apicoplast is blocked, the infectious stage of the malaria pathogens initially reproduces in the liver. This means that the immune system in the liver is confronted with all the markers of the pathogens and builds up immunity. The disease-causing stage, however, is subsequently unable to enter the blood cells and trigger the typical symptoms of the illness. (Science Translational Medicine, July 14, 2010)

Ye Shall Know Them by Their Gestures

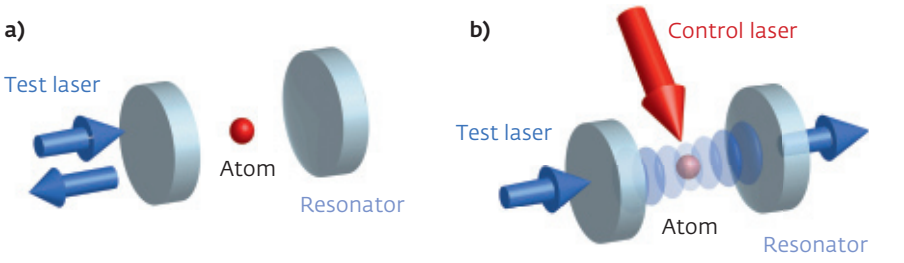
Media appearances by today's politicians are meticulously planned. Political advisors even recommend that their charges gesticulate with their right hand, because in many cultures, "good" and "evil" are associated with "right" and "left." An investigation by the Max Planck Institute for Psycholinguistics in Nijmegen in the Netherlands reveals, however, that humans do not associate positive messages with a certain side of the body, but with the side that is dominant for them personally. Consequently, right-handed people associate honesty or intelligence with their right-hand side, while left-handed people associate these characteristics with their left-hand side. Scientists at the Institute analyzed the spontaneous gestures made by the American presidential candidates in 2004 and 2008 in their speeches for their positive and negative content. According to this analysis, the right-handed candidates George W. Bush and John Kerry supported positive statements with their right hand, but they accompanied negative statements mainly with the left hand. This was exactly reversed for Barack Obama and John McCain, who are both left-handed. John McCain, for example, emphasized negative content with his right hand twelve times more frequently. (PLoS ONE, July 28, 2010)

Show me your gestures and I'll tell you if you are lying: Right-handed George W. Bush associates positive messages more frequently with gestures by his right hand, but negative messages with gestures by his left hand. Left-handed Barack Obama uses his hands in the opposite way.

Photos: SPL – Agentur Focus (top), dpa Picture-Alliance (2. bottom)

Quantum Transistors for Photons

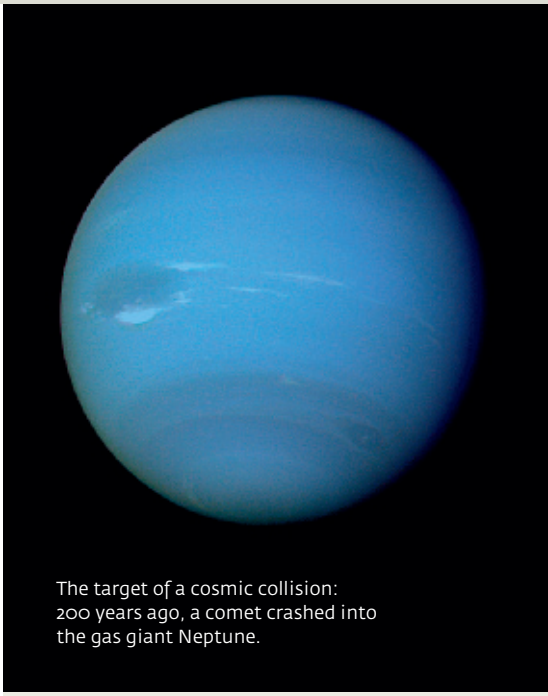
In the future, light might do the job that electrons do today, processing huge quantities of data quickly and reliably in computers. Physicists at the Max Planck Institute for Quantum Optics have constructed an optical transistor using principles that could allow even the tiniest logic elements to work in a computer of the future. The researchers use a laser to control whether a single atom allows a test laser to pass between two mirrors, in the same way as a control voltage regulates the flow of current through a transistor. They draw on a quantum mechanical interference effect called electromagnetically induced transparency. As long as the controlling laser remains switched off, the atom interacts with the test laser in the space between the mirrors and prevents it from shining through the system. Then the control laser manipulates the atom and mirror system so that it no longer interacts with the test laser – it becomes invisible to the test laser and allows it to pass through again. Up to now, it has been possible to demonstrate the effect only with a large quantity of atoms. (Nature 465, 755-758 (2010) doi:10.1038/nature09093)



Light switches light: The physicists in Garching were able to adjust the resonator-atom system so that it did not allow the test laser to pass (a). They then used the control laser to switch it to be transparent (b).

The Proton – Smaller Than It Was Thought to Be

Sometimes, big problems can be very small. The problem physicists are now grappling with measures just 0.0350 millionths of a millionth of a millimeter. This is exactly how much smaller a proton, the nucleus of a hydrogen atom, is than was previously thought. Instead of 0.8768 femtometers, it measures 0.8418 femtometers. This measurement was made by an international team of researchers working with physicists at the Max Planck Institute for Quantum Optics in experiments at the Paul Scherrer Institute in Switzerland. These experiments are ten times more accurate than all the previous experiments. The researchers examined tiny subtleties in the atomic structure of muonic hydrogen in which, not an electron, but a much heavier muon orbits the nucleus. It is only with the heavier muon that the atom can be observed to assume states in which the electron (or the muon) sometimes resides in the atom nucleus, while in other states it avoids the nucleus. This leads to a tiny energy differential between the states that depends on the size of the nucleus or that of the proton. The physicists used a laser with an extremely precisely defined wavelength to measure the energy differential and calculated the size of the proton from it, leaving physics with some tough problems: at least one natural constant has now changed, and the calculations of quantum electrodynamics must be reviewed. This theory is considered very well proven, but its predictions do not match the current measurements. (Nature, July 8, 2008)



The target of a cosmic collision: 200 years ago, a comet crashed into the gas giant Neptune.

Struck by a Comet

The large planets in the solar system are repeatedly the target of cosmic bombs – comets and planetoids. The projectile that probably resulted in the extinction of the dinosaurs on the Earth 65 million years ago is legendary. And in 1994, fragments of the Shoemaker-Levy 9 comet smashed into Jupiter's atmosphere. Scientists at the Max Planck Institute for Solar System Research recently discovered that Saturn was hit around 230 years ago. Working with Max Planck colleagues in extraterrestrial physics and the French Lesia Observatory, this group has now made another find: 200 years ago it was Neptune's turn to be a target. In data from the Herschel Space Observatory, they noticed a characteristic distribution of carbon monoxide in the atmosphere of the gas giant. There were higher concentrations of carbon monoxide in the stratosphere than in the troposphere below it. This increased accumulation can only be explained with an external source, such as the impact of a comet. When this happens, the "dirty snowball" breaks up and, over the years, the carbon monoxide fixed in the comet ice is distributed from the location of the collision throughout the stratosphere. (Astronomy & Astrophysics, online, July 16, 2010)

Photo: NASA (top), graphic: MPI for Quantum Optics