The alchemy of neutron stars

Researchers have discovered that collisions between these cosmic objects actually produce heavy elements

On August 17, 2017, when astronomers observed gravitational waves from two merging neutron stars together with a kilonova in the optical range at the same location, it was nothing short of a sensation. At that time, it was assumed that such a cosmic collision and the succeeding explosion would produce heavier elements such as iron. Researchers, including scientists from the Max Planck Institute for Astronomy in Heidelberg, have now actually identified such an element in the spectra that appeared at that time: strontium, which was evidently produced during the so-called r-process. This rapid neutron capture appears to be of key importance for the production of heavy elements. The kilonova generated a bubble that expanded at 20 to 30 percent of speed of light. The quantity of newly-formed strontium in the expanding shell amounts to around five Earth masses. With this discovery, the scientists have now demonstrated beyond all doubt that the fusion of two neutron stars creates the conditions for the r-process in which new elements are formed. (www.mpg.de/14032050)

Collision in space: this artist's impression shows the fusion of two extremely dense neutron stars. Events of this type are followed shortly afterwards by a kilonova.

Dual-class society in the Bronze Age

Grave finds provide evidence of stable hierarchies on South German farms

A research team whose members include scientists from the Max Planck Institute for the Science of Human History uncovered early signs of social inequality while investigating Bronze Age cemeteries in the Lech Valley near Augsburg. These showed that there was a significant divide between rich and poor as far back as 4,000 years ago – both within households and between generations. The families of wealthy landowners were buried with weapons and elaborate jewelry. However, the grave sites also contained the bodies of poor people who came from the region and were part of the household but were not related to the family. It is not clear whether these were servants and maids, or perhaps even slaves of some kind. The findings suggest the existence of a social structure of the type known to have existed in ancient Greece and Rome. However, the families studied in the Lech Valley lived more than 1500 years earlier. Another interesting fact is that the women of these families were not local but came from some 400 to 600 kilometers away. The study was also the first to reconstruct family trees spanning several generations. (www.mpg.de/13979712)

Valuable indicator: the ornamental dagger found in a Bronze Age grave south of Augsburg shows that the person buried there enjoyed a high social status.

Graphic: University of Warwick/Mark Garlick/ESO (top); photo: K. Massy (bottom)

In good company

Large brains are not a requirement for the formation of multilevel social groups

The social structure of some fowl populations is more complex than originally thought. Researchers at the Max Planck Institute of Animal Behavior have discovered that vulturine guineafowl form stable social units. These African birds, which are the size of turkeys, must therefore be able to keep track of individuals in their own and in other groups – even though they have relatively small brains. This is the first time that such a social structure has been described among birds. The researchers spent one year tracking the social relationships of more than 400 birds, using GPS transmitters to record their positions round the clock. During this period, they discovered that each bird lives with 13 to 65 others of its species. Although the guineafowl regularly came into contact with other groups during the day, they did not change group. (www.mpg.de/14071193)

Vulturine guineafowl live in close-knit groups. This allows for mutual coordination on their journeys through the countryside.

Staying healthy in old age is a lifelong task

Changing the diet of elderly mice can no longer improve their health

How can we stay fit and healthy for as long as possible as we grow older? Researchers into aging have a simple answer: eat small amounts and eat healthily. But when do we have to start doing this if we wish to reap the benefits? And is it sufficient if we only manage to keep it up for a short time? Researchers led by Linda Partridge, Director at the Max Planck Institute for Biology of Ageing, conducted animal experiments that involved putting young and old mice on diets – with varying degrees of success. Mice live longer and enjoy a healthier old age if they are given 40 percent less to eat from the time they reach adulthood. These mice are given food enriched with vitamins and minerals in order to prevent malnutrition. However, waiting until they reach old age before reducing their food intake has hardly any effect on their life expectancy at all. Moreover, short periods of fasting do not provide lasting protection: if the mice eat the same quantities afterwards as they did before, their life expectancy once again declines. The reason for this appears to be that the fatty tissue can remember the diet consumed over the preceding years. This tissue is no longer able to adapt the activity of its genes to the change in diet. The researchers assume that the results can also be applied to humans. (www.mpg.de/14021239)

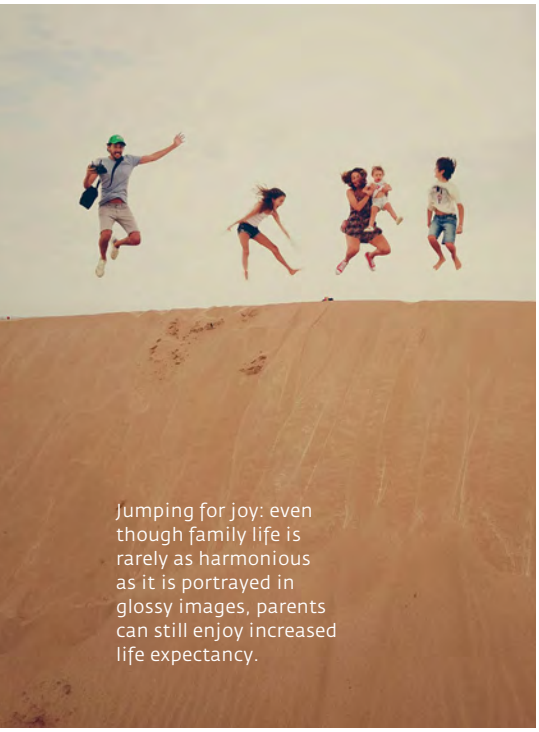
Heavyweight at the heart of Abell 85

In space, black holes appear in various sizes and masses. The record is now held by a specimen in the Abell 85 cluster of galaxies, where a black hole 40 billion times the mass of our Sun sits in the middle of the central galaxy Holm 15A, which is located 700 million light years away. Researchers at the Max Planck Institute for Extraterrestrial Physics and the University Observatory in Munich discovered it by evaluating photometric data and spectral observations. The astronomers had already suspected that Holm 15A must be something special: the heart of this gigantic galaxy – one of the largest in existence – appears extremely faint and diffuse through the telescope. The dimmer the center of the galaxy, the denser the black hole. It is highly likely that the massive black hole in Holm 15A originated when two galaxies collided and the black holes at their hearts merged. (www.mpg.de/14210061)

Record in a galaxy cluster: Abell 85, taken at the Ludwig Maximilian University of Munich's observatory on the Wendelstein. The bright central galaxy Holm 15A has an extended, diffuse core. This conceals a black hole with 40 billion times the mass of our Sun.

Photos: James Klarevas (top); Matthias Kluge/USM/MPE (bottom)

Children increase life expectancy



Jumping for joy: even though family life is rarely as harmonious as it is portrayed in glossy images, parents can still enjoy increased life expectancy.

There appears to be a link between people's life expectancy and the number of children they have: those who have one or two biological or adopted children usually live longer than those who have none. A study carried out by Kieron Barclay from the Max Planck Institute for Demographic Research and a Swedish colleague investigated the reasons for this. Their analysis revealed that parents are better off right from the start than people who have no children. In simple terms: healthy, well-educated and prosperous men and women are more likely to find a partner and have the resources to start a family than those in poorer circumstances. Moreover, the data suggests that most people change their lifestyle when they have children: mothers and fathers adopt healthier behaviors and are less accident-prone than childless people, and they are also less likely to suffer from cardiovascular disease. (www.mpg.de/14064449)

Imagined movements can alter the brain

Computer interfaces have a structural impact on brain substance

Brain-computer interfaces work on the principle that just thinking about performing a task triggers measurable changes in brain activity. These signals can be read and automatically converted into control signals, which can then be used to operate a prosthesis, for example. Researchers from the Max Planck Institute for Human Cognitive and Brain Sciences and their colleagues have now discovered that these thoughts can leave traces in the brain. During this study, the test subjects were set the task of imagining specific movements of their arms and feet. The participants used the brain-computer interface to fine-tune these imaginary movements. Their brains were examined before and after the training using magnetic resonance tomography (MRT). The researchers actually found measurable changes in the part of the brain responsible for motor tasks after just one hour of training. This method could be suitable for rehabilitating patients who have suffered a stroke or brain tumor. (www.mpg.de/14090102)

Less is more

Whales and dolphins developed from land-dwelling ancestors approximately 50 million years ago. Nowadays, these air-breathing mammals spend their whole lives in the sea. Researchers at the Max Planck Institute of Molecular Cell Biology and Genetics and the Max Planck Institute for the Physics of Complex Systems have now identified 85 genes that the aquatic mammals lost as they evolved. Some of them simply became superfluous. Whales and dolphins lack a gene involved in the secretion of saliva, for example – they do not require saliva to swallow food underwater. The loss of other genes is actually an advantage: the lack of one specific gene means that they are now better able to repair DNA damage caused by the considerable oxygen deficiency that occurs when they are diving. Since losing other genes, the animals are presumably protected from blood clots and lung problems under water. They have also lost all the genes required for the production of the sleep-regulating hormone melatonin. This might be the reason why these animals can sleep with just one hemisphere of the brain, while the other hemisphere coordinates their movement and breathing. Sometimes the loss of genes can drive evolution forward. (www.mpg.de/13915292)

Whales and dolphins evolved from land-dwelling ancestors. Some of their genes were not required for aquatic life.

Photo: Juan Cruz Mountford/unsplash; graphic: Carl Buell, John Gatesy

Every mouse is different

Scientists measure the personalities of rodents

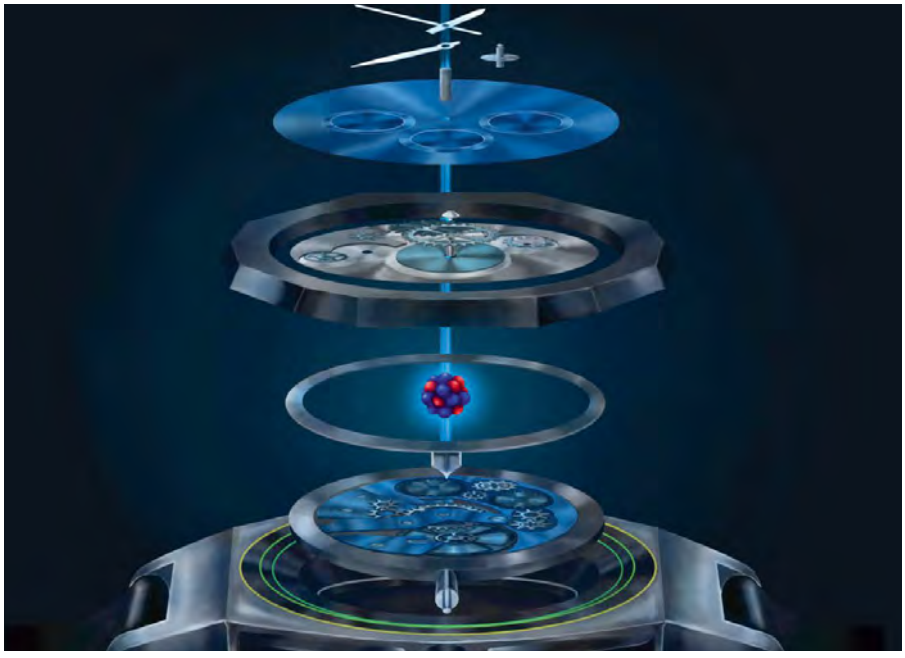
Some mice are curious and explore any new hiding place. Others are more fearful and prefer to stay in their nest.

Animals have personalities, too: some are brave, others fearful; some are loners, while others love company. Human character can be analyzed directly using multiple-choice tests; in animals, this is considerably more difficult. Scientists at the Max Planck Institute of Psychiatry in Munich have now developed a method of calculation with which they can measure the personalities of mice. The researchers analyzed 60 different behaviors in videos and used an algorithm to search for stable personality traits. While human character is commonly described on the basis of five categories, scientists found four categories in mice. These character traits remain stable over time, even when the animals live in different social groups. Furthermore, genetic analysis showed that various characteristics are associated with different types of gene activity in the brain. The results form the basis of a more precise, personalized form of psychiatry, as researchers are now able to investigate how character is influenced by genes, medication and age. (https://www.mpg.de/14109680)

Nuclear clocks get to the core

Excitation of thorium-229 facilitates greater precision in timekeeping

If global satellite navigation systems such as GPS or Galileo are to measure distances to within a few centimeters rather than to the nearest meter, they need more precise nuclear clocks. A team led by the Ludwig Maximilian University in Munich, whose members include researchers from the Max Planck Institute for Nuclear Physics, has now taken a step towards realizing these enhanced timekeepers. The physicists have succeeded in exciting oscillations in thorium-229 nuclei. These nuclei achieve significantly higher frequencies than the electrons that have served as the timekeepers in nuclear clocks until now. At the same time, nuclear excitation in this thorium isotope requires much less energy than in other elements and can be achieved using compact lasers. It should therefore be possible to integrate the necessary technology in nuclear clocks. (https://www.mpi-hd.mpg.de/mpi/en/public-relations/news/news-item/on-the-way-to-a-nuclear-clock)



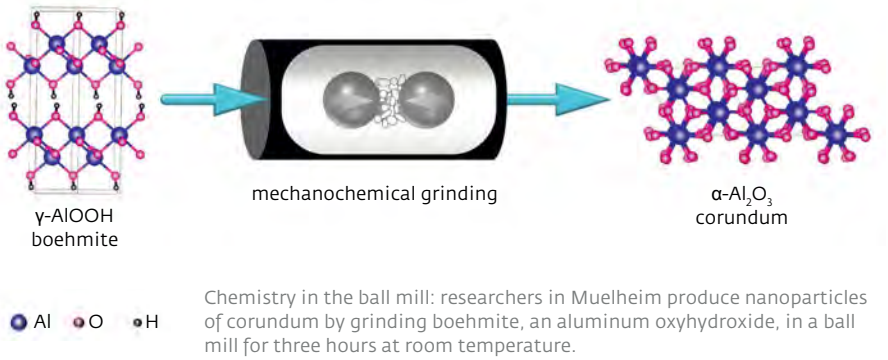
Assembly instructions for a nuclear clock: by exciting thorium-229 nuclei, scientists have created the conditions required to manufacture more accurate nuclear clocks that could also make satellite navigation more precise.

Photo: MPI for Molecular Genetics; graphic: Daria Bilous

Nanoceramics from the ball mill

Tiny corundum particles for automotive catalysts and stable ceramics can now be easily produced

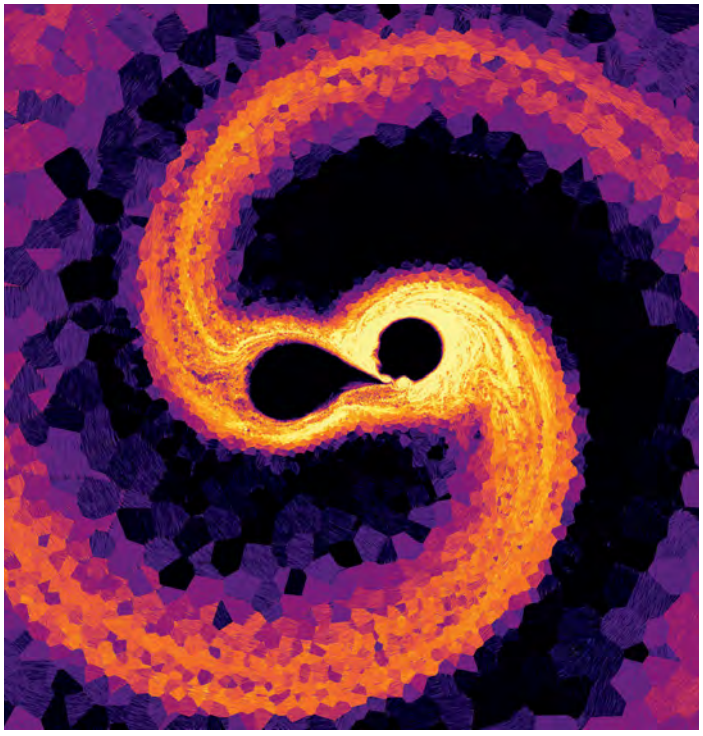
Automotive catalysts and materials for cutting tools and dental implants could become more robust and easier to manufacture than ever before. This is because chemists at the Max-Planck-Institut für Kohlenforschung have found a way to produce nanoparticles of corundum, a particularly stable variant of aluminum oxide, simply by grinding boehmite, an aluminum oxyhydroxide, in a ball mill for three hours. Until now, corundum could only be produced at temperatures of 1000 degrees or under high pressure in a week-long procedure which resulted in particles that were larger in size. The particles produced by the chemists in Muelheim using mechanochemical processes could be used as a resistant carrier material in automotive catalysts, for example, or as a starting material for particularly hard ceramics. The first industrial company is already working on the large-scale production of nanocorundum using the method developed in Muelheim. (www.mpg.de/14078015)



Chemistry in the ball mill: researchers in Muelheim produce nanoparticles of corundum by grinding boehmite, an aluminum oxyhydroxide, in a ball mill for three hours at room temperature.

Magnetars – simply irresistible

Computer simulations show how a strong magnetic field is generated when two stars merge



Magnetic mountains are the stuff of fairy tales, but magnetic stars really do exist. These magnetars, compact remnants of supernovae, are the most powerful magnets in space. Yet how do they acquire their remarkably powerful magnetic force – 100 million times stronger than the strongest magnetic field ever created by humankind? A team of astrophysicists from Germany and Britain has now solved this 70-year-old conundrum. The researchers merged two stars with normal magnetic fields in a computer simulation. These magnetic fields are nothing special; our sun also has one that produces convective currents in its gas envelope. Collisions between stars are also relatively common in nature. This is precisely the process that the astrophysicists reproduced. The end-product of the simulation was a single star with an exceptionally powerful magnetic field similar to Tau Scorpii, which can actually be observed in the sky. Should it one day explode as a supernova, a magnetar will be born from the debris. (www.mpg.de/13960571)

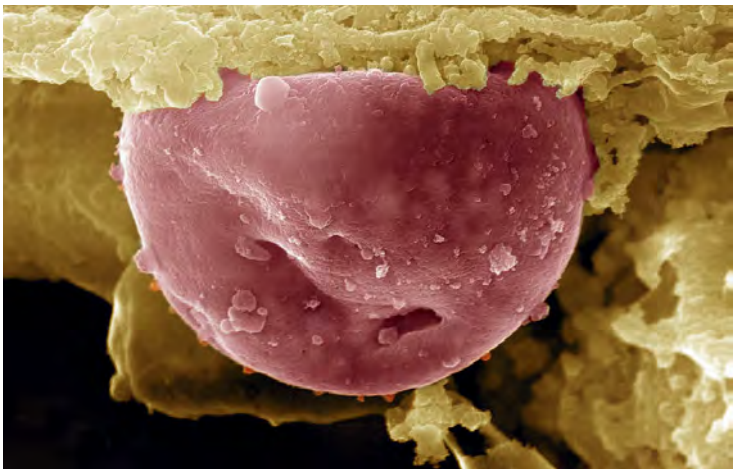
Fusion in the computer: the simulation shows the birth of a magnetic star such as Tau Scorpii. The illustration shows a cross-section through the orbital plane. The color reflects the strength of the magnetic force, while the hatching shows the field lines.

Graphics: Amol Amrute/MPI for Coal Research (top); Fabian Schneider, Sebastian Ohlmann (bottom)

Deadly networks

Immune cells cause malaria organ damage

15 years ago, researchers at the Max Planck Institute for Infection Biology in Berlin discovered a previously unknown defense mechanism utilized by the immune system. Special white blood cells dissolve their cell and nuclear membrane to release network-like DNA structures when they come into contact with a pathogen. The pathogens adhere to these DNA traps, known as NETs, and are killed. However, the NETs may only be activated locally for short periods, otherwise they attack the body's own tissue and trigger autoimmune diseases. According to the latest results obtained by the scientists in Berlin, NETs cause cases of malaria to progress with particular severity. High concentrations of NETs in the blood cause red cells to adhere to capillary walls in the organs, thus blocking them. Insufficient oxygen supply and bleeding from burst capillaries can then cause liver and kidney failure, pulmonary edema or cerebral swelling. (www.mpg.de/14014501)



A red blood cell adheres to the wall of a small blood vessel in the liver. This can damage the organ.

A fortress for sensitive data

New technology allows software components to be isolated from each other with little computational effort

Safeguarding passwords, credit card numbers or cryptographic keys in computer programs will require less computational effort in the future. Researchers at the Max Planck Institute for Software Systems have developed a technology known as ERIM with which software components can be isolated from each other. The system functions like a fortress, with various defenses that can be protected separately. This could protect sensitive data in the event of cyber attacks, which frequently target a single weak point, for example in an online service. The new method developed by the Max Planck scientists requires three to five times less computational work than the second best isolation technology. This makes the technology more feasible for use by online services such as Google or Facebook. (https://www.mpg.de/13848156)

Graphic: MPIIB/Volker Brinkmann