

Flying optical cats

An entangled atom-light state raises new prospects for quantum communications



Alive and dead at the same time: Schrödinger's cat is entangled with an atom. If the atom is excited, the cat is alive. If it has decayed, the cat is dead. In this experiment, a pulse of light forms a superposition state of this kind, as represented by the pulse profile in the middle of the image.

allowed a cat to be simultaneously dead and alive in what is known as a superposition state. In this version of the experiment, however, the role of the cat was played by a pulse of light. After bringing an atom into two physical states that existed simultaneously, the researchers caused the light signal to interact with the atom in a resonator – a tiny cavity between two mirrors. This interaction caused the light to adopt a similar state. Using other optical operations, the researchers ultimately caused the pulse of

At no point did researchers put a cat's life in jeopardy. Rather, a team led by Gerhard Rempe, Director at the Max Planck Institute of Quantum Optics in Garching, conducted a paradoxical thought experiment in the laboratory. Devised by the quantum physicist Erwin Schrödinger, this experiment

light to continue flying independently of the atom in a superposition state similar to that of Schrödinger's cat. As optical superposition states of this kind can be used to encode quantum information, the experiment raises new possibilities for quantum communication. (www.mpg.de/12651632)

In the whirlpool around a gigantic black hole

Quasars are the turbulent nuclei of galaxies that serve as the home of supermassive black holes. In these cosmic powerhouses, gravitational energy is converted into heat as material falls into the black hole at the center. In the process, the gas glows so brightly that it illuminates the entire galaxy and is visible even from billions of light years away. This brightness complicates the measurement of active black holes, because it is no longer possible to see the stars whose orbits are used to calculate the central mass. However, using the Gravity instrument on the Very Large Telescope at the European Southern Observatory, astronomers from the Max

Planck Institute for Extraterrestrial Physics have peered deep into the heart of the quasar 3C 273 and succeeded in determining its precise mass for the first time based on the swirling motion of the gas clouds that surround the black hole. The distance of 150 light days from the clouds to the center, in combination with their orbital velocity, produced a value of 800 million solar masses. (www.mpg.de/12545668)



A power plant in space: the quasar 3C 273 is located in a gigantic elliptical galaxy in the constellation Virgo, some 2.5 billion light years from Earth. It was the first quasar ever identified as such.

Who lies the most

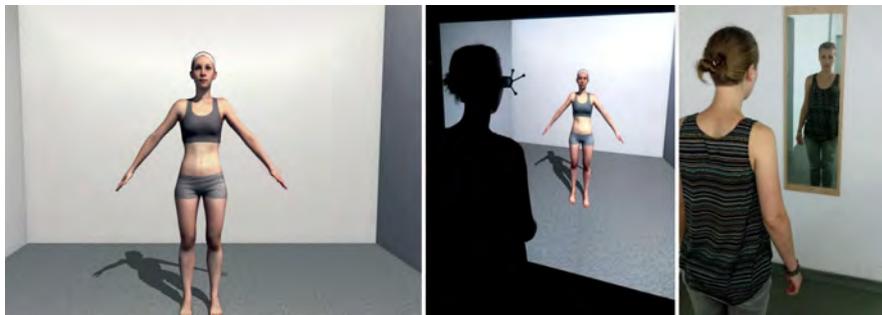
Meta-analysis synthesizes results of 565 studies on the psychology of dishonesty

Experimental studies have long sought to identify the personal and environmental factors that turn people into liars. Now, scientists from the Max Planck Institute for Human Development have teamed up with Israeli colleagues to synthesize the results of 565 studies as part of a comprehensive meta-analysis. This confirmed the conjecture that men lie more often than women – although the

Preference for underweight bodies

Anorexia nervosa patients prefer extremely slender bodies

Scientists are increasingly relying on the use of virtual reality in order to research how people perceive their bodies. The researchers scan subjects' bodies and create a digital copy using the latest computer technology. This approach is more realistic than, for example, squeezing or stretching photos to simulate variations in body weight. Using the new technique, researchers from the Max Planck Institute for Biological Cybernetics and the Max Planck Institute for Intelligent Systems studied the body perceptions of over 100 people with eating disorders. With the help of a joystick (similar to a Playstation controller), the subjects were asked to vary their avatars until the weight of their virtual alter ego matched their perception of their own weight. The results showed that patients with anorexia nervosa estimated their weight just as accurately as healthy women. Many previous studies suggested that anorexic women suffer from distorted visual self-perception and perceive themselves as too fat, even though they are generally severely underweight. The researchers also investigated what



Personalized avatar of a test subject. Anorexia nervosa patients are just as accurate as healthy women in estimating their real body weight. Unlike healthy women, however, they perceive severely underweight bodies as attractive.

body weight the participants considered desirable and found that women with anorexia nervosa considered severely underweight bodies ideal. For example, they perceive a weight of 43 kg at a height of 1.60 m as beautiful. According to the researchers, the fact that women with anorexia nervosa have a different opinion about what weight is desirable should be at the forefront of future therapies for people suffering from eating disorders. (www.mpg.de/12332536)

Photos and graphic: MPI for Biological Cybernetics/A. Thaler (top), Adobe Stock (bottom)

difference is slight, with 42 percent of men and 38 percent of women lying in the experiments. What is clear is that younger people lie more than older people: the probability of lying is about 47 percent for 20-year-olds and falls to just 36 percent by the age of 60. However, the results also show that the experimental set-up can influence subjects' behavior. In other words, people are not honest or dishonest per se, but rather their behavior depends partly on circumstances. This should be taken into account in future studies. (www.mpg.de/0120194/en)

Geckos walk on water

When it comes to walking, geckos have evolved some extraordinary abilities. For example, tiny hairs allow many of them to walk upside down across a sheet of glass, and some medium-sized species can even walk on water, as researchers led by Ardian Jusufi at the Max Planck Institute for Intelligent Systems in Stuttgart have discovered. To prevent themselves from sinking, the lizards – which weigh around six grams, about the same as a sheet of paper – appear to use a variety of techniques. For example, they exploit the surface tension of water, as do some species of insects, but they are too heavy for this alone to keep them afloat. The reptiles therefore rapidly slap the water with their feet, like ducks and swans during takeoff, to cre-

ate air pockets that support them. In addition, their water-repellent skin appears to allow them to plane across the water. Finally, they use wavelike movements of their tails to create thrust and lift. Based on these findings relating to geckos' ability to walk on water, researchers want to develop robots with similar abilities. (www.mpg.de/0120192/en)



Medium-sized geckos cannot rely on surface tension alone in order to stay afloat.

Reaching into the box of psychological tricks

The degree of willingness of men and women to assert themselves in competitions can be balanced out



Unequal opportunities: women are generally less willing than men to face competition. A psychological method known as priming can be used to iron out behavior differences between genders.

There are significant differences between men's and women's attitudes to competition – and this is one of the key reasons why women are often at a disadvantage in the world of work. This inequality can be reduced considerably using a psychological trick, as demonstrated by Matthias Sutter of the Max

Planck Institute for Research on Collective Goods together with Austrian colleagues. In an experiment, some of the subjects were prepared using a psychological method called priming. This group was asked to remember an event over which they exerted an influence. Another group of subjects went unpre-

pared. When all of the participants subsequently faced a competitive situation, 40 percent of men but only 14 percent of women in the neutral group were willing to enter into competition. Following priming, men in particular behaved differently, with only 28 percent of them choosing to face the competition. On the other hand, a slightly larger proportion of the women – 20 percent – opted for the competitive situation. Remembering an influential situation appears to enable individuals, regardless of their gender, to arrive at a realistic assessment of their own abilities. According to the research team, the method could be applied in the education system and in professional training. (www.mpg.de/12381578)

A cold super-Earth in our neighborhood

Barnard's Star, which is six light years away, is home to an exoplanet

An international group of astronomers, including from the Max Planck Institute for Astronomy, has succeeded in detecting a planet orbiting Barnard's Star, which is only six light years away. The planet has just over three times the mass of Earth and is about as cold Saturn. The discovery was made by measuring the periodic changes in radial velocity of the parent star – that is, the movement of the star in response to the planet's pull. To do this, the astronomers extracted a signal from 771 individual measurements they had collected over the course of two decades. The celestial body, which has been named "Barnard's Star b", orbits its host star once every 233 days at a distance of around 60 million kilometers. With a temperature of about -170°C , it is probably a hostile, icy desert in which there is no liquid water. (www.mpg.de/12486212)



An alien world: this illustration shows the surface of the planet "Barnard's Star b".

The toolmakers of the bird world

New Caledonian crows combine individual parts to form a long-distance reaching aid

For a long time, tool use appeared to be an exclusively human trait. We now know that tools are widespread in the animal world, although it was thought that only humans and great apes could use complicated objects consisting of multiple components. Now, however, it is clear that this illustrious group of animals also includes crows. Scientists from the Max Planck Institute for Ornithology in Seewiesen and the University of Oxford have discovered that New Caledonian crows can create compound

tools in order to access food that is out of reach. In an experiment, the researchers offered the birds treats that they could not reach, as well as several sticks that were each individually too short. Without any external help or prior training, the crows combined the short pieces to create a stick of sufficient length. One of the birds even made tools out of three and four parts. The results show that crows are among the few animals that can respond flexibly to novel problems. (www.mpg.de/12401947)



New Caledonian crows – from the eponymous archipelago in the South Pacific – are extremely intelligent birds. If necessary, they can combine several elements to create a working tool.

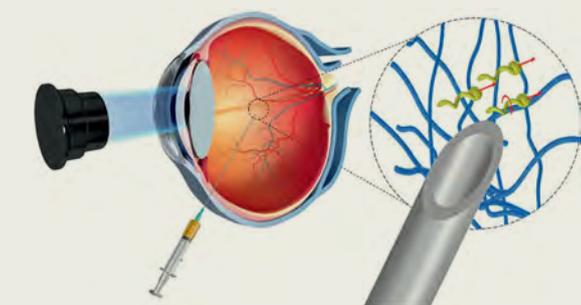
Symbiosis of burying beetles

The animals rely on their gut symbionts in order to transform decaying carcasses into healthy nurseries for their young

Burying beetles bury the cadavers of small animals in soil to use them as a food source for their offspring. However, the nursery decomposes progressively over time, and the resulting toxic substances, microbial pathogens, and nutrient loss are a threat to the beetle larvae. According to scientists from the Max Planck Institute for Chemical Ecology in Jena, the beetles therefore replace harmful microorganisms with their own beneficial gut microbes. Symbiotic yeasts from the beetle's gut thus suppress the soil-associated molds that quickly overgrow a cadaver in normal circumstances. In this way, the parent beetles ensure that their offspring remain healthy and can thrive in the dead body. In cadavers without microbes from the parents' intestinal flora, on the other hand, the larvae remain a significantly smaller size. The burying beetle is therefore another example of how insects can use symbionts to exploit challenging resources. (www.mpg.de/12358349)



A pair of burying beetles of the species *Nicrophorus vespilloides* attend to their young in a dead mouse. The beetles have preserved the cadaver with microorganisms from their gut.



Corkscrew-shaped nanorobots are injected into the vitreous humor of an eye and steered towards the retina using an external magnetic field.

Nanorobots enter the eye

In the future, nanorobots could perform medical tasks directly on the retina. A team led by Peer Fischer, a scientist at the Max Planck Institute for Intelligent Systems, has moved a step closer to this goal. The researchers steered a corkscrew-shaped nanopropeller through the vitreous humor of a dissected pig's eye. They had incorporated particles of iron into the silica propellers so that they could actively control the movement from the outside using magnetic fields. By applying a coating that was not only hydrophobic but also oleophobic, they ensured that the propeller slipped through the gel-like substance in the vitreous humor. Nanovehicles of this kind could be used to deliver medicines or to perform minor operations. (www.mpg.de/0120193/en)

Illuminating women's role in the creation of medieval manuscripts

Traces of blue paint in dental plaque offer the first clear evidence that women were involved in illustrating manuscripts



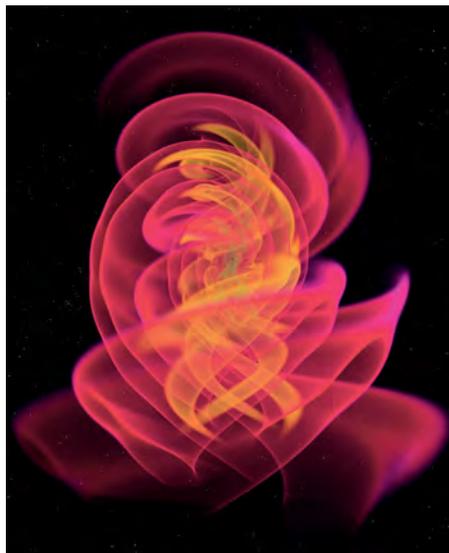
An unspectacular place for an archaeological find: a community of religious women lived in Dalheim, near Paderborn, in the Middle Ages. At least one of them illustrated elaborate manuscripts – a job that, until now, has been attributed solely to men.

Germany was a center of book production in the Middle Ages. As a sign of humility, many medieval scribes and painters of manuscripts did not sign their work – which may explain why illumination was long attributed solely to men. Now, an international team of researchers with significant participation by the Max Planck Institute for the Science of Human History has shed light on women's role in this profession. When analyzing the dental calculus of a woman buried at a small women's monastery near Paderborn in around 1000 AD, the team came across lapis lazuli pigments. Along with gold and silver, this precious blue paint was reserved for illustrating the most luxurious manuscripts, and only people with exceptional skill were entrusted with its use. Based on the distribution of the paint particles in her mouth, the researchers concluded that the woman probably painted with lapis lazuli and repeatedly licked the end of the brush while she worked. (www.mpg.de/12632827)

Four new sources of gravitational waves

The LIGO and Virgo observatories are also publishing their first catalog

Scientists have carried out a closer analysis of previously recorded data from the LIGO and Virgo gravitational wave detectors, tracking down four new signals. All of them originate from the fusion of pairs of black holes, which is accompanied by the release of part of the mass as energy and a distortion of space-time. The masses of the black holes varied widely, from 7.6 to 50.6 solar masses. One of the newly discovered events – known as GW170729 – was attributed to the most massive and distant gravitational-wave source ever observed: in this coalescence, which took place roughly five billion years ago, an amount of energy equivalent to almost five solar masses was converted into gravita-



tional radiation. To coincide with the announcement of the new findings, the scientists presented a catalog of all known gravitational wave detections and candidate events from the first two observing runs, O1 and O2. The catalog describes the characteristics of the merging black hole population. So far, the astronomers have tracked down eleven signals, one of which does not originate from black holes but rather from a collision between two neutron stars. (www.mpg.de/12552357)

Space is moving: this numerical-relativistic simulation reflects the first observed fusion of two black holes, as measured by the Advanced LIGO detectors on 14 September 2015.

Appealing art has a lasting effect

Paintings can trigger reactions in areas of the brain that are normally used for reflection

Based on measurements of brain activity, a team including researchers from the Max Planck Institute for Empirical Aesthetics is studying how our brain reacts when we look at works of art. Cognitive researchers expect primarily sensory brain regions to be active when we look at images, as the focus is – of course – on the outside world. At the same time, there should be a reduction



in brain activity in areas that support reflective processes. However, the researchers observed that aesthetically pleasing images activated the observers' "default mode network" – an area of the brain that allows us to think independently of external stimuli, for example, in the form of daydreams or future plans. When subjects saw an artwork they did not find attractive, however, this effect was not observed. In other words, if – and only if – artworks are aesthetically pleasing, they activate an unusual process in the brain that deals not only with external stimuli but also with mental and emotional responses.

Impressive: the painting *The Starry Night* by the Dutch artist Vincent van Gogh triggers a reflective response in many people even 130 years after it was created.

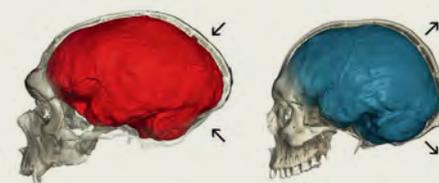
It's an animal!

Traces of organic material in fossils dating back over 550 million years allow classification of the primeval organism Dickinsonia

Dickinsonia was an unusual creature. Examples of this genus are thought to have moved about on the seabed until approximately 550 million years before our time, reaching a size of up to 1.40 meters and bearing no resemblance to present-day organisms. It was hitherto unclear whether the organism was a lichen, an extinct form of large single-celled amoeba, or indeed the earliest known animal on Earth. Now, this question has been answered by an international team including scientists from the Max Planck Institute for Biogeochemistry. The researchers classified Dickinsonia by analyzing traces of

An animal with no modern relatives: Dickinsonia, whose fossils have been found in the White Sea, in Russia, for example, is unlike any present-day organism.

organic material in fossils dating back 558 million years. According to their analyses, the substances are residues of cholesterol molecules that are typically found in animals. Dickinsonia are therefore the earliest known animals on Earth. (www.mpg.de/0120191/en)



Skulls of a Neanderthal (left), with the typical elongated brain shape (red), and a modern human (right), with the typical rounded brain (blue). The arrows point to the enlarged cranial fossa at the back of the skull, which is home to the cerebellum, and the arching of the parietal bones in modern humans.

Neanderthal genes influence the shape of the brain

One characteristic feature of modern humans is their unusually round skull and brain in contrast to other forms of human. An international team including scientists from the Max Planck Institutes for Evolutionary Anthropology and Psycholinguistics has now discovered genes that influence the shape of the brain and therefore the skull, in modern humans. The researchers analyzed skulls from Neanderthals and modern humans using an MRI scanner and produced virtual imprints of the inside of the skull. These imprints reflect the shape of the individual's brain but not their intellectual capacity. According to the analyses, significant differences in brain and skull shape are found not only between Neanderthals and modern humans but also between the skulls of some humans who are alive today. A genome analysis showed that humans with more elongated skulls carry Neanderthal DNA on chromosomes 1 and 18. These fragments alter the activity of two genes involved in brain development and the formation of nerve cells. However, brain shape is probably not affected solely by these two genes, but rather results from the combined effect of many different genetic variants. (www.mpg.de/12565720)