Photons made to change colour and shape

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FORGET the X-Men - photons are the true superheroes. Not only do they travel at the universe's fastest possible speed, now they have been made to both change colour and shape-shift. The feat brings the dream of ultrafast quantum computers a step closer.

Photons are waves of electromagnetic energy that come in different wavelengths, or colours. The wave patterns also vary in shape, depending in part on how they came into being. The shape of a photon produced by a laser resembles a bell curve, for example, while a photon emitted spontaneously by an atom when an electron loses energy has a peak that rises quickly and tails off slowly. The shape can affect how a photon interacts in collisions.

Photons normally maintain their size and shape until they are absorbed by matter. Now Matthew Rakher at the National Institute of Standards and Technology in Gaithersburg, Maryland, has made photons behave like shape-shifting chameleons. They piped infrared photons with a wavelength of 1300 nanometres into a crystal, into which they also pumped photons from a 1550-nm-wavelength laser. Each had different shapes.

The crystal acted as a waveguide, channelling the photons to hit each other at a specific angle and place, making them blend together to form photons with a wavelength of 710 nm with the same shape as the laser photons (*Physical Review Letters*, DOI: 10.1103/physrevlett.107.083602).

Such transformations will be crucial for developing networked quantum computers. These replace binary bits with quantum bits, or qubits, which can exist in a multitude of quantum states at once, allowing multiple simultaneous calculations.

Quantum computers could send and store data using photons' quantum properties, such as polarisation, which is a measure of a photon's angular momentum. The problem is that the fibre-optic cables that would transmit the photons between computers operate most efficiently at infrared wavelengths, while quantum-memory devices - made of atoms that would absorb the photons - work best with visible photons of a given shape.

The new work would minimise the data lost in translation, says Rakher. "Our research provides a method to take telecommunications-band single photons and change their wavelength and shape so they can be stored in visible-wavelength quantum memories," he says.

Hayden McGuinness at the University of Oregon in Eugene calls the work "a clever method for tackling two difficult problems".

Black holes and pulsars could reveal extra dimensions

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MAKING a black hole let go of anything is a tall order. But their grip may slowly weaken if the universe has extra dimensions, something that pulsars could help us to test.

String theory, which attempts to unify all the known forces, calls for extra spatial dimensions beyond the three we experience. Testing the theory has proved difficult, however.

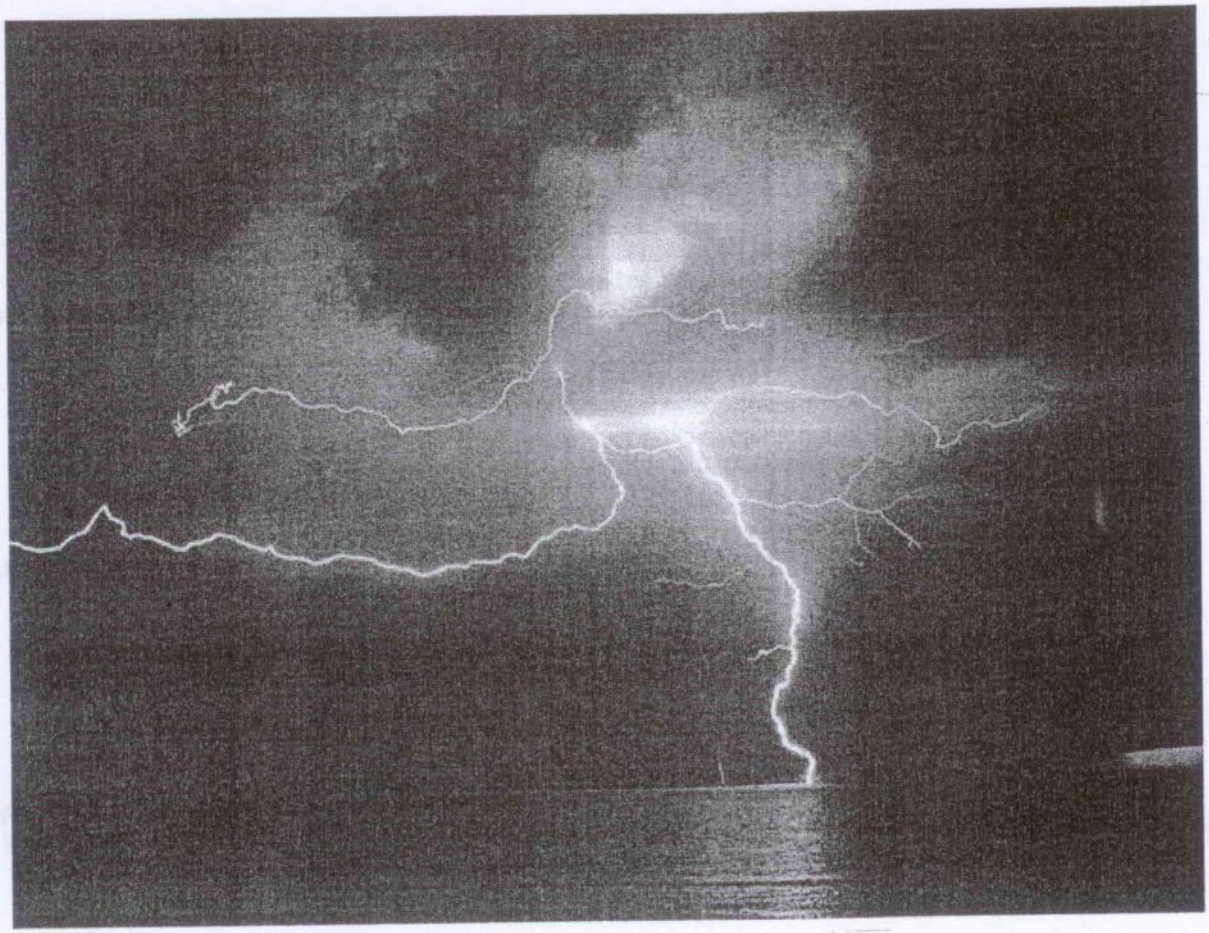
Now John Simonetti of Virginia Tech in Blacksburg and colleagues say black holes orbited by neutron stars called pulsars could do just that - if cosmic surveys can locate such pairings. "The universe contains 'experimental' setups we cannot produce on Earth," he says.

Black holes are predicted to fritter away their mass over time by emitting particles, a phenomenon called Hawking radiation. Without extra dimensions, this process is predicted to be agonisingly slow for run-of-the-mill black holes weighing a few times as much as the sun, making it impossible to measure.

Extra dimensions would give the particles more ways to escape, speeding up the process. This rapid weight loss would loosen a black hole's gravitational grip on any orbiting objects, causing them to spiral outwards by a few metres per year, the team calculates (*The Astrophysical Journal*, DOI: 10.1088/2041-8205/737/2/l28).

A pulsar orbiting a black hole could reveal this distancing. That's because the lighthouse-like pulses of radiation they emit would vary slightly depending on the size of the star's orbit.

Lightning



Photograph by William R. Curstinger

Lightning Can Strike Twice

Cloud-to-ground lightning bolts are a common phenomenon—about 100 strike Earth's surface every single second—yet their power is extraordinary. Each bolt can contain up to one billion volts of electricity.

This enormous electrical discharge is caused by an imbalance between positive and negative charges. During a storm, colliding particles of rain, ice, or snow increase this imbalance and often negatively charge the lower reaches of storm clouds. Objects on the ground, like steeples, trees, and the Earth itself, become positively charged—creating an imbalance that nature seeks to remedy by passing current between the two charges.

A step-like series of negative charges, called a stepped leader, works its way incrementally downward from the bottom of a storm cloud toward the Earth. Each of these segments is about 150 feet (46 meters) long. When the lowermost step comes within 150 feet (46 meters) of a positively charged object it is met by a climbing surge of positive electricity, called a streamer, which can rise up through a building, a tree, or even a person. The process forms a channel through which electricity is transferred as lightning.

Black gold holds a charge for green cars

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THE tiny glass bottle in my hand is filled with what looks like crude oil, but it's actually oil's nemesis. If it works, this black sludge will transform the rechargeable battery, doubling the range of electric cars and making petroleum obsolete.

Today's electric cars are handicapped by batteries that are heavy, expensive and a waste of space. Two-thirds of the volume of the battery in Nissan's Leaf electric car, for example, consists of materials that provide structural support but generate no power. And those materials cost more than the electrically active components.

One way to vastly improve rechargeable batteries is to put more of that deadweight to work. That's the purpose of the secret sauce in the bottle, nicknamed "Cambridge crude" by Yet-Ming Chiang and his colleagues at the Massachusetts Institute of Technology, who developed it.

In a standard battery, ions shuttle from one solid electrode to the other through a liquid or powder electrolyte. This in turn forces electrons to flow in an external wire linking the electrodes, creating a current. In Chiang's battery, the electrodes take the form of tiny particles of a lithium compound mixed with liquid electrolyte to make a slurry. The battery uses two streams of slurry, one positively charged and the other negatively charged. Both are pumped across aluminium and copper current collectors with a permeable membrane in between. As they flow the streams exchange lithium ions across the membrane, causing a current to flow externally. To recharge the battery, you apply a voltage to push the ions back across the membrane.

The MIT creation is a type of flow battery, which normally has a liquid electrolyte that moves past stationary electrodes. Chiang reckons that the power per unit volume delivered by his lithium "semi-solid" flow battery will be 10 times that of conventional designs (*Advanced Energy Materials*, DOI: 10.1002/aenm.201100152).

"This is probably the most exciting development in electrical energy storage in the past couple of years," says Yury Gogotsi of Drexel Nanotechnology Institute in Philadelphia, Pennsylvania. "Chiang offers a unique hybrid between a flow battery and a lithium-ion battery."

Drivers could have three ways of recharging the semi-solid flow battery. They could pump out spent slurry and pump in fresh; head to a recharge station where tanks of spent slurry would be replaced with fresh ones; or recharge the slurries with an electric current. In the first two cases regaining full power should only take a matter of minutes.

Rechargeable batteries are the heaviest and most expensive components of electric cars by a large margin. Chiang estimates that the cost of manufacturing his team's battery will be $250 per kilowatt-hour of generating capacity. So if one were built to replace the 24-kWh battery in the Nissan Leaf, it would cost $6000. That is about one-third the cost of existing batteries, and just low enough to compete with gasoline. Chiang also calculates that Cambridge crude would let a car travel at least 300 kilometres on a single charge, double what is possible with today's batteries.

"This is an especially beautiful technology," says Dan Steingart of the City University of New York Energy Institute, because you can recharge the spent slurry. But he adds that even if the team manages to create a prototype car battery within five years, building the recharge stations to support it would take much longer.

Last year Chiang, his colleague Craig Carter and entrepreneur Throop Wilder founded a company called 24M Technologies to develop the battery. They have raised $16 million in funding so far, and plan to have a compact prototype ready in 2013.

Ionised gas keeps Milky Way's lights on

- 21:00 29 August 2011 by Lisa Grossman

What keeps the Milky Way's lights on? Giant gas clouds have been found close enough to home to keep the galaxy ablaze.

About one sun-sized star is born in the Milky Way's starry disc every year, a process that requires a constant source of fuel. "The gas associated with [star formation in] galaxies would have run out a long time ago, unless there's a source of gas from the intergalactic medium," says Christopher Howk of the University of Notre Dame in Indiana.

Now he and Nicolas Lehner, also at Notre Dame, think they've found a source in the Milky Way: fast-moving clouds of hydrogen raining down on the galaxy's disc.

The hydrogen is ionised, which makes it hard to detect. While atomic hydrogen can emit light, ionised hydrogen cannot. It can, however, absorb light, meaning it can be detected only if it lies in front of a bright background source.

Uncertain distance

Previously, brilliant galaxies in the distant universe called quasars had provided the backlight to detect ionised gas clouds suspected of fuelling new stars in the Milky Way's disc. But it was impossible to tell how far away the clouds were – they could have been anywhere between the Milky Way and the quasars billions of light years away.

Lehner and Howk used the Cosmic Origins Spectrograph, one of the newest instruments on the Hubble Space Telescope, to observe 27 stars known to be within a vertical distance of 10,000 light years from the galaxy's disc. About half were obscured by gas clouds, meaning the gas must be within that same distance.

The researchers calculated the mass of the gas clouds to be equivalent to 110 million suns, providing plenty of fuel for new stars in the disc.

Mysterious origin

"This is certainly a big step," says Filippo Fraternali of Bologna University in Italy.

But the clouds' birthplace is still a mystery (see illustration). They could be structures that formed soon after the big bang and simply remained outside of any galaxy until falling into the Milky Way relatively recently.

Or they could come from the Milky Way itself. Exploding stars in the galaxy's disc may have blown material outwards, and that material might now be falling back towards the disc in these clouds.

"I don't think we know it yet," Fraternali says. Determining the chemical makeup of the clouds with future ultraviolet telescopes could reveal the answer, since exploding stars create heavy elements that would not be present in "primordial" gas created after the big bang.

Some types of lightning, including the most common types, never leave the clouds but travel between differently charged areas within or between clouds. Other rare forms can be sparked by extreme forest fires, volcanic eruptions, and snowstorms. Ball lightning, a small, charged sphere that floats, glows, and bounces along oblivious to the laws of gravity or physics, still puzzles scientists.

Lightning is extremely hot—a flash can heat the air around it to temperatures five times hotter than the sun's surface. This heat causes surrounding air to rapidly expand and vibrate, which creates the pealing thunder we hear a short time after seeing a lightning flash.

Lightning is not only spectacular, it's dangerous. About 2,000 people are killed worldwide by lightning each year. Hundreds more survive strikes but suffer from a variety of lasting symptoms, including memory loss, dizziness, weakness, numbness, and other life-altering ailments.

NATURAL DISASTERS QUIZ

1. Which natural disaster can produce the fastest winds on Earth?
   Tornado Hurricane Cyclone Tsunami
2. Which natural disaster cannot be caused by shifts in tectonic plates?
   Avalanche Earthquake Volcanic eruption Hurricane
3. In what country did the strongest earthquake on record occur?
   Chile(1960) USA Indonesia Iran
4. What natural phenomenon is a hypocenter associated with?
   Earthquake Hurricane Tsunami Tornado
5. What is the most dangerous type of avalanche?
   Wet avalanche Dry slab avalanche Ice fall avalanche Loose snow avalanche
6. Which of the following islands was completely destroyed during an 1893 hurricane ?
   Sumatra, Indonesia Hog Island, New York Rotuma,Polinesia Bimini, Bahamas

HABITATS QUIZ

1. What is the largest non-polar desert in the world?
   Mojave Arabian Gobi Sahara
2. What percentage of the world's water is freshwater?
   3% 7% 11% 20%
3. Which of the following is a problem facing the world's oceans?
   Overfishing Coastal development Pollution All of these
4. True or false. The Amazon rain forest covers over a billion acres (405 million hectares).
   True False
5. On what continent are grasslands called savannahs?
   North America(prairies) Africa Asia(stepe) South America (pampas)
6. In what habitat would you find permafrost?
   Desert Grasslands Tundra Rain forests

QUIZZ – WHAT DO YOU KNOW ABOUT ENERGY

1. HOW MUCH ENERGY FROM A COAL POWER PLANT MAKES IT TO CUSTOMERS AS ELECTRICITY?

   A quarter a third half two-thirds

2. What standard homebuilding practice guarantees large heating and cooling losses?

   Locating heating units in basements
   Installing double- paned windows
   Using fiberglass insulation
   Hiding ductwork in attics and crawlspaces.

3. What country is the premier source of steel for nuclear power plants?

   USA Japan Chile Scotland

4. Estimates of what US fuel resource have grown 40% or more since 2006?

   Natural gas Coal Wind Geothermal

5. What global treaty has slashed world greenhouse gas emissions by 11 gigatons a year?

   The Kyoto Protocol The UN Framework Convention on Climate Change
   The Montreal Protocol The UN Convention on the Law of the Sea

6. What solution is said to have potential for 57% of needed carbon cuts by 2030?

   Space-based solar systems Energy efficiency
   Carbon capture and storage Nanotechnology

Image searches 'poisoned' by cybercriminals

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Hijacking your Google image searches is just the latest ploy by fraudsters

ALL Pedro Bueno did was run a regular Google search for "iPhone with antenna" while trying to fix the Wi-Fi on his wife's cellphone. Moments later he was yet another victim of "search engine poisoning" - the latest battleground in the ongoing war between cybercriminals and Google.

The Google results page offered Bueno several image hits as well as the regular results. "I decided to see one of the pictures and clicked on it. It then started to load and suddenly I was redirected to another page," he wrote in a posting on the Internet Storm Center website, a volunteer group that monitors computer crime.

Claiming to be an antivirus program from the non-existent "Apple Security Center", this web page displayed a list of files that were supposedly trojans, spyware and other malware hidden on his computer. In fact, he had been sent to a fake antivirus website. At this point, the user may be tricked into paying for unnecessary antivirus protection or a virus is downloaded onto the unwitting user's computer. If you're unlucky and unwary, both.

Search engine poisoning is booming. Internet security firm Trend Micro estimates that in May 2011, more than 113 million users were redirected to malicious pages due to search engine poisoning. Hijacking image searches rather than text-based web searches is the fraudsters' latest twist on a popular scam.

"It's an arms race," says Christian Platzer of the cybersecurity lab at the Technical University of Vienna, Austria. Hackers write code to fool search engines into giving bogus results, and search-engine companies fight back by writing code to block their scams.

These scams are "pretty much automated" says Bojan Zdrnja, a computer security specialist in Croatia. It works like this: hackers gain access to legitimate websites and install programs which monitor Google Trends for hot keywords - words relating to any major news story, for example. The program then searches for content - including images - related to the hot topics and uses that material to automatically generate new web content of its own. Often they will hack a legitimate site that Google's software bots rate as credible and simply add their own content. This is not normally visible on the site, nor does the owner know about it.

As Google's bots crawl through the web, the malicious program identifies them and feeds them the automatically generated content from these faked web pages. Because everything on the page is specifically chosen to relate to that topic - be it Amy Winehouse's death or the shootings in Norway - the fake web page and the "poisoned" image quickly appear near the top of the relevant search results.

Next the user clicks on the thumbnail of the photo they want and the user's browser requests the page the image originated from. The attacker's program redirects the user to a fake antivirus website - putting them at risk.

"Google has done a pretty good job with standard searches," says Zdrnja, by detecting malware and warning users of potentially harmful pages. Blocking poisoned images from searches is the next challenge. A Google spokeswoman said: "We have cut down on the bad Image Search links by over 90 per cent since their peak at the start of May."