Quantum computing goes nuclear

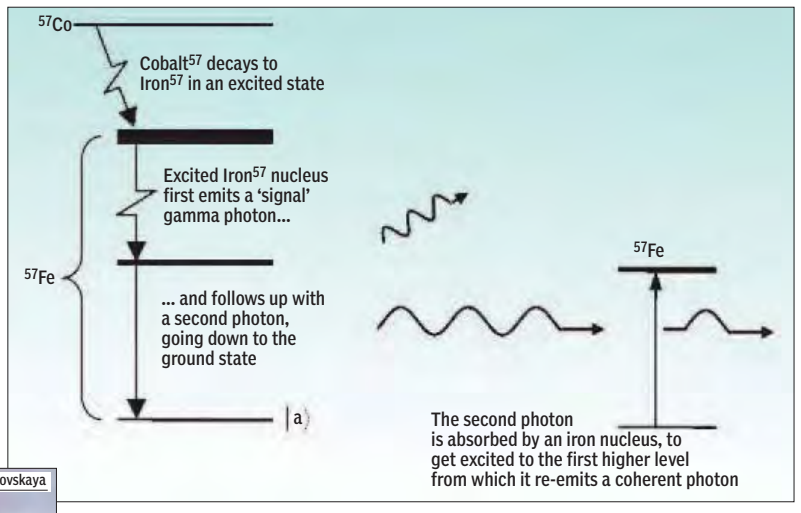
THE NUCLEUS OF THE ATOM HAS BEEN PRESSED INTO SERVICE TO IMPROVE COMMUNICATION, SAYS **S ANANTHANARAYAN**

The counter-intuitive ways of nature at the small dimension hold out a promise of near-magical computing speeds and messaging with foolproof security. On the one hand, sub-atomic dimensions can be measured, even in theory, only approximately and the outcome of interactions can be any one of a brace of possibilities. This allows a sub-atomic particle to be in "many states at once" and different computations can, hence, be carried out "at the same time". On the other hand, a measurement on one of a pair of that share a combined state, known as "coherent particles", affects the other particle even if it is at a distance away.

This property makes it possible to watch one of the pair to know if a message sent via the other particle has been compromised. But all these processes call for information to be passed on in the form of a photon, or a particle of light, which carries with it the secret of its internal state. And for the photon to be used over a reasonable distance there is the need boost or renew photons along the way in a manner that does not affect their delicate, uncommitted internal state. The method of doing this has been by letting the photon be absorbed by an atom, which re-emits the photon without a change. But this device has been possible so far with the external electron energy states of the atom, and these energies correspond to low-energy photons, like visible light or infra-red light.

Farit Vagizov, Vladimir Antonov, YV Radeonychev, RN Shakhmuratov and Olga Kocharovskaya, at Texas and at Kazan and Nizhny Novgorod in Russia, report in the journal *Nature* that they have succeeded in the absorption and coherent emission of a high energy, gamma ray photon by the nucleus of iron atoms. Low energy radiation, like visible or infra-red light, has a number of limitations for use in quantum communication, which high energy radiation does not. Using gamma ray photons in place of low energy radiation would, thus, expand the field of applications.

A first limitation of low energy radiation is that it is often not detected, or that false detection is provoked by some outside disturbance. This limitation could be likened to communicating in whispers. The second limitation is that low energy radiation has a large wavelength. Longer waves need larger optical scattering and detection devices and this limits how small the electronics can get. Next, low energy radiation is easily stopped by most materials and only special materials that are transparent to such radiation can be used. And, finally, a low energy radiation channel has low frequency and cannot code a large amount of information.




Olga Kocharovskaya

High energy radiation, like gamma rays, on the other hand, is always detected and chance disturbances cannot lead to false detection. Next, gamma rays have a short wavelength and devices can be miniature, currently nanometer and potentially much smaller. Third, gamma rays are penetrative and can pass through many materials. And, finally, gamma ray photon channels are high frequency channels and can carry large quantities of information.

But the carriers of quantum information used so far have been in the low energy region because lasers were first developed in the microwave and, later, in the infra-red or the visible region and atomic transitions that lead to absorption or emission of light are also in this energy region. The best that can be done with atomic transitions is to tap these between different electron shells in atoms, which correspond to X-rays. And this region has not been suitable because devices typically need to be kept at very low temperatures to be used. But the scene has been changing, with the use of suitable radioactive sources of gamma rays or even laser-like sources, which create high energy radiation of specific frequencies by moving electrons along a rapidly undulating path. But for the detection or manipulation of gamma rays, electron transitions cannot be used; it has to be transitions between energy levels inside the atomic nucleus. Just as the atom is modelled as a series of shells of electrons, the protons and neutrons that make up the nucleus also have energy levels that can be grouped into shells. But the energies separating these levels are high and correspond to gamma rays. A gamma ray photon could, thus, be absorbed by an atomic nucleus, with the nucleus getting pumped up to a higher energy level, followed by the emission of the same photon, in the act of de-exciting.

The authors of the paper note that using nuclear transitions has other advantages. The energy differences, for one, are more exact because the nucleus has less recoil. There are also good sources of single gamma ray photons in the form of radioactive nuclei that decay relatively slowly. In fact, in some forms of the two-step decay of the source, the first emission acts as a signal to say that the second emission is about to take place.

Olga Kocharovskaya, of Texas A&M University, and her team arranged for gamma radiation from cobalt nuclei to be absorbed and re-emitted by iron nuclei in a sheet of iron foil. By setting the sheet vibrating, the absorption of the gamma ray photon can take place at different distances from the source. As the arrival of the source gamma ray photon is heralded by a first emission, it is possible to manipulate the vibration of the sheet and, hence, control the exact moment of absorption and also a spreading out of the frequency, depending on whether the iron sheet was moving towards the photon or away from it.

The result is sensitive control, based on the extent and speed of the vibration of the sheet, of the timing and the spectral spread of emitted gamma photons. The movement of the sheet, in fact, gets superimposed on the photons, which helps create a series of evenly spaced, coherent pulses, control of the shape and duration of the pulses and even pairs of emitted photons. The technique is, thus, the implementation in the gamma region of methods that have been developed for visible and lower energy radiation, which brings with it the advantages of working with higher energies.

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NOT TO BE SNIFFED AT

THE HUMAN NOSE CAN DISTINGUISH BETWEEN MORE THAN A TRILLION ODOURS ~ A BILLION TIMES MORE THAN WAS THOUGH. **STEVE CONNOR** REPORTS

The remarkable and unforeseen ability of the nose to distinguish between different kinds of odours has been revealed in the first scientific study to accurately estimate the olfactory power among humans. It has been widely accepted for nearly a century that people are able to discriminate between no more than about 10,000 odours, but the latest findings show that the true number is much greater, conservatively estimated at one trillion.

This would make the human sense of smell more discriminatory than human colour vision, which can distinguish between 2.3 million and 7.5 million colour variations, or human hearing, which can discriminate between about 340,000 sound tones.

"We have debunked an old idea that humans can only smell about 10,000 odours and we're the first to come up with an accurate number, which is far, far higher than anyone had calculated," said Professor Leslie Vosshall of the Rockefeller University in New York. "The nose is really like a massive broadband technology that can take in huge amounts of information and pass it on to the brain. It is the only part of us that connects directly to the brain.

"Our analysis shows that the human capacity for discriminating smells is much larger than anyone anticipated. Everyone in the field had the general sense that this number was ludicrously small, but (we were) the first to put the number to a real scientific test," she said.

The 10,000 figure came from a 1927 study that had not been seriously challenged until now.

"Objectively, everybody should have known that the 10,000 number had to be wrong," Professor Vosshall said. The latest study, published in the journal *Science*, involved the creation of a unique combinations of smells derived from mixtures of 128 odour molecules derived from scents such as orange, anise and spearmint. Volunteers were asked to distinguish between different combinations of these odour mixtures, which were made from groups of 10, 20 or 30 different odour molecules.

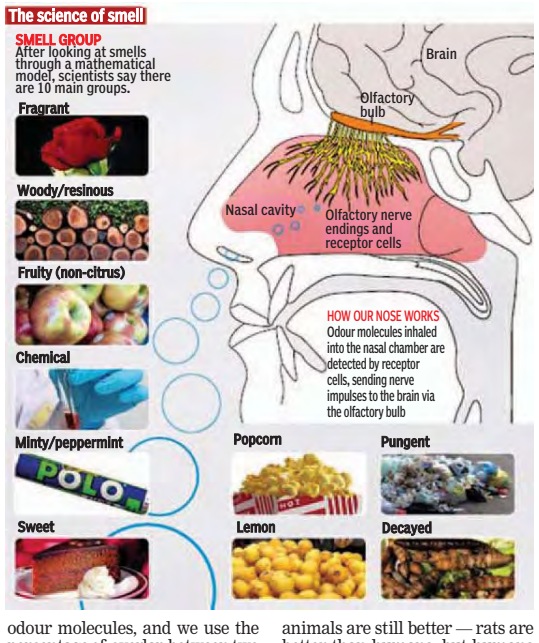
They were given three vials to smell, two of which were identical, and were asked to pick the odd one out. The third vial started out the same as the other two but was gradually altered to become more different. This enabled the scientists to gradually manipulate the molecular composition of each odour to eventually make it different enough for the nose to make a clear distinction.

Each of the 26 volunteers — 17 women and nine men — had to make 264 comparisons and, from these combined results, the scientists were able to make an extrapolation that gave them a conservative estimate of the overall olfactory power of the human nose. "Our trick is we use mixtures of odour molecules, and we use the percentage of overlap between two mixtures to measure the sensitivity of a person's sense of smell," said co-author Andreas Keller of Rockefeller's laboratory of neurogenetics and behaviour.

"We didn't want them to be explicitly recognisable, so most of our mixtures were pretty nasty and weird. We wanted people to pay attention to 'here's this really complex thing – can I pick another complex thing as being different?'," Dr Keller said.

"The message here is that we have more sensitivity in our sense of smell than we give ourselves credit. We just don't pay attention to it and don't use it in everyday life," he said.

Human smell relies on two small odour-detecting patches in the upper nasal chamber each containing about five or six million receptor cells — comprising 400 receptor types — which send signals directly to the brain via the olfactory bulb, attached to the base of the brain. By comparison, the rabbit has 100 million olfactory receptor cells and the dog has some 220 million. This helped to explain why humans are much poorer at smelling than other animals, Professor Vosshall said. "We show that humans have a good sense of smell that's not been appreciated before but other animals are still better — rats are better than humans, but humans are still pretty good. I like to think that it's incredibly useful to have that capacity, because the world is always changing. Plants are evolving new smells. Perfume companies are making new scents."

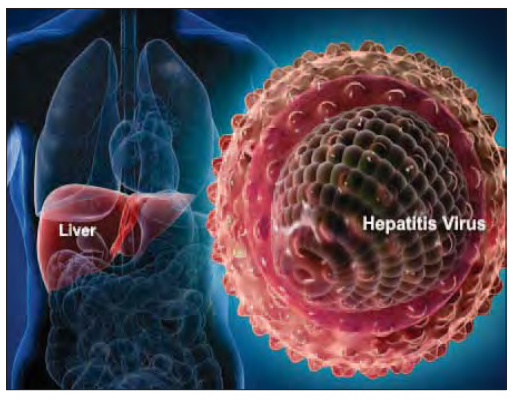


THE INDEPENDENT

Plugging causative agents

TAPAN KUMAR MAITRA EXPLAINS THE DETECTION OF HEPATITIS VIRUSES

Virus (infectious) hepatitis has been around for centuries and Hippocrates described it as a contagious form of jaundice. Other physicians gave it different names like catarrhal jaundice, parenchymatous hepatitis and epidemic jaundice. In 1883, SP Botkin conducted deep research and pointed to its infectious nature. In 1943-1944, J Cameron, R McCollum, W Havens and others proved that the filtrates of faeces, urine and serum of sick persons and carriers contained infectious agents that caused typical serum hepatitis.



Over the last 30 years the causative agent of virus hepatitis could not be deciphered. Very many pathogenic agents were isolated, to which the aetiological role in infectious hepatitis was attributed. Now it has been established that there are two main types of virus hepatitis, A and B, which, according to their properties, should be classed in entirely different taxonomic groups.

The hepatitis A virus was found in the faeces, plasma, bile and gastric contents of patients at the end of the incubation period and during the acute stage of the disease. Modern methods of examination (immunoelectron microscopy, radioimmunological analysis, etc) reveal that the virus is spherical and 22-25 nanometres in size. The type of nucleic acid has not been identified. The hepatitis B virus was discovered in 1970 (D Dane, J Cameron and others) and it contains DNA. Its main components are the surface hepatitis B antigen (HbsAg, previously known as Australia antigen) and the core antigen (HBcAg).

The surface hepatitis B antigen, discovered by B Blumberg in 1964, is constantly found in the blood of patients and sometimes in the saliva and perspiration, but it is not revealed in patients with virus hepatitis A. It is a component of the virus B membrane and is synthesised in great amounts.

On electronographs, the hepatitis B virus is spherical or elongated and measures 42 nanometres. It consists of a nucleocapsid enclosed in an outer protein membrane. In addition to virus hepatitis A and B, undifferentiated virus hepatitis has been revealed.

The hepatitis A virus grows in South American marmosets and survives for a lengthy period in the hepatic cells. The hepatitis B virus is reproduced in the organs and tissues of chimpanzees and in organ cultures and human hepatocytes. No serotypes have been detected in the hepatitis *A* virus and it is characterised by immunological specificity and interacts only with antibodies against it. Virus hepatitis A leaves a stable and lasting post-infection immunity. After recovery, the blood contains antibodies capable of rendering the virus harmless.

Genetic factors play a definite role in susceptibility to hepatitis B (children inherit the HBs antigen according to the autosomal-recessive type). There is no cross immunity between hepatitis A and B and people who had virus hepatitis A in the past are susceptible to hepatitis B, and vice-versa.

In virus hepatitis B diagnosis, the presence of the HBs antigen is determined in a patient's serum by means of a gel precipitation test, immuno-electroosmosis, passive haemagglutination and the radioimmune method. It should be borne in mind that the HBs antigen is detected in only 50-70 per cent of patients. It is found in convalescents for many months and is demonstrated in chronic and asymptomatic infection. The HBs antigen is always present in the sera of those with Down's syndrome, lepra, leukaemia and other diseases that are treated by a repeated transfusion of blood. Tests for liver function (blood bilirubin and cholesterol) and enzyme (aldolase, transaminase, etc) activity are also conducted.

There is no specific therapy. Ascorbic and nicotinic acids and glucose, which possesses a detoxification action, produce a favourable effect. Plasma and hormones (cortisone, prednisolone, etc) are prescribed in marked toxicosis. Rest and a diet rich in carbohydrates, proteins and vitamins are provided.

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PLUS POINTS

Letter decoded

A student has decoded an 1,800-year-old letter sent by an Egyptian soldier to his family which bears striking similarities to those serving on the front line today. Graduate student Grant Adamson of Rice University, USA, cracked the words on the document after being assigned the task in 2011 during a summer institute at Brigham Young University in Utah. The letter, written mostly in Greek, was sent by Aurelius Polion, a military recruit serving in a Roman legion in Europe. According to Adamson, the soldier addresses his brother, sister and family who have not been writing to him for some time.

"I pray that you are in good health night and day, and I always make obeisance before all the gods on your behalf. I do not cease writing to you, but you do not have me in mind. But I do my part writing to

you always and do not cease bearing you (in mind) and having you in my heart. But you never wrote to me concerning your health, how you are doing. I am worried about you because although you received letters from me often, you never wrote back to me so that I may know how you (are)," the letter says.

"I sent six letters to you. The moment you have me in mind, I shall obtain leave from the consular (commander), and I shall come to you so that you may know that I am your brother. For I demanded nothing from you for the army, but I fault you because although I write to you, none of you (?)… has consideration. Look, your (?) neighbour… I am your brother."

Adamson, who majors in religious studies, believes Polion was stationed in the province of Pannonia Inferior at Aquincum, now Budapest, but may have travelled as far as Byzantium, now Istanbul, as he was part of a legion known to be mobile. The letter was originally discovered in 1899 by an expedition team of Grenfell and Hunt in the ancient Egyptian city of Tebtunis. It had been catalogued briefly but no one had been able to break its writings. And even now, some of the letter's contents remain uncertain and impossible to reconstruct.

In a statement, Adamson said, "This letter was just one of many documents that Grenfell and Hunt unearthed. And because it was in such bad shape, no one had worked much on it for about 100 years. Polion was literate, and literacy was rarer then that it is now, but his handwriting, spelling and Greek grammar are erratic. He likely would have been multilingual, communicating in Egyptian or Greek at home in Egypt before he enlisted in the army and then communicating in Latin with the army in Pannonia."

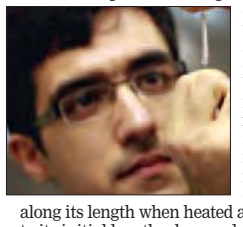
To work out the date of the letter, Adamson relied on handwriting styles and other hints such as the soldier's name, Aurelius. Because of the letter's close relation to familial concern, his publication has featured in the latest bulletin of the *American Society of Papyrologists*.

JACK GEVERTZ/THE INDEPENDENT

Powerful strings

Scientists have succeeded in making artificial muscles from strings made of polyethylene and nylon. These cost as little as Rs 350 a kg and could be used in robotics, prosthetics and climate compatible clothes. Artificial muscles have been made successfully from materials like metal wires and carbon nanotubes in the past, but these are expensive?and difficult to control.?This is the first time artificial muscles have been made from materials used for making fishing lines and sewing thread.

A team led by Ray Baughman from Alan G MacDiarmid NanoTech Institute in the University of Texas, Dallas, took the fibres and twisted them till they coiled up like a spring. When these "springs" were exposed to a temperature change, they contracted and expanded, just like a muscle. The temperature changes can be produced electrically by absorption of light or by chemical reaction of fuels. The artificial muscle dramatically contracts



along its length when heated and returns to its initial length when cooled, the researchers say in the paper published on 21 February in *Science*. These muscles match or exceed the performance of the mammalian skeletal muscle which contracts by only about 20 per cent. The new material can contract by about 50 per cent of its length and lift?100 times more weight than a human muscle of the same length and weight.

"The application opportunities for these polymer muscles are vast," says Baughman. "Today's most advanced humanoid robots, prosthetic limbs and wearable exoskeletons are limited by motors and hydraulic systems, whose size and weight restrict dexterity, force generation and work capability," he says. These artificial muscles can be used to bring life-like facial expressions to humanoid companion robots. They can also be used to develop textiles in which pores open and close with changes in temperature.

VIBHA VARSHNEY/CSE-DOWN TO EARTH FEATURE SERVICE