Turning the heat off

Letting molecules successively lose energy is the new way to reach the lowest temperatures, says s ananthanarayanan

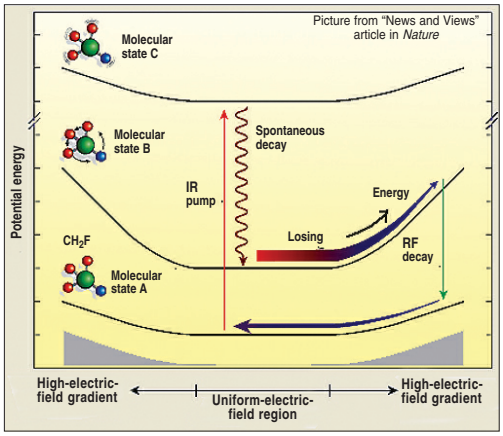
WATCHING the way things behave at very low temperatures has helped the progress of science in many respects. The lowest temperatures we can reach were with atoms or only very simple molecules. There is interest in doing the same with complex molecules as well, as this would open a window into the forces that act at those small distances. But the methods that worked well with atoms could be used with molecules and there was need to find and test a new way.

Martin Zeppenfeld, Barbara GU Englert, Rosa Glöckner, Alexander Prehn, Manuel Mielenz, Christian Sommer, Laurens D van Buuren, Michael Motsch and Gerhard Rempe of the Max Plank Institute for Quantum-optics in Garsching, Germany, report in the journal *Nature* that they have implemented a method that works effectively with the fluoromethane molecule and is general enough to work with other similar molecules.

into the physics of low temperatures. But the trouble with the method is that it can be used only when the energy levels of atoms match the energy of laser beams and also, in the case of molecules, that laser beams that can excite the electrons of atoms would affect the bonds in molecules, or introduce "noisy" vibration and rotation, before the cooling begins.

Sisyphus cooling

The alternate method, which has now been implemented by the group at Garsching, is *Sisyphus cooling*, and uses only the low energy modes of rotation and vibration of molecules to alternately couple and decouple with an electric field to lose energy in each cycle. For the reason that fast moving molecules slow down when they are affected by the electric field, which amounts to their energy of motion being converted into an electric potential, the effect is compared with the case of a boulder losing speed as it rolls up a hill, which happens in the Greek myth of Sisyphus. King Sisyphus was punished to expend energy in rolling a boulder up a hill, only to find that it rolled back down before he reached the top. In Sisyphus cooling, molecules slow down and lose energy in the same way, by pushing



Martin Zeppenfeld (from left to right), Alexander Prehn, Manuel Mielenz, Christian Sommer and Laurens D van Buuren.

Michael Motsch and Gerhard Rempe.

The most effective method of cooling to date has been laser cooling, where a laser beam and the *Doppler effect* nudge atoms of a gas to get cooler. The laser light chosen is just short of the energy needed to knock an electron in the atom to a higher energy level. This slight shortfall of energy makes sure that most of the atoms of the gas will not absorb the laser beam photon. But the atoms that are moving towards the laser, and fast enough, would add their own energy of motion to that of the beam and these atoms would absorb a photon. In the process of absorption, these atoms, which are moving towards the laser, also absorb the momentum of the photon and they slow down. But when they later emit that photon, which would speed them back up, the emission could be in any direction. The result is that atoms moving in one direction keep getting slowed down, with the momentum lost being sent out in all directions, and the gas as a whole gets cooler.

This method of cooling has been successful in going down as low as 0.00015? Celsius below freezing point and has enabled vast research against an electric field and then repeatedly finding themselves back to losing more energy in the same way.

Atoms and simple molecules behave like point objects, which have only energy of motion or the high energies of their electronic states. But in the case of large molecules, the bonds between the atoms can stretch and twist and the whole molecule can spin like a top around different axes. The molecule can thus store energy in small packets in its internal state. At the same time, the different internal states amount to a different distribution of the charged atoms that make up the molecule and the molecule in different internal states would behave differently in an electrical field.

These two properties of many molecules make it possible for the internal state of the molecules to be alternated between one where they interact strongly with the electric field and lose energy and the other, where they are relatively unaffected but decay to the first state, where, once again, they interact with the field and lose energy. As the energy required to change the state of the molecule is small compared to what it loses to the electric field, the result is rapid cooling.

The method used was to "trap" pre-cooled molecules of flouromethane (CH_3F) in an electric "bowl", which is a region where the electric field gets stronger as one moves the edges of the region. Microwave radiation drive molecules that are in a state that is weakly affected by the electric field to change internal state to one that is strongly affected. In this state, molecules spread to the boundary region and lose energy of motion.

Once here, they are subjected to radio-frequency radiation to bring them back to the weakly affected internal state. When they become weakly affected, they drift back to the low field area, but without regaining the energy that they have lost. And once back in the low field area, they are again "pumped" by an infra-red laser into the initial state from which they decay to the strongly affected state, again to move to the boundary and lose energy.

Uses

Low temperature capability in atomic systems has enabled advances in fields of superconductivity and superfluidity and the creation of states of matter, the Bose-Einstein condensate, where an ensemble of particles likes one particle. Extending the capability to molecular systems, where a number of atoms stay in combination, would expand the range of interactions that can be studied.

Asymmetric molecules act like electric dipoles and could be the units that carry bits of information. Studying their behaviour at low temperatures could enable their use in the quantum computer. Ultra-cold molecules are significantly affected by electromagnetic fields, which could allow sensitive control of chemical reactions. Even sophisticated areas like the test of the Standard Model, where the Higg's field, which gives mass to particles that should act differently when seen as a mirror image, can be studied with the help of low energy molecules.

The writer can be contacted at simplescience@gmail.com

A terrifying degree of accuracy

Research on birds shows that a new blood test can determine the speed of ageing, writes steve connor

A BLOOD test to determine how fast someone is ageing has been shown to work on a population of wild birds, the first time the ageing test has been used successfully on animals living outside a laboratory setting. The test measures the average length of tiny structures on the tips of chromosomes called *telomeres* that are known to get shorter each time a cell divides during an organism's lifetime.

Telomeres are believed to act like internal clocks by providing a more accurate estimate of a person's true biological age rather than his/her actual chronological age. This has led some experts to suggest that telomere tests could be used to estimate not only how fast someone is ageing but possibly how long they have left to live if they die of natural causes. Telomere tests have been widely used on experimental animals and at least one company is offering a £400 blood test in the UK for people interested in seeing how fast they are ageing based on their average telomere length.

Now scientists have performed telomere tests on an isolated population of songbirds living on an island in the Seychelles and found that the test does indeed accurately predict an animal's likely lifespan.

"We saw that telomere length is a better indicator of life expectancy than chronological age. So by measuring telomere length we have a way of estimating the biological age of an individual – how much of its life it has used up," said David Richardson of the University of East Anglia.

David Richardson.

The researchers tested the average telomere lengths of a population of 320 Seychelles Warblers living on remote Cousin Island, which ornithologists have studied for 20 years, documenting the life history of each bird.

"Our results provide the first clear and unambiguous evidence of a relationship between telomere length and mortality in the wild, and substantiate the prediction that telomere length and shortening rate can act as an indicator of biological age further to chronological age," says the study published in the journal, *Molecular Ecology*.

Studying an island population of wild birds was important because there were no natural predators and little migration, meaning that the scientists could accurately study the link between telomere length and a bird's natural lifespan. "We wanted to understand what happens over an entire lifetime, so the Seychelles Warbler is an ideal research subject. They are naturally confined to an isolated tropical island, without any predators, so we can follow individuals throughout their lives, right into old age," Dr Richardson said. "We investigated whether, at any given age, their telomere lengths could predict imminent death. We found that short and rapidly shortening telomeres were a good indication that the bird would die within a year.

"We also found that individuals with longer telomeres had longer life spans overall. It used to be thought that telomere shortening occurred at a constant rate in individuals, and that telomere length could act as an internal clock to measure the chronological age of organisms in the wild," he added. "However while telomeres do shorten with chronological age, the rate at which this happens differs between individuals of the same age. This is because individuals experience different amounts of biological stress due to the challenges and exertions they face in life. Telomere length can be used as a measure of the amount of damage an individual has accumulated over its life."

The Independent, London

Proof of alien existence?

Scientists say planets supporting extraterrestrial life beyond the solar system will be found within the next 50 years

STRANGE glows on distant worlds could indicate extraterrestrial civilizations — or intriguing new astronomical phenomena. As astronomers uncover a bewildering array of planets orbiting distant stars, four top researchers in the field reveal their plans to study these exotic worlds and search for signs that "we are not alone in the universe".

Around 15 years ago, two Swiss astronomers discovered a planet orbiting the sun-like star, 51 Pegasi. Until then, nobody had known if our solar system was unique; now we have a catalogue of more than 500 extra solar worlds. Though we still have no idea whether there is any planet beyond earth that harbour's life, that could soon change; scientists are

Planet PH1 with four suns and Sir Patrick Moore.

increasingly optimistic that they will find evidence of biological activity on an alien planet within the next few years.

Planets supporting alien life beyond the solar system will be found within the next 50 years, says renowned astronomer Sir Patrick Moore.

Asked if recent discoveries of earth-like planets meant that we were closer to discovering proof of alien life within the next 50 years, he said, "Yes, we are not far off. We have found other planets. The next stage is to detect the atmosphere." Sir Patrick wrote *The Cosmic Tourist* with his BBC astronomy programme *Sky at Night* colleague Chris Lintott from Oxford University and Brian May, who has a doctorate in astrophysics and is a close friend.

"To get to the nearest stars would take thousands of years," said Lintott. "In the next 100 years, I hope cosmic tourism will be possible; we could go to the (outer) part of the solar system." Distances in space are too vast to go further.

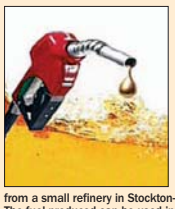
Recently, Lintott announced the discovery of a new planet, PH1, which is around 5,000 light years away. It is believed to be six times the size of earth and has four suns in its sky – two orbit and are in turn circled by a pair. It was discovered by two armchair astronomers or amateurs using data from the Planet Hunters website run by Lintott and colleagues, and later verified by experts. The website allows visitors to identify dips in the output of stars caused by their light being blocked by "transits" of an orbiting star.

Groundbreaking

New technology can produce 'petrol from air'

A SMALL British firm has claimed to have developed a revolutionary new technology that can produce petrol using just air and electricity. Based in the north of England, it has developed the "air capture" technology to create synthetic petrol that experts have hailed as a potential "game-changer" in the battle against climate change and a saviour for the world's energy crisis.

The technology, presented at a London engineering conference recently, works by removing carbon dioxide from the atmosphere. This "petrol from air" exercise involves taking sodium hydroxide and mixing it with carbon dioxide before "electrolysing" the sodium carbonate that it produces to form pure carbon dioxide. Hydrogen is then produced by electrolysing water vapour captured with a dehumidifier.



The company, Air Fuel Syndication, uses the carbon dioxide and hydrogen to produce methanol, which in turn is passed through a gasoline fuel reactor, creating petrol. Company officials claimed to have produced five litres of petrol in less than three months from a small refinery in Stockton-on-Tees, Teesside. The fuel produced can be used in any regular petrol tank and if renewable energy is used to provide the electricity it could become "completely carbon neutral". The company hopes to build a large plant that could produce more than a tonne of petrol every day, within two years, and a refinery size operation within the next 15 years. Institution of Mechanical Engineers officials admitted that while the described technology is "too good to be true but it is true", it could prove to be a "game-changer" in the battle against climate change.

The technology's potential is unusual as well as exciting since it utilises renewable energy in a slightly different way. This is an opportunity for a technology to make an impact on climate change. Apparently it looks and smells like petrol but is much cleaner.