



Dr Matt Visser says no one has proved that wormholes don't exist. Picture / Mark Mitchell

## Scotty may soon be able to beam us up

24.07.2004 - Physicists are working at the far reaches of theoretical science but even their most difficult and abstract ideas can have practical applications, as SIMON COLLINS reports

When Captain James Kirk wanted to get the Starship Enterprise to the other side of the galaxy he ordered engineer Montgomery Scott to change "warp factor", and the ship was away.

Powered by an explosive mix of matter and antimatter, the Enterprise could travel through time as well as space to save Earth from some awful fate.

It seemed like pure fiction at the time. But a generation later, some of Star Trek's ideas are beginning to look possible.

Otago University physicist Dr Murray Barrett and a team of American scientists have just "teleported" the state of an atom from one place to another - only about 0.3mm away, but the principle has been established.

And Dr Matt Visser, a Victoria University mathematician who has written a book on space-time "wormholes", says the logic of Einstein's general relativity is "completely infested with time machines".

"Antimatter" is now well established. All subatomic particles, such as electrons, muons and quarks, are now believed to have corresponding antiparticles with names like positrons and antiquarks. There is even something called "negative energy".

In this looking-glass world, the certainties we take for granted are liable to dissolve. Fundamental uncertainty is the hallmark of the "quantum world" at extremes of sub-microscopic size and hugely accelerated energy.

This is the world where scientists expect the next big breakthroughs in technology. Switches on computer chips have already become so small that electrons are leaking out of one circuit into another, signalling an imminent end to "Moore's law", which has seen computer power double every 18 months for the past 40 years.

The next computer innovation is expected to be a different technology, using the strange features of the subatomic world - a quantum computer or a computer based on DNA, the stuff of all living things.

Scientists have known about this world for a surprisingly long time. It is 99 years since Albert Einstein published his theory that any observer travelling at a constant speed would see light travelling at a fixed speed of about 300,000km/sec.

His theory seemed to contradict common sense. You would have thought that

light would appear to be travelling faster to someone travelling towards the source of light than to someone travelling away from it, in the same direction as the ray of light.

But the theory, based on the then-new understanding of light as a wave of electromagnetic energy, was true. Precise measurements showed that the speed of light going in opposite directions was indeed the same.

However, Einstein showed that this could be true only if our measuring rods of both distance and time varied according to the speed at which we were travelling relative to someone else. In effect, he rescued the common-sense view that our own relative speed should affect the speed at which we see things passing by.

At normal human speeds, the difference was trivial. But if humanity ever built a spaceship that could travel close to the speed of light, its clocks and rulers would measure the passage of time and space more slowly than an observer left on Earth.

Finally, Einstein noted that gravity also affected space and time. A heavy object, such as the Sun, somehow squeezed space and time around it. The result was that the four-dimensional "space-time" that we live in (up/down, left/right, forward/back in space and forward/back in time) was "warped" into some sort of mountainous landscape, with deep valleys attracting all objects inwards to big stars such as the Sun, separated from one another by high ranges.

In this extraordinary vision, the fastest way to get to some place or time was not necessarily over the mountain range - it might be to tunnel through a "wormhole" from one valley in spacetime to the next.

Visser, who grew up in Lower Hutt, the son of a factory foreman, and then spent 24 years researching abstruse physics in the United States, admits that no one has found a wormhole yet. But nor has anyone found any proof that they do not exist.

The idea, he says, originated with Professor Kip Thorne, a Californian physicist who was asked by science fiction writer Carl Sagan in the 1980s for a scientifically feasible way to get a character from one side of the galaxy to the other.

"We thought we'd be able to knock these things down and prove it couldn't be done," says Visser. "But the answer is much more ambiguous: well, it's going to be difficult [to find or create a wormhole], but it's by no means clear that it's impossible.

"My attitude is always that it would be great if these things exist, and even if they don't, the process of proving that they don't will tell us something about how the theory breaks down and give us a better handle on a modified theory for general relativity or quantum physics theory or whatever."

As Visser has noted in an article for the science fiction magazine *Phlogiston*, there are clear problems if wormholes do exist.

"You know that you, the reader, are alive right now, so no one can ever send a time traveller to five minutes ago to kill you as you pick up your copy of *Phlogiston*," he writes. "If someone tries, something must go wrong: the gun must misfire, or the time machine malfunction, or the assassin miss the bus, or any of a potentially infinite list of increasingly contrived excuses."

But even worse than such problems with logic, there is a basic contradiction between the two current fundamental theories of the nature of matter - Einstein's general relativity and quantum theory.

Relativity may seem to have a bizarre view of space and time but it has proved reliable in predicting such things as the movements of stars and planets. Even its prediction that time passes more slowly at high speeds has been proven by

Careful measurements with atomic clocks on high-speed aircraft and spaceships.

But quantum theory is even more odd. After a century of delving deeper into the microscopic world, quantum theorists have found that they simply cannot pin down the smallest bits of atoms at all. Some are so tiny that they are smaller than the smallest rays of light that we need to look at them, so that in observing them we are liable to "bump into" them and change them.

Moreover, these tiny things appear to behave at the same time both as particles, which are in one place, and as waves which stretch out and sometimes get deflected, split or absorbed. The only way we can describe their position is as a range of probabilities, such as a 50 per cent chance that right now the thing is between A and B.

This is the mysterious world in which people like Barrett are experimenting with "teleporting" subatomic particles of matter or light, taking advantage of uncertainty to perform magic tricks that appear to shift things from one place to another.

The tricks start by firing a beam of laser light into a bunch of particles to "entangle" them, giving them all a common clockwise or anticlockwise spin and other properties.

As long as the particles in the group are then kept isolated from other matter or energy, they all keep the same properties. Change one, by mixing in a new particle, and you change them all - even those that are now far away from the original bunch.

In effect, teleportation is not really shifting matter from one place to another. The particle being changed was already there. But the process of changing that particle's properties destroys the state of the original particle, so it is equivalent to moving it.

Cristian Calude, a computer science professor at Auckland University, is among those trying to use this peculiar uncertainty to produce a quantum computer, which can do multiple calculations at once.

"Classical computers do everything sequentially," he says. All problems are reduced to zeroes and ones and solved one by one.

Quantum computers would use the fact that we cannot be sure what state a subatomic particle is in. All we can say is that it has a certain probability of one state and a certain probability of another. Several particles together would multiply the uncertainty - and ironically, multiply the power of the computer, by allowing it to represent a lot more potential numbers and do many calculations at once.

Calude says that is why the human brain can still do many tasks much faster than most of today's computers.

"I do all my work during my sleep. I dream my proofs [of mathematical problems]. You concentrate yourself so much on the problem and at some stage you can solve it. You live it, and naturally it comes into your dreams. This is a kind of activity which is very, very unlikely to be simulated by a classical computer."

Australia's eight-site Centre for Quantum Computer Technology has said it hopes to have a working quantum computer by 2007. IBM, Microsoft and other big companies are working on it, although Barrett warns that it may take 10 years to build a computer with just 10 "quantum bits" of information.

"It wouldn't surprise me if it was 50 years away," he says. "It could be longer, or shorter, or it could be scrapped as a scientific avenue of research tomorrow."

As Visser says, the whole field is extraordinarily uncertain and full of

contradictions. "I've got the nasty feeling that we've got something fundamentally wrong and that we are asking the wrong question.

"This is not an attack on general relativity, because it's clear that in its appropriate realm it works beautifully. And it's not an attack on quantum physics because in its appropriate realm it works beautifully, too.

"But the fact that we are having so much trouble putting the two together indicates to me that there is something fundamentally misguided with the theories we are using."

## SCIENTISTS WHO MADE CERTAINTY COLLAPSE

New Zealand-born Ernest Rutherford found things that seem solid are made up of atoms that are largely empty, with what appears to be a small central nucleus and tiny electrons spinning around it.

Austrian physicist Erwin Schrodinger discovered that both light and matter are made up of waves that cannot be pinned down to a specific point in space.

Germany's Werner Heisenberg concluded that it is impossible to determine both the position of a particle and its direction and speed at the same time. The best you can do is a statement of probability.

Swiss scientist Albert Einstein found that space and time can only be defined relative to a particular observer. For example, both the size and speed of an object would appear different to observers in different places and travelling at different speeds themselves.

Einstein also found that space and time are "warped" by the gravity of large objects such as stars.

All this uncertainty opens up possibilities for jumping through space (teleportation) and time (time travel) - at least until scientists find a better way of describing the world.

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