Cosmic hero still hungry for more

In a rare interview, Stephen Hawking tells **Wong Chun Wai** there is much more he wants to do, like go to space and co-write a third book for children based on the Big Bang theory

HE'S been described as the most brilliant living genius and in the realm of physics he is ranked after Galileo Galilei, Isaac Newton and Albert Einstein. Indeed, Stephen Hawking is more than deserving of being called "the world's most famous living scientist" because he has achieved so much, charting new frontiers despite his disabilities that keep him confined to a wheelchair.

His 1988 book, *A Brief History of Time*, topped the bestselling list for 237 weeks, having reportedly sold one copy for every 750 people on earth. It is regarded as a layman's guide to the origins of the universe and the theory of "Black Holes" and has since become a modern classic. He is currently working on *What Happened to the Big Bang?*— which simplifies the subject matter for a young audience — with his 41-year-old daughter Lucy, a journalist and author.

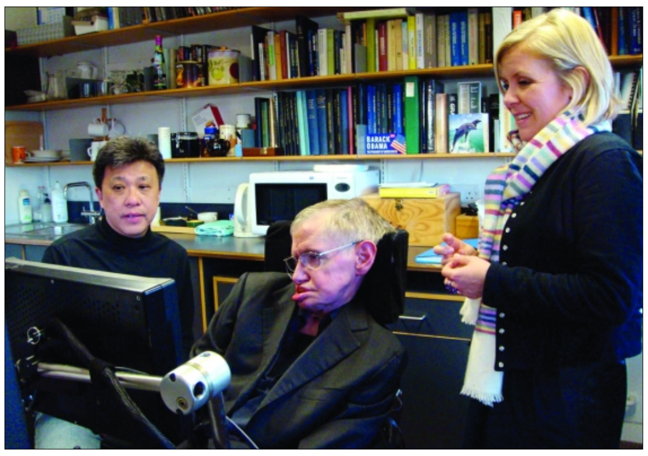
At 68, his health has deteriorated but it does not stop him. Afflicted with neuro-muscular dystrophy since he was 21, he is unable to use his fingers and has long lost the ability to speak. With nurses to watch over him 24 hours a day, he can only communicate using facial gestures, including blinking. His computerised voice system is controlled by a blink-activated infrared monitor embedded in his glasses. There is a barely perceptible movement of his lips but his eyes are incredibly knowing.

Hawking no longer gives press interviews even if his office, located at the University of Cambridge, is said to receive thousands of e-mails each day that include requests for media interviews, some of which come with offers of payment for the privilege of meeting this world-renowned British scientist whose career spans more 40 years. Now the director of research for the Department of Applied Mathematics and Theoretical Physics, he was the university's Lucasian Professor of Mathematics — the world's most famous academic chair — for 30 years until last January when he had to give it up because it is the university's policy for the holder of the chair to retire at 67. Previous holders include Isaac Newton, who formulated the gravitational theory.

It is hard to associate the Hawking in a wheelchair with the young Hawking who loved riding horses and coxing a rowing team when he was studying at Oxford. As a first-year doctorate student at Cambridge and shortly before his first marriage, he was diagnosed with motor neurone disease and told he had only a few more years to live. He has certainly defied the odds. The disease did not stop him from marrying language student Jane Wilde in 1965 and having three children, Robert, Lucy and Timothy. He wrote scientific papers, delivered lectures and wrote his best eller despite being in a electric wheelchair that is fitted with a portable computer and speech synthesiser.

There has also been no shortage of controversies in his private life. His wife Jane described him as a "tyrant" after their divorce and wrote that he had a "God-like complex". He subsequently married his nurse, Elaine Mason, but it ended following allegations of mistreatment.

I had e-mailed my list of questions to his daughter Lucy about a month before my trip to Cambridge. The questions were short, direct and numbered as requested. Another journalist lucky enough to have been granted



an interview had her questions returned because Hawking wanted them "stripped of extraneous details".

White steam puffed out of a dehumidifier, camouflaged by sea shells near his table, Hawking sat in the middle of the room with a team of nurses and aides watching. There was a moment of awkwardness. Awed by the presence of this great man and my inability to deal with his disability, I felt uneasy and felt strangely ashamed. Perhaps sensing my hesitance, Lucy took her father's hand and asked me to shake it. "Dad, Wong has travelled all the way from Malaysia to meet you. He says he likes our books," she said in an attempt to break the ice.

There was a long silence, punctuated only by the whirring and beeping sounds from his computer. I looked at the screen and could not be sure whether he was responding. Numbers and words filled the screen, giving me the impression that he was doing many things at the same time. After a while, he responded, through the voice box, that he was glad that I liked the two children's books he had written with Lucy. There were smiles all around the room.

Lucy explained to me how the machine, which reportedly can only manage 15 words a minute, had been used to write e-mail and even to laboriously write his bestseller. Malaysian student Vincent Tang, a first class honours graduate in physics who had joined me for the interview last month, told Hawking about the latest design for a similar voice synthesiser by Cambridge University.

That seemed to interest Hawking more than my questions, and earned a response from him. After another question from me on how he felt about the fate of the earth, there was a longer silence. His face showed an agonised look, as though he was struggling with an answer, and his cheeks were twitching. While waiting for his response, Lucy took the opportunity to show me around his office.

Hawking, despite his intellectual capacity, has a strong sense of humour. In one interview he was reportedly asked how he had managed to father three children and he replied, "The disease only affects voluntary muscles." He has also told the media that he loves watching TV crime series and *The Simpsons*. A figurine of him sitting in a wheelchair, especially made for him as a gift by the producers of the TV cartoon show, sits proudly on his table. It is one of his favourite ornaments. There are more caricatures of him with *The Simpsons* characters. He has even appeared in cameo roles in the series.

There is also a picture on the wall of a grinning and delighted Hawking with a superimposed visual of a very sexy Marilyn Monroe. The late actress remains one of his idols. Then there is a picture of him with US President Barack Obama who awarded him with the Presidential Medal of Freedom at the White House in August 2009. It was one of his rare trips overseas. Hawking clearly adores Obama because there are Obama buttons on the bookshelves.

There is still much he wants to achieve. An advocate of space exploration, he wants to travel to space as a tourist. "Perhaps, one day I will go to space," he said. For the moment, he still has one mission to accomplish with Lucy. They have finished two children's books — *George's Secret Key to the Universe* and *George's Cosmic Treasure Hunt* which give children and even adults a better grasp of cosmic mysteries — and are working on a third that is expected to be published later this year.

Asked what his average day was like, he said, "I get up every morning and go to my office where I work with colleagues and students at Cambridge University. Using e-mail, I can communicate with scientists all over the world. Obviously, because of my disability, I need assistance but I have always tried to overcome the limitations of my condition and lead as full a life as possible. I have travelled the world, from the Antarctic to zero gravity. Perhaps one day I will go into space."

Having been associated with finding answers to how the universe began and having mentioned that earth would be wiped out either by a sudden nuclear war, a genetically engineered virus or something as catastrophic, did he still think so? "The universe is expanding and will continue to expand for ever, but only very slowly, at a rate of about one part in 10 billion each year. Of more immediate concern is that the sun will exhaust its nuclear fuel in five billion years. It will swell up, and engulf the earth. It will be time to move to another system, if we are still around.

"But will the human race even survive the coming century, let alone the coming millennium? There are many dangers, but the one that worries me most is global warming, as it may trigger the release of large amounts of carbon dioxide from the oceans, which would add to the warming. We might end up like Venus, with a temperature of 250° Celsius, and raining sulphuric acid."

He once said that mankind had no future but to go to space. There was now a new discovery of water on the moon and a possible earth-like planet. Was time on the side of humankind or were we really far off? "Moving the human race out into space won't happen quickly. By that, I mean it could take hundreds, or even thousands of years. We could have a base on the moon within 30 years, reach Mars in 50 years and explore the moons of the outer planets in 200 years.

"By reach, I mean with manned flight. We have already driven Rovers on Mars and landed a probe on Titan, a moon of Saturn, but if one is considering the future of the human race, we have to go there ourselves and not just send robots."

Being a man of science, was there room for God? "Is the way the universe began chosen by God for reasons we can't understand, or was it determined by a law of science? I believe the second. If you like, you can call the laws of science God, but it wouldn't be a personal God that you could meet and ask questions of, though if there were such a God, I would like to ask how He thought of anything as complicated as M-theory in 11 dimensions."

What was his view on the issues like poverty, disease, war, hunger, etc? "I'm not worried about the future of the universe. It will continue, whatever happens. But the future of the human race, and of life on earth, is much less certain. We are in danger of destroying ourselves by our greed and stupidity."

What about climate change? What were his thoughts on that? "Climate change is happening at an ever-increasing rate. While we are hoping to stabilise it, and may be even reverse it, by reducing our CO_2 emissions, the danger is that climate change may pass a tipping point at which the temperature rise becomes self-sustaining. The melting of Arctic and Antarctic ice reduces the amount of solar energy that is reflected back into space, and so increases the temperature further. The rise in sea temperature may trigger the release of large quantities of CO_2 trapped at the bottom of the ocean, which will further increase the Greenhouse effect."

Would humankind survive the next 100 years or more? "I see great dangers for the human race. There have been a number of times in the past when its survival has been a question of touch and go. The Cuban missile crisis in 1963 was one of these. The frequency of such occasions is likely to increase. We shall need great care and judgment to negotiate them all successfully. But I'm an optimist. If we can avoid disaster for the next two centuries, our species should be safe as we spread into space."

The Star/Asia News Network

High and dry

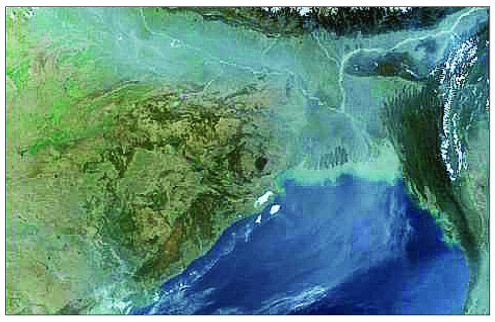
Shompa Das has the lowdown on soot-coated glaciers that are on a melting spree

CLIMATE scientists have said the Himalayan glaciers will disappear by the end of this century, courtesy soot or black carbon that is increasing the sunlight-absorption capacity of the snow. With its strategic location between India and China, this is one field where the competing countries must together break their backs to find a solution. Why? Because this giant castle of ice towers feeds some of the world's longest rivers – the Indus, Brahmaputra, Mekong, Yellow and Yangtze.

American and Chinese researchers have collected ice core samples from five Tibetan glaciers to understand why the region has been warming at 0.3° Celcius per decade for the past three decades. It is more than what the greenhouse gases have been contributing to. They found that black carbon concentrations of the glaciers have risen since the 1990s. The ability of snow to reflect light is called *albedo* and it is 0.9-0.97, normally. With 10 ng of soot on every gramme of snow, the albedo reduces by 0.01-0.04. In other words, sunlight absorption increases by 10-100 per cent, says a study in the December 2009 issue of *Proceedings of the National Academy of Sciences*.

Black carbon is an integral part of coal emissions. Bundled in aerosols, it is carried around by winds. The South Asian Haze is one such aerosol. It starts from the South Asian region and is carried to the north, with soot spewing all over the northern glaciers. Using satellite and ground-based observations, the scientists simulated the spread. The South Asian Haze peaks from November to March when the soot concentration along with the freshly formed snow content of the Tibetan glaciers is at the highest.

Come spring and the amount of added soot only helps in melting the freshly formed snow faster than usual. As the snow tends to retain some aerosols, the surface concentration of soot increases and adds to further melting. For example, fresh snow sampling at the Qilian Shan glacier revealed that fresh snow cover melted within two days. The exposed underlying layer



Grey haze over the Ganges Plain and Bay of Bengal, due to black carbon and other soot resulting from incomplete combustion in biomass burning mainly for cooking, heating and field clearing, and fossil fuel burning. This is thought to be contributing to reduction in monsoon rainfall and snowfall, and the retreat of Himalayan glaciers. Most black carbon over the Himalayas and Tibet is thought to now come from the Ganges region.

showed a soot concentration seven times greater than fresh snow, only too ready to melt.

Surabhi Menon, a scientist at the Lawrence Berkeley National Laboratory in Berkeley, USA, quantified melting of the glaciers for the period 1990-2010 and pointed to black carbon as a probable cause. Her study was published in *Atmospheric Chemistry and Physics Discussions* in December. "This study proves that black carbon is indeed the culprit," she said.

Henning Rodhe, professor of chemical meteorology at Stockholm University in Sweden, said that "the quantitative importance of black carbon deposition for the mass balance of the glaciers remains to be determined".

MM Sarin, professor of Planetary and Geosciences Division at the Physical Research Laboratory, Ahmedabad, has a different take on this study. "The role of total dust deposition on the glaciers is equally important. Soot alone does not count. These factors must be addressed," he said.

Coal emissions must be phased out in the forthcoming decades to save the Tibetan glaciers, said the authors.

CSE/Down To Earth Feature Service

Spinning to leap barriers

There is now a way to pass an electric current through an insulator. **S Ananthanarayanan** explains

THE way electricity passes through a conductor comes about because there are "free" carriers of charge that help transfer a charge applied to one end of the conductor to the other end. In the case of insulators, it takes too much work for the carriers of charge to get free and electric current cannot flow.

Eiji Saitoh and colleagues in Japan recently reported in *Nature* that they had succeeded in passing a current through an insulator, but using a property quite different from the transfer of charge by "free" charge-carriers.

Conductors and insulators

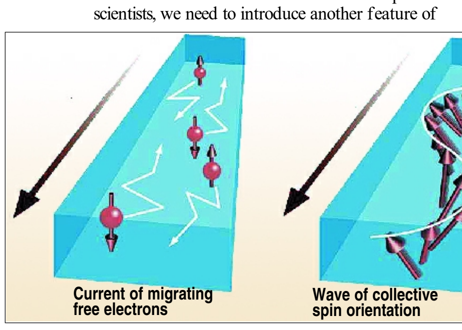
Conductors are usually metals (with exceptions, like carbon), the outer electrons of whose atoms are loosely bound, when the atoms of the conductor are in bulk, in crystals, like in a rod or wire. Atoms consist of a large, positive charge in the centre, surrounded, equally in all directions, by smaller but more numerous negative electric charges. Thus, while the charges of an atom balance each other and the atom is neutral when seen from a distance, at close quarters it is the nearest collection of charges that dominate. In this way, the large positive charge at the centre of an atom is attracted to the nearest electrons of neighbouring atoms and the atoms (of groups of atoms) stick together, as a crystal. The atoms arrange themselves in the most economical pattern and metals are usually strong and resilient. But the actual outermost electrons, although attracted by the nucleus of the next atom, are also repelled by proximate electrons and these outermost electrons are actually quite "loosely bound".

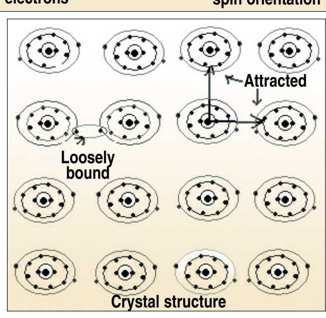
When a charge is applied to such a conductor, the nearest "loosely bound" electrons are repelled (or attracted, depending on the charge applied). This causes a charge imbalance that propagates through the conductor body, ending up with the charge applied to one end being perceived at the other end. Although the motion of individual electrons is comparatively slow, the transfer is nearly instantaneous and the effective speed of electric current can approach the speed of light.

In insulators, these free electrons (or the lack of an electron, which can also can be passed on among atom groups) are absent and applying opposite charges to the ends of such a material causes no current to flow. If a *very large* charge is applied, some charge-carriers may be ripped out by "brute force" and the insulator is said to have "broken down". But in the usual course, insulators almost completely block any electric current. Many non-metals and most compounds, where the outer electrons are engaged in chemical combination, are insulators.

The Hall effect

Before we talk about the work of the Japanese scientists, we need to introduce another feature of electric currents. When a current flows through a conductor it more or less flows equally through all parts of the cross section of the conductor. But if there is a *sideways* magnetic field applied to the conductor, then the charge-carriers get pushed to one side of the conductor because of the magnetic field. The result is, apart from the current that keeps passing from one end of the conductor to the other, there is also a bunching of charges to one side that creates a difference of charge, or voltage, in the transverse direction.





It is known that rotating a coil in a magnetic field will produce a voltage, in the manner of the dynamo. But here is an effect of a voltage created in a stationary wire carrying a current! This effect was first seen by Edwin Herbert Hall, in Maryland in 1879, which is before the electron was discovered. The voltage produced is closely related to the strength of the current and the magnetic field and the effect has application in measurements in isolated places.

While this effect is called the classical Hall effect, at low temperatures and high fields we have the Quantum Mechanical Hall effect. Quantum mechanics is the refined way of describing nature at the atomic or electron level, where levels of energy are seen not to change in a continuous stream but in steps, or *quanta*. The QM Hall effect, then, is that the Hall voltage increases, with current and field strength, in steps and the effect, which is well understood, is exceedingly precise.

The Spin-Hall effect

The work of the Japanese scientists concerns another effect of magnetic fields on the electrons in a conductor, on their "spin", which is a property related to their energy as rotating charges. A major difference when we consider spin energy is that the effect is not only on "free" electrons but on other electrons too. Thus, in the case of a conductor carrying a current, there would be, in addition, a "spin current" of conduction electrons and also a spin wave of collections of electrons. And, what is important, the spin wave would be there in an insulator too!

The spin wave could then propagate and carry the electrical signal through the insulator.

In practice, it is seen that the conduction electron spin current survives for a very short time, unlike the spin wave. And then, in conductors, the spin wave is snuffed out very quickly by the presence of conducting electrons in large numbers, which does not happen in insulators because of the lack of conducting electrons. The net result is that the Spin-Hall effect is a promising medium for transfer of electrical signals through material which will not carry an electric current!

The Japanese scientists worked with a particular compound ($y_3Fe_5O_{12}$), which is magnetic but cannot carry an electric current. A sliver of this material was sandwiched between layers of platinum conductor. When an electric current is applied to the first platinum layer, a spin wave is created because of the Spin-Hall effect. As the spin wave is not dampened in the insulating medium, it carries on to the next interface. Here, in the reverse process, the spin wave induces a spin current in the platinum, which generated a voltage to drive an electric current.

The effect can be switched on and off by a magnetic field. This hybrid electrical transmission, part through conductors and part through insulators, has the potential for new devices and processes in electrical circuitry.

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