Physics Web, June 2004

News for June 2004

Could dark energy be studied in the lab?

29 June 2004

It might be possible to measure the properties of "dark energy" in the laboratory according to physicists in the UK and Canada. A relatively simple experiment based on superconducting devices known as Josephson junctions could show if some or all of the dark energy in the universe is due to quantum fluctuations of the vacuum (C Beck and M Mackey 2004 *arXiv.org/abs/astro-ph/0406504*).

Quantum fluctuations mean that the vacuum is not empty as is assumed in classical physics. These fluctuations, also known as zero-point fluctuations, are a consequence of the uncertainty principle, and they give the vacuum a structure that manifests itself in a variety of different ways such as the Casimir effect. Physicists have already measured the effects of this "vacuum energy" in circuits containing Josephson junctions.

A series of astrophysical observations have suggested that as much as 73% of the universe is made of dark energy -- a gravitationally repulsive material that is causing the expansion of the universe to accelerate. However, no one knows what dark energy is made of. Vacuum energy is one candidate for dark energy, although the amount of energy in the vacuum predicted by theory is some 120 orders of magnitude more than the amount indicated by observations.

In 1982, Roger Koch and colleagues, then at the University of California at Berkeley and the Lawrence Berkeley Laboratory, performed an experiment in which they measured the frequency spectrum of current fluctuations in Josephson junctions. Their system was cooled to millikelvin temperatures so that thermal vibrations were reduced to a minimum, leaving only zero-point quantum fluctuations. Now, Christian Beck at Queen Mary University of London and Michael Mackey at McGill University in Montreal have re-analysed these results in the light of recent astrophysical estimates of the density of dark energy in the universe.

Beck and Mackey argue that the zero-point fluctuations measured by Koch's team imply a non-zero density for the vacuum energy, and say that this value cannot exceed the value for the density of dark energy in the universe. Using this premise, they predict that there should be a cut-off in the spectrum of the fluctuations at a frequency of around 1.69×10^{12} Hertz.

Beck and Mackey believe that future experiments with a new generation of Josephson junctions that work at higher frequencies could help to clarify whether or not this cut-off exists. Such experiments would also show if dark energy is indeed related to vacuum energy.

Author

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New Scientist, July 2004

A table-top test for dark energy?

MARCUS CHOWN

THE nature of dark energy, the mysterious stuff that is relentlessly pushing the universe apart, could be revealed by a simple table-top experiment.

Physicists dreamed up dark energy in 1998, when they found that distant supernovae appeared fainter than expected, showing that they were farther away than previously thought. To explain this, they concluded that the expansion of the universe must be accelerating and that dark energy was responsible.

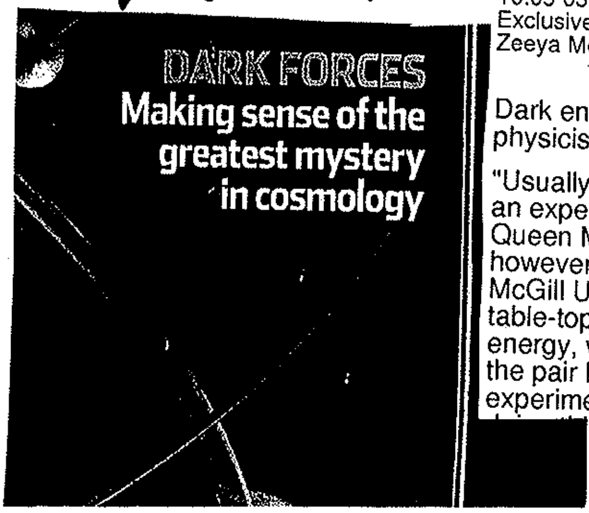
One possible origin for dark energy arises from a prediction made by quantum physics: that the vacuum of space is a choppy sea of "quantum fluctuations". This quantum vacuum could be the source of dark energy.

The effects of the quantum vacuum have already been observed in a device known as the Josephson junction, an extremely thin layer of insulator sandwiched between two superconducting layers. Josephson junctions have the curious property of being able to contain a varying current even

gigahertz. Koch's team originally measured these fluctuations up to a frequency of 600 gigahertz. "So it is necessary only for someone to improve on his experiment by a factor of 3," says Beck.

If such an experiment showed no cut-off in the frequency of fluctuations in the Josephson junction, the energy density in the fluctuations will exceed the density of dark energy observed in the universe. And since the fluctuations in the device are caused by quantum vacuum, this will mean that quantum vacuum is not the source of dark

Cosmos Magazine Sept. 2007



IF DARK ENERGY is truly a cosmological phenomenon that has its roots in the fabric of the universe and physics as we understand them, then as Kirshner points out, it should show up in Earth-based laboratories. To date, particle physicists have been unable to test dark energy experimentally here on Earth.

The reasons why are reminiscent of an earlier era when astronomers wrangled with another problem in physics: the speed of light. They were able to determine that indeed the speed of light was finite from observations within the Solar System. However, they were unable to determine its speed until French physicist Armand Fizeau made ground-based measurements in 1849.

Christian Beck, a mathematical physicist at Queen Mary College, University of London, and colleagues, have proposed a way that dark energy be measured in the laboratory. The idea is that dark energy might be produced by very low frequency electromagnetic vacuum fluctuations. These might be detectable using current laboratory superconductors. Three such European experiments are already in the works with first results expected in 2008.

New Scientist, April 2007

Superconductors inspire quantum test for dark energy

10:05 03 April 2007

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Zeeya Merali, London

Dark energy is so befuddling that it's causing some physicists to do their science backwards.

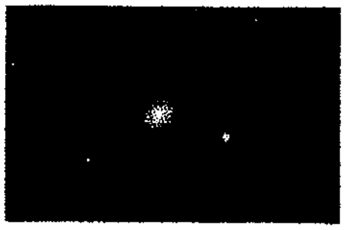
"Usually you propose your theory and then work out an experiment to test it," says Christian Beck of Queen Mary, University of London. A few years ago, however, he and his colleague Michael Mackey of McGill University in Montreal, Canada, proposed a table-top experiment to detect the elusive form of energy, without quite knowing why it might work. Now the pair have come up with the theory behind the experiment.

Nature, July 2004

nature

Philip Ball

A cosmic force that is thought to drive the accelerating expansion of the Universe could be probed using desktop electronics, two researchers have claimed.



Give it a whirl: could a simple test detect energy that, so far, has only been measured by cosmologists?

J. NEWMAN/UCB & NASA

The force — usually known as dark energy — seems to oppose gravity, making galaxies fly apart with increasing speed. Detected eight years ago, it presents one of the biggest puzzles in cosmology.

But we may not need high-powered telescopes to study it, according to Christian Beck, a mathematical physicist at Queen Mary, University of London, and mathematical biologist Michael Mackey of McGill University in Québec (C. Beck & M. C. Mackey, preprint at xxx.arxiv.org/abs/astro-ph/0406504; 2004).