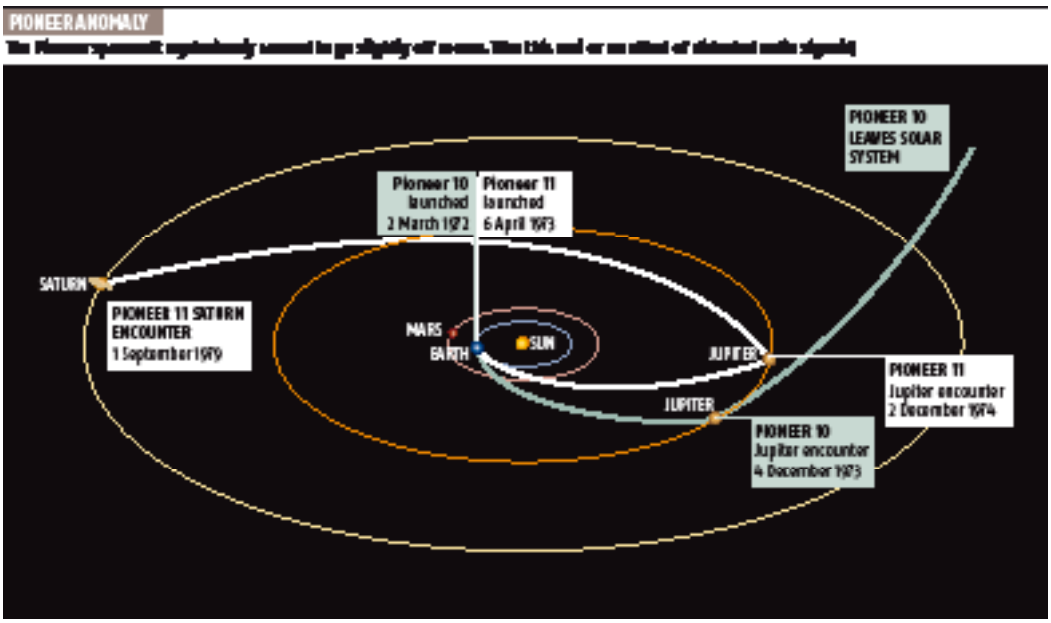

Is dark energy fattening the sun?

ZEEYA MERALI

TWO mysteriously off-course spacecraft and the biggest puzzle in physics today – the nature of dark energy – could have a common explanation. If so, be prepared to accept that our sun is putting on some weight.

Hans Fahr at the University of Bonn in Germany and Michael Heyl at the German Aerospace Centre, also in Bonn, set out to solve a puzzle that has been vexing cosmologists ever since it was first noticed that the expansion of the universe is accelerating. This acceleration has been attributed to dark energy, which many think is the inherent energy of space-time, described by the so-called cosmological constant (CC). But there's a problem. Particle physics predicts that the CC should be more than 10^{120} times larger than observed – a value so large it would have blown the universe apart before stars or galaxies formed.

Fahr and Heyl take the view that this constant can change over time. They suggest that it did indeed start out at its huge predicted value after the big bang, but has been decaying ever since, reaching its relatively small value today. "The natural question is, what happens to this energy during decay?" Fahr says.

In their model, the missing energy is converted to mass in the form of new particles. Most of this new matter would have appeared soon after the birth of the universe, as the cosmological constant decayed rapidly, Fahr says, but small amounts of matter will be spontaneously popping up even today (*Naturwissenschaften*, DOI: 10.1007/s00114-007-0235-1).

Astrophysicist James Overduin at Stanford University, California, likes the idea. "It's not as crazy as it sounds," he says. "After all, the big bang is just matter creation all at once. Fahr just wants to spread this out over time."

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Recent observations of the galaxy cluster A586 suggest that dark energy does interact with matter – in this case dark matter (*New Scientist*, 7 April, p 10). This lends credibility to the notion that dark energy could decay into dark matter, says Orfeu Bertolami at the Instituto Superior Técnico in Lisbon, Portugal, who has studied A586. He cautions that cosmologists will need much more evidence before seriously considering Fahr and Heyl's model, though.

That's where the Pioneer anomaly comes in. Launched 35 years ago, NASA's Pioneer 10 was the first spacecraft to reach the outer solar system. Its sister ship, Pioneer 11, set out a year later to visit Saturn. Before losing contact with Earth, both spacecraft seemed to be drifting off course, as if they were being tugged towards the sun slightly more than expected – enough to shift Pioneer 10 400,000 kilometres from its expected position.

According to Fahr and Heyl, this mysterious drift can be explained if the sun is gradually increasing in mass from matter being created by a decaying cosmological constant. They show that this increase would shift the wavelength of the radio signals exchanged with the Pioneers as the signals pass by the sun. "The spacecraft are actually on the correct course, but this distortion of radio signals gives the illusion that they are off track," says Fahr.

However, there is a wealth of alternative theories to explain the Pioneer anomaly. Bertolami's team have developed their own, to appear in the journal *Physical Review D*: they calculate that an extra gravitational force, which takes different values at different points in space-time, could be shifting the spacecraft.

Fahr agrees that Bertolami's explanation is just as valid as his own. We need a test, he says, to differentiate between theories such as Bertolami's, in which the Pioneers are really veering off course, and theories such as his own, where just the tracking signals are being distorted.

Bertolami and his colleague Jorge Páramos are putting together a proposal to the International Space Science Institute in Bern, Switzerland, for just such a test. They want to launch two spheres from a mother ship and track them with lasers. The spheres would have different mass-to-surface-area ratios such that any mysterious extra force would cause them to accelerate relative to each other. "This would verify that the Pioneer anomaly is real and not just an error with spacecraft instrumentation," Bertolami says.

The mother ship would also be subject to any unknown force. It could be tracked using radio signals and also by an on-board accelerometer: if anomalous motion was picked up in the radio signals, but didn't show up on the accelerometer, that would favour Fahr's model, Bertolami says. "We hope to piggy-back on another mission to keep down the cost," he says. "It would be a cheap way to test one of the biggest puzzles in physics."

Smart drug kills pain and only the pain

IMAGINE a painkiller that only switches on in injured tissue, leaving the rest of the body unaffected. That is the idea behind a new class of pH-dependent drugs that interfere with nerve signals to the brain and spinal cord – but only where the tissue is slightly acidic due to injury.

Normal tissue has a pH of around 7.4, but this drops to around 7.0 in injured tissue, largely because the blood supply is disrupted, resulting in the accumulation of waste products such as carbon dioxide and a switch to anaerobic respiration, which produces lactic acid.

The new drugs act by blocking NMDA receptors, which are found on cells throughout the brain and central nervous system and are implicated in a variety of nerve functions, including pain sensitisation. Earlier generations of drugs, such as ketamine, also targeted NMDA receptors, but these often have unwanted side effects such as impaired movement or hallucinations, because they act on undamaged nerve tissue as well.

Ray Dingledine of the Emory University School of Medicine in Atlanta, Georgia, and his colleagues have now developed a compound called NP-A, that binds to the base of NMDA receptors and stops glutamate and a related neurotransmitter called NMDA from binding. A slight drop in pH can cause a significant boost in NP-A's ability to block the receptor – for example, a drop in pH from 7.6 to 6.9 causes the compound's activity to increase 62 fold.

This means that NP-A gets switched on only where it's most needed, says Dingledine, who has now set up a company called NeurOp to develop the drug further. "It's a context-dependent blocking of pain, which is a new strategy for these receptors," he says.

He showed that rats were significantly less sensitive to pain in an injured paw when they were injected with NP-A. Usually, rats will flinch when their paw is touched using a force greater than 15 grams. When they have injured paws, however, they pull their leg back when the force is only 2 g. Forty-five minutes after an NP-A injection, the rats did not move their injured paws away until the force was about 12 g.

The pain stayed away for about 3 hours, and the animals showed no signs of side effects. The results were presented at the annual meeting of the Biotechnology Industry Organization in Boston, Massachusetts, last month.

> "The drugs act by blocking NMDA receptors, which are found on cells throughout the brain and central nervous system"

Dingledine believes that a compound like NP-A could one day provide pain relief for people with agonising peripheral nerve damage, or neuropathy. Doctors often prescribe drugs such as gabapentin, which boost a pathway in the brain that inhibits pain through a neurotransmitter called GABA. However, these drugs don't work for everyone – possibly because GABA misfiring is not necessarily the cause of the pain.

Min Zhuo of the University of Toronto in Canada, who studies NMDA receptors and pain, says that a drug targeting NMDA receptors might help a different subset of patients who experience pain because of NMDA overactivation. "GABA inhibition and NMDA firing are like yin and yang," he says. Roxanne Khamsi