Fred - thought you'd be interested to see this - JAJ

SCIENCE

Energy of 'nothing' upsets cosmology

John Gribbin

ACCORDING to quantum theory, a vacuum contains energy. According to relativity theory, this "zero point energy" must have a gravitational effect, influencing the Universe at large. However, these two requirements are irreconcilable, according to Paul Wesson of the University of California, Berkeley. He says that if the zero point energy really exists, "major revisions may be necessary in quantum mechanics and/or gravitation".

The zero point energy of the vacuum arises in quantum physics because of "quantum uncertainty". If the energy of the vacuum were precisely zero, there would be no uncertainty about its energy. Quantum uncertainty allows "virtual" photons to pop in and out of existence all the time, contributing energy to the vacuum.

The effect seems to be real, not just some quirk of the equations, because it produces measurable effects, including the Casimir force of attraction between two metal plates in a vacuum, and the Lamb shift in the wavelength of spectral lines of atoms. But its presence poses a puzzle for cosmologists.

If the entire Universe is filled with zero point energy, its gravitational field should affect the structure and evolution of the Universe. In relativity theory, all energy is associated with mass, and therefore with gravity. This is a long-standing problem with zero point energy, which has largely been ignored until recently. In 1989, Harold Puthoff, also based in Berkeley, suggested a new way to describe the vacuum energy in a cosmological context. Wesson continued the work where Puthoff left off (*Astrophysical Journal*, 10 September).

Puthoff's key proposal (*Physical Review*, vol 39, p 2333 and vol 40, p 4857) was that the zero point energy is not something that is set by the initial conditions of the Universe, the big bang (like the famous cosmic microwave background radiation). Instead, he argues that it is generated by the motion of charged particles, and that charged particles in turn get their vibrational energy from the field (dubbed the "zpf") associated with the zero point energy.

As Wesson says: "This sounds neat." But he shows that the resulting energy density of the vacuum must, in fact, decrease as the Universe expands, pushing back the ultimate source of the energy to the origin of the Universe itself.

Wesson shows that the gravitational influence of this energy cannot be ignored, and says that he has "confirmed in specific terms the widespread scepticism of workers in gravitation about the reality of the zpf".

And yet, the Casimir effect and the Lamb shift still show the influence of the zero point field at work. So, says Wesson, either the zero point field does not gravitate (flying in the face of relativity theory), or, as Sir William McCrea, of the University of Sussex, has suggested (*Quarterly Journal of the Royal Astronomical Society*, vol 27, p 137), somehow the virtual photons of the zpf do not have time, during their brief lives, to interact gravitationally with ordinary matter.

A third possibility, requiring modifications to quantum theory, is that the positive energy of the zpf is cancelled by another, hypothetical, negative energy field.

Whatever the resolution of this conundrum, it seems that the energy of nothing at all may be telling us something fundamental about the relationship between relativity theory and quantum physics. □

Woodland soil yields a multitude of insect species

OLD woodland rivals tropical rainforest in the numbers of species it contains, according to American biologists. But most of the species are hidden away in the soil.

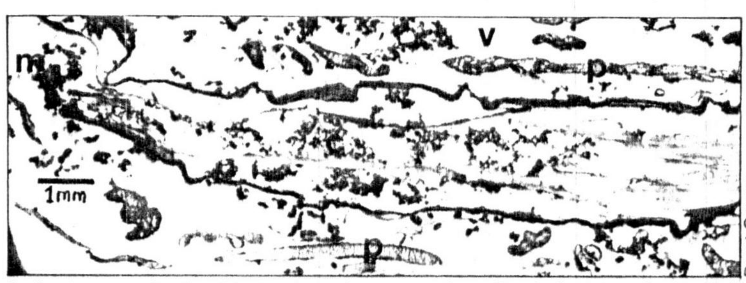
Andrew Moldenke and his colleagues at Oregon State University carried out a study of the Andrews Experimental Forest in Western Oregon. They used a technique borrowed from petrology to look at the tiny insects, arachnids, centipedes and millipedes in the soil. The majority of the species in the soil have not even been classified, though they play a crucial role in decomposing wood and leaves, and recycling nutrients into new trees.

According to Moldenke, an entomologist: "The majority—by weight or volume—of the particles in forest soil in the Pacific Northwest are arthropod faeces." He says that in a single location there may be as many as 8000 arthropod species. This compares with only 143 species of reptiles, birds and mammals in the Andrews forest.

The first scientist to realise just how many arthropods live in forest soil was Joseph Anderson of the University of Exeter. According to Moldenke, "no one knows what most of the arthropods eat, what eats them, or what they contribute to the soil."

One reason for this is that the creatures are so small: few of these beetles, pseudoscorpions and mites are more than a millimetre long, and most range from 150 to 1000 micrometres in length, says Moldenke. The creatures spend their entire lives inside the decaying organic matter of the soil, and are hard to distinguish from it.

Moldenke has been able to see, count and study these organisms thanks, in part, to thin-section microscopy, long used by petrologists. The technique involves sawing rock samples into transparent discs a few micrometres thick, then examining them under a microscope. Petrologists use it to identify tiny diatoms in rock samples brought up from hundreds of metres underground.



Brent Gowen

Soil micrograph: the thin section above reveals collembola (c) and mite (m) faeces inside the shell of a coniferous cone. Elsewhere can be seen a decomposing plant fragment (p) and a void (v)

Moldenke worked with Cindy Shaw, a soil scientist, and James Boyle, a forest ecologist. Shaw's technique is to extract a core of soil with a volume of about half a litre, and insert it into a pressure chamber. She then introduces epoxy into the soil sample, while carefully controlling the temperature and pressure to prevent the soil altering. When the epoxy hardens, Shaw slices it and views it under a microscope.

"The technique is better than previous ideas such as freezing the soil," says Moldenke. Frozen samples are hard to handle. He says the technique is also better than simply crumbling the soil to remove insects. "That enables you to see them, but you lose their location in the soil, and the soil's structure as well," says Moldenke.

Moldenke and his colleagues have been collaborating on their soil structure work with researchers at the University of Alberta. He says that there is only one other laboratory in North America using thin-section microscopy in soil research.

Moldenke says he has been surprised by how much his soil samples reveal. He can tell whether a sample came from a north or south slope, he can tell the age and species of the trees in the area, and, in some cases, he can also tell the distance to the nearest tree.

Moldenke says he has looked at samples from two tracts of forest that were clear-cut 35 years ago. One tract was burnt over after cutting, while debris on the other was left to rot. "There are still significant differences in the arthropod species and their numbers, all from a couple of hours of fire 35 years before."

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