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I'm not looking, honest!

Mar 5th 2009

From *The Economist* print edition

The good news is reality exists. The bad is it's even stranger than people thought

"HOW wonderful that we have met with a paradox. Now we have some hope of making progress." So said Niels Bohr, one of the founders of quantum mechanics. Since its birth in the 1920s, physicists and philosophers have grappled with the bizarre consequences that his theory has for reality, including the fundamental truth that it is impossible to know everything about the world and, in fact, whether it really exists at all when it is not being observed. Now two groups of physicists, working independently, have demonstrated that nature is indeed real when unobserved. When no one is peeking, however, it acts in a really odd way.

In the 1990s a physicist called Lucien Hardy proposed a thought experiment that makes nonsense of the famous interaction between matter and antimatter—that when a particle meets its antiparticle, the pair always annihilate one another in a burst of energy. Dr Hardy's scheme left open the possibility that in some cases when their interaction is not observed a particle and an antiparticle could interact with one another and survive. Of course, since the interaction has to remain unseen, no one should ever notice this happening, which is why the result is known as Hardy's paradox.

This week Kazuhiro Yokota of Osaka University in Japan and his colleagues demonstrated that Hardy's paradox is, in fact, correct. They report their work in the *New Journal of Physics*. The experiment represents independent confirmation of a similar demonstration by Jeff Lundeen and Aephraim Steinberg of the University of Toronto, which was published seven weeks ago in *Physical Review Letters*.

The two teams used the same technique in their experiments. They managed to do what had previously been thought impossible: they probed reality without disturbing it. Not disturbing it is the quantum-mechanical equivalent of not really looking. So they were able to show that the universe does indeed exist when it is not being observed.

The reality in question—admittedly rather a small part of the universe—was the polarisation of pairs of photons, the particles of which light is made. The state of one of these photons was inextricably linked with that of the other through a process known as quantum entanglement.

The polarised photons were able to take the place of the particle and the antiparticle in Dr Hardy's thought experiment because they obey the same quantum-mechanical rules. Dr Yokota (and also Drs Lundeen and Steinberg) managed to observe them without looking, as it were, by not gathering enough information from any one interaction to draw a conclusion, and then pooling these partial results so that the total became meaningful.

What the several researchers found was that there were more photons in some places than there should have been and fewer in others. The stunning result, though, was that in some places the number of photons was actually less than zero. Fewer than zero particles being present usually means that you have antiparticles instead. But there is no such thing as an antiphoton (photons are their own antiparticles, and are pure energy in any case), so that cannot apply here.

The only mathematically consistent explanation known for this result is therefore Hardy's. The weird things he predicted are real and they can, indeed, only be seen by people who are not looking. Dr Yokota and his colleagues went so far as to call their results "preposterous". Niels Bohr, no doubt, would have been delighted.

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