



## **The physical world: quantum**

*Einsteins' challenge to quantum theory*

### **David Papineau - King's College, London:**

The most famous is the EPR Thought Experiment - the Einstein-Podolsky- Rosen Thought Experiment.

#### **Presenter:**

The EPR Experiment is a bit tricky to get your head around. Imagine the glove in this box is a tiny quantum particle, only this time we've got a pair of particles, well gloves. Now we haven't opened the box or made any measurements of the gloves, so according to Niels Bohr neither of these gloves knows whether it's left or right handed; they're in some strange state, a kind of mixture of left and right.

We can't know anything about these quantum particles except that, like gloves, they have to come in pairs, but before they're observed the particles remain in a strange, unknown state.

OK, says Einstein, I don't believe it, but just suppose it were true? If I open one of these tins we force nature to make a decision. Now because the gloves must be a pair, the other glove must instantly become the opposite to this one. Its state is no longer uncertain. But how does this glove know when we open this tin? Can the gloves communicate? Maybe there's some special way we don't understand where they can send a message to each other. But even if that was true, the message can't travel faster than the speed of light due to Einstein's Theory of Relativity. But if we could open the tins at exactly the same moment, well there'd be no time for the message to travel.

### **David Papineau - King's College, London:**

Now that's instantaneous action at a distance and modern physics, because of Einstein's own Theory of Special Relativity, doesn't allow that, so Einstein was pointing out that if you believe quantum mechanics is normally understood, you're believing something that's inconsistent with Special Relativity, and that just looks wrong.

### **Abraham Pais - Rockefeller University:**

I said this to the professor, I said why don't you either, why don't you accept this, these words? It works so well. He said yes, I know it works so well but, he said, Newton had a wonderful theory which worked for two centuries perfectly, until I came along and I saw there were little things where it did not work so well. Well, so the fact that it worked so well is not a guarantee that it is the truth.

#### **V/O:**

The EPR Thought Experiment was Einstein's last and best challenge to the quantum theory. After 1935 he moved on to other things, but he remained unconvinced about the theory for the rest of his life, despite the efforts of Niels Bohr.

### **Abraham Pais - Rockefeller University:**

It bothered him tremendously that he could never convince Einstein; it was a real aggravation to him. He felt that he had failed because he couldn't convince Einstein. Now it was in some ways it was great fortune to have such a formidable opponent because it forced him to make his language ever more precise.

#### **V/O:**

As the theory was refined it became more and more successful. Despite the philosophical difficulties, most scientists just got on and used it. But the EPR Thought Experiment remained. Einstein's challenge was untested for nearly fifty years, but it was not forgotten.