CAN YOU

Believe it?

WITH ASSOCIATE PROFESSOR DEREK LEINWEBER

To be or not to be

The weird, ghostly worlds of Einstein's mind.

IF a tree falls in the forest, and nobody is around to hear it, does it make a sound? Welcome to Einstein's bizarre and spooky world, where an object's characteristics don't actually exist until you perceive them.

Scientific thinking in the 1920s posed a direct challenge to established perceptions. The smallest known materials in the universe, fundamental particles such as electrons, simply do not appear to behave in ways that traditional science would consider "real".

Suppose you had placed a pair of gloves in a coat pocket and one fell out. Imagine a world where the glove remaining in your pocket is a spooky graft of both left-handed and right-handed gloves. Imagine it as a ghostly glove with see-through thumbs half there and half not.

Suppose the lost glove is lying behind your sofa where your coat had been thrown earlier. This glove, too, would be in a weird ghostly state.

Now imagine you just flew to Paris and, upon pulling the glove out of your pocket and examining it, you see that it is the right-hand glove.

Of course, you would immediately conclude that the lost glove is left-handed.

But in this bizarre quantum world, the act of examining the glove in Paris would, without any delay, snap the glove behind your sofa in Adelaide into a state of left-handedness.

This is an example of the kind of worlds that Albert Einstein spent considerable time thinking about in the twilight years of his life.

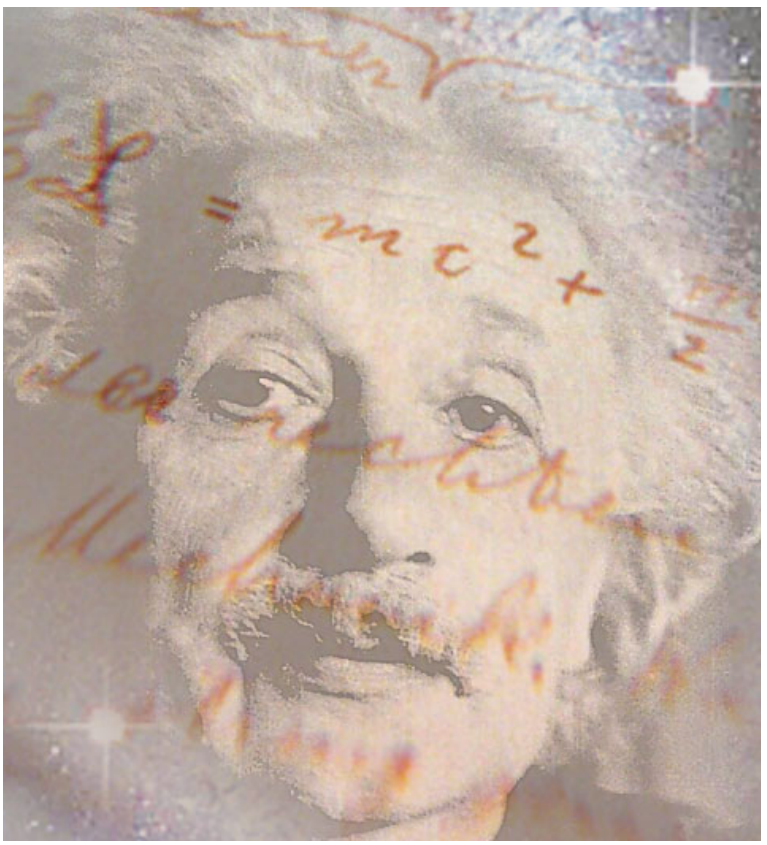
Einstein's point would be that the probability of finding a left or right-handed glove in your pocket is one-half. But his main point was that such a statement is an incomplete description of the world. A complete description would say that the glove is, or is not, left or right handed.

But Einstein admitted there is another answer: both gloves are half at home and half in the pocket. This state, which combines both possibilities, would be described in quantum mechanics as a "wave function". Of course, if you take the glove out of your pocket you will find out if it is left-handed or not.

In quantum mechanics, the act of looking at the glove "collapses the wave function" to one of the two observable outcomes: "the glove is left-handed" or "the glove is right-handed".

It is this instantaneous collapse of the wave function that concerned Einstein, and continues to attract the attention of physicists today.

Einstein's theory of relativity emphasises the role of the finite speed of light in our universe, central to the concept of "locality" or "separability". The idea is that an event at one point in space cannot influence what happens at another point in space until enough time has passed to allow light to pass between them.



Yet, in the realm of quantum physics, the act of checking the glove instantaneously determines which glove is back home – even if that's the other side of the world. Einstein argued that checking your pocket exerts a "spooky action at a distance" (spukhafte fernwirkungen).

But Einstein's personal feeling was that the left and right handed gloves were in one place or the other (not half-and-half), and pointed out that quantum mechanics did not tell us which glove was in the pocket. Therefore quantum mechanics was not describing what was actually happening in reality, and could not be classified as a true theory. Experiments have since revealed the quantum world really is truly weird.

This depth of thought is representative of Einstein's genius celebrated this year as the 2005 Einstein International Year of Physics.

So does a single glove actually exist in a ghostly mix of left and right pairs until one looks? No. One needs to remember that these scenarios are presented in order to illustrate in familiar terms how our world works at the smallest scale ever probed – the quantum level.

Derek Leinweber is an Associate Professor of Physics at the University of Adelaide.