# THE REALITY OF NON-LOCALITY

**Bell's theorem is the most profound discovery of science.**

Henry Stapp (1977)

**Einstein was concerned about the entanglement of separated systems at least as early as 1925.**

James Cushing (1994)

**The outcome of experiments performed on one member of the pair appears to depend not just on that member's own intrinsic state but also on the result of experiments carried out on its twin.**

Tim Maudlin (2002)

**The message seems to be this: reality is non-local, so get used to it.**

Jim Baggott (2004)

**The kind of nonlocality one encounters in quantum mechanics seems to call for an absolute simultaneity, which would pose a very real and ominous threat to special relativity.**

David Alpert (2009)

Just as I see my situation here becoming more uncertain, just as I find that I must wonder about him, he and I must take another run at what may be the weirdest weirdness of them all. In the 1920s Einstein is the first to find it. He says QM says two particles that get together as a quantum system keep up this relationship regardless of their separation when they part. This helps to convince him that QM is wrong. But it turns out that QM is right. It takes a while for physics to catch up. Indeed the more I read the more it seems it still is trying to catch up.

Non-locality, as it is called, can sound like science fiction. It's somehow mixed with spooky action at a distance, which will be a Problem of its own. I've been putting off as long as possible the time when he will have to take a look.

Non-locality is slippery. What is reality? Merry echoes of MacRury or Ken Kesey greet my question. The problem isn't non-locality itself. Non-locality is just the way it is. What happens here at A's related to what happens over there at B. And C somewhere else. They are related even though 'over there' and 'somewhere else' may mean Manhattan and the Moon.

The problem isn't even that it happens instantly, with what Alpert labels absolute simultaneity. That too is just the way it is. This seems weird but that's be-

cause we're used to thinking in a different way. As Baggott says, I'll say to him: Get used to it.

So, what's the problem? Well, the problem is that physics by and large has missed the bus. The concept of non-local doesn't jibe with lots of physics. So physics is, to this extent, at odds with what is real. And it is hard for me to sort out what 'to this extent' may mean. I don't suppose he'll like it but we'll have to try.

It really is a mental tangle. I sense a ho-hum attitude to the idea. I mean, how long should it take? Einstein and two colleagues write of it in 1935. It's published in the leading physics journal of the day and is *the* most-cited physics paper ever. They claim QM is two bricks short of a load. Bell looks into this three decades later. He publishes his theorem in 1964. It sets up a deep test of quantum theory. Success will mean the universe must be non-local. This may be the most important physics ever. So say some physicists. Yet it struggles for a place in physics as it's taught.

The silence is so deafening Bell fashions a Bell's-Theorem-for-Dummies version. It's based on the sock habits of his colleague Bertlmann. To ensure that readers realize it is the straight goods he entitles it 'Bertlmann's Socks and the Nature of Reality.' It even has a cartoon—which, since this is physics-journal world, must be called a Figure—of Bell's colleague Dr. Bertlmann as he comes round a corner, left foot leading, right foot not quite yet in view. The text says:

> Dr. Bertlmann likes to wear two socks of different colors. Which color he will have on a given foot on a given day is quite unpredictable. But when you see (Fig. 1) that the first sock is pink you can already be sure that the second sock will not be pink.

The point of Bell's Theorem is: The universe presents us with—or may be made of—relationships of the sock-color kind. Of course in Bertlmann's case there's no mystery. The reader knows that Bertlmann wears socks of unlike colors. As his right foot emerges from behind the wall we see a blue or purple, but not pink, sock—no surprise. So what's the big deal? Where's the Bertlmann who keeps tabs on the universe's socks?

By the 1980s measurements confirm: QM is right and Einstein's wrong. They are repeated and improved on many times.

Recently more physicists are making peace with non-locality. But in some recent physics papers it still seems to be an option to pretend there is no Bell. There is no option. Physics has to grasp the nettle. *My* Frank would figure if it is non-local now, it must begin that way in the Beginning. To be fair non-local isn't a description LAPD Frank was used to using for an APB.

It seems to me this is a prize that's of great worth, a thread of thought that

might link back to when the world began. How to sell him on it? Even physics doesn't fully buy it yet. The Problem is there is no way that it can *happen*. The Reality of Non-Locality demands an answer to the question: How?