THE SPOOKY ACTION PROBLEM

Reality cannot be found except in one single source, because of the interconnection of all things with one another.

Gottfried von Leibniz (1670)

According to the theory of relativity, action at a distance with the velocity of light always takes the place of instantaneous action at a distance or of action at a distance with an infinite velocity of transmission.

Albert Einstein, (1916)

Two particles that can be miles, or light years, apart may behave in a concerted way: what happens to one of them happens to the other instantaneously, regardless of the distance between them.

Amir Aczel (2002)

The particles communicate faster than light.

Tim Maudlin (2002)

Nonlocality implies that a fist in Des Moines can break a nose in Dallas without affecting any other physical thing (not a molecule of air, not an electron in a wire, not a twinkle of light) anywhere in the heartland.

David Albert (2009)

Today he's here on time for spooky action. Einstein is the first one whom this action spooks. He thinks it obvious that no such action can exist. His term, *spukhafte Fernwirkung*, or spooky action at a distance, is dismissive. A more polite term is *Entanglement*. It's the principle of non-locality made manifest. Aczel calls Entanglement 'the greatest mystery in physics.' Of all the weird things QM predicts, Entanglement may be the weirdest. It's not hard to understand but it's not easy to accept. I find it hard. Einstein found it harder. When I try it out on Frank he doesn't see it should be hard. He sits back and says: So what?

Here's how it works. Take two somethings. In principle it doesn't matter what. But they are usually tiny and of the same ilk. Like two electrons or two photons. Make them interact. A simple way is make them as a pair in one event. QM tells us they are now entangled. Let them wander off. Though far apart they stay entangled.

Entangled means their properties are linked. The reason is that they comprise a single quantum state. For example if it's made of two electrons their spins must be opposite. Thus, no matter where they are, one measures one and knows the answer for the other. It's like a Bertlmann who only owns two socks.

So far so good but here's the thing: QM says an electron doesn't *have* a spin that's up or down until its spin is measured. It's the measurement that makes it pick which spin to have. But measure one and find it's up—instantly the other is now down no matter where it is. That's what makes it spooky: It's the distance.

Experiments confirm that this is so. It makes no sense. There has to be a trick. QM says there is a trick. It's simply this: It doesn't *have* to make sense. I can see why Einstein doesn't like it.

It gets worse. If two objects—call them *A* and *B*—become entangled and two others *C* and *D* become entangled with each other too, if one entangles *A* and *C* then this entangles *B* and *D* though they were *never near each other*.

When something's done to one of any number of entangled objects it is done to all of them wherever they may be. Despite relativity, 'simultaneous' has special meaning in QM.

Some physicists would minimize this fact's significance. But, as Greene says,

> Physicists say that the [measurement] results … do not stand in a traditional cause-and-effect relationship because nothing travels between the two distant locations. … Many physicists find this convincing, but others have a nagging sense that there is more to the story.

I take his term 'traditional cause-and-effect relationship' to mean one can't use the Entanglement to send a message. So the speed of light still limits messages as well as mass. But it seems clear Entanglement has action one place causing instant change some other place. Reading further I find that this happens all the time and everywhere.

The Spooky Action Problem isn't that the action's spooky. The problem is QM says nothing about how it works. But then QM explains nothing. This doesn't seem to bother Frank. He yawns; he's bored. *My* detective wouldn't have that problem. It's not in his script. I close my eyes and think his one-track mind is thinking: What would spooky action do in the Beginning? This Problem too comes down to how it's done.