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The Loose Ends of the Universe

The ability of particles to communicate faster than light may be the result of mini-wormholes

BrimmingThe Sombrero Galaxy, 28 million light years away, has an unusually large 'dust ring.' Photo: SSPL via Getty Images

by John Gribbin

Albert Einstein used the term "spooky action at a distance" to refer to the way that, according to quantum theory, particles that have once interacted with each other seem to remain in some sense "entangled" even when they are far apart. Poke one particle, in the right quantum-mechanical way, and the other particle jumps, instantly, even if it is on the other side of the universe.

Einstein did not mean the term as a compliment, and did not believe that the effect could be real. Alas for Einstein experiments based on the theoretical work of the physicist John Bell some 30 years ago proved that this entanglement is real. More precisely, they proved that something called "local reality," which is a feature of everyday common sense, is not real.

Local reality says that there is a real universe out there, even when we are not observing it. The "local" bit of the name says that these real objects can only affect one another by means of influences that travel at less than or equal to the speed of light. In entanglement experiments, however, "locality" seems to be violated. Alternatively, there may not be a real world out there that exists independently of our measurements—"reality" may be what is being violated. In that case, the conceptual problems arise because we are trying to imagine what "particles" are like when they are not being measured; if we discard the idea of such a reality, we can preserve locality. And if you really want a sleepless night, consider that both locality and reality may be violated.

Spooky Action at a Distance

by George Musser
Farrar, Straus and Giroux, 286 pages, $27

George Musser's book "Spooky Action at a Distance" is likely to provoke such sleepless nights. He starts off with Bell's work and its implications, in effect tracing the history of the development of quantum physics. This, you should be warned, is the easy bit. Having established that local reality is not a valid description of how the universe works, Mr. Musser takes us out into far deeper waters. Quantum field theory is just the beginning, and introduces another form of non-locality. "Fields" seem to be everywhere at once, like magnetism.

The general theory of relativity and black holes, Mr. Musser explains, offers up another candidate for this entanglement, now seen as a universal effect—not something only particle physicists have to worry about. After all, the general theory allows for the existence of so-called "wormholes," tunnels through space and time that link different parts of spacetime—distant parts of universe, or (conceivably, although Mr. Musser does not elaborate on this) different universes. A wormhole is intrinsically nonlocal. Some theorists have even suggested that mini-wormholes might link entangled particles and explain their shared properties.

The island of knowledge that we are swimming toward, frantically trying to keep afloat, is the understanding that both space and time are illusions. Non-locality is the natural order of things, and space itself is manufactured out of non-local building blocks. "Locality," says Mr. Musser, "becomes the puzzle," but another puzzle is the precise nature of those building blocks. The analogy he uses to explain this involves water. Individually, the building blocks of water—molecules—are not wet, but collectively they produce the sensation of wetness. Individually, the building blocks of the universe, yet to be identified, are not spatial, but collectively they produce the sensation of space.

All this is tough going, and in spite of the author's heroic efforts to make difficult concepts comprehensible, he does not always succeed. But the ideas he discusses, such as so-called matrix theory, or the possibility that “our” universe could be a sort of holographic image projected from some higher reality, illuminate concepts at the cutting edge of physics today, and nobody should expect all the loose ends to be neatly tied up.

Indeed, the most powerful message to take from this book is tucked away, almost apologetically, near the end. Science is all about debate, and progress is made by arguing about cherished (but not necessarily correct) ideas, until some consensus emerges. When the consensus is reached, the physicists become bored and move on to something new. The sound of physicists arguing is the sound of science making progress. That is the “sound” of this book. But even Einstein is not always right, and “yesterday’s drag-out fights are tomorrow’s homework problems,” as Mr. Musser succinctly puts it.

As this example illustrates, the author has a neat turn of phrase that helps to make the difficult ideas described here slightly less difficult to comprehend. But don’t think “less difficult” means “easy.” “Spooky Action at a Distance” is an important book that provides insight into key new developments in our understanding of the nature of space, time and the universe. It will repay careful study, and I am sure it will become a well-thumbed feature of my reference shelf, while the extensive bibliography will help those who want to delve further. But this is not a book you can digest in a single reading.

—Mr. Gribbin is a Visiting Fellow in Astronomy at the University of Sussex. His book The Quantum Mystery will shortly be available as a Kindle Single.