Opposites interfere

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In a classic physics experiment, photons (light particles), electrons, or any other quantum particles are fired, one at a time, at a sheet with two slits cut in it that sits in front of a recording plate. For photons, a photographic plate reveals an oscillating pattern (bands of light and dark) – a sign that each particle, behaving like a wave, has somehow passed through both slits simultaneously and interfered, canceling the light in some places and enhancing it in others.

If single quantum particles can exist in two places at once, and interfere with themselves in predictable patterns, what happens when there are two quantum particles? Can they interfere with each other?

Prof. Mordehai Heiblum of the Weizmann Institute's Condensed Matter Physics Department and his research team have been experimenting with electrons fired across special semiconductor devices.

Quantum mechanics predicts that two electrons can indeed cause the same sort of interference as that of a single electron – on one condition: that the two are identical to the point of being indistinguishable. Heiblum and his team showed that, because of such interference, these two particles are entangled – the actions of one are inextricably tied to the actions of the other – even though they come from completely different sources and never interact with each other.

The team's findings recently appeared in the journal *Nature*.

Dr. Izhar Neder and Nissim Ofek, together with Dr. Yunchul Chung, Dr.

Diana Mahalu and Dr. Vladimir Umansky, fired such identical electron pairs from opposite sides of their device, toward detectors that were placed two to a side of the device.

In other words, each pair of detectors could detect the two particles arriving in one of two ways: particle 1 in detector 1 and particle 2 in detector 2, or, alternatively, particle 2 in detector 1 and particle 1 in detector 2. Since these two 'choices' are indistinguishable, the 'choices' interfere with each other in the same way as the two possible paths of a single quantum particle interfere.

The scientists then investigated how the 'choice' of one particle affected the pathway taken by the other, and found strong correlations between them. These correlations could be affected by changing, for example, the length of the path taken by one particle. This is the first time an oscillating interference pattern between two identical particles has been observed, proving, once again, the success of quantum theory.

Source: Weizmann Institute of Science