

# Letting the spin loose

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*A team of scientists at the Weizmann Institute of Science has recently demonstrated conclusively that, in very specific circumstances, spin can become separated from charge and progress independently down a wire*

Two properties of an electron - its spin and its charge - are generally thought to be inseparable, intrinsic characteristics, no more given to sudden changes or going off on their own than say, the fur on a cat or the paint on a bicycle. But a team of scientists at the Weizmann Institute of Science has recently demonstrated conclusively that, in very specific circumstances, spin can become separated from charge and progress independently down a wire. Their findings appeared in a recent issue of *Science*.

Spin-charge separation was first predicted in the sixties. The idea was based on a theory that electrons with a range of movement limited to one dimension alone would behave differently from those moving in two or three dimensions. This is because when electrons are lined up head to tail, the influence of the repulsive forces between them becomes overwhelmingly significant. But demonstrating the phenomenon had to wait until technology caught up to the theory.

Prof. Amir Yacoby of the Institute's Condensed Matter Physics Department and research students Dr. Ophir Auslaender and Hadar Steinberg set up an experiment with quantum wires - so thin that electrons must go single file down their length, limiting flow to a single dimension and direction. "Up to a certain point, one can think of these

electrons as cars on a narrow, one lane road: there's no passing, and the slowest car sets the speed for the rest. A block in the road will bring all traffic to a halt. But here the analogy ends. If you increase car density on a road, traffic invariably slows down, while electrons speed along merrily in high-density flow and slow down when the density decreases. It is in these slow-moving, low density electron flows that things become interesting."

The separation the team achieved between spin and charge rests on the fact that the spins of electrons in these low density, single dimension flows generally follow a preferred arrangement: alternating between the two possible directions of electron spin - up and down. In the experiment, single electrons here and there could jump from wire to wire, allowing the scientists to jumble traffic a bit. So when an electron in the middle having, say, a down spin stepped out of the line, the next electron moved up to fill in, creating a situation with two neighboring ups. This non-ideal state of affairs caused one of them to flip its spin to down, which then caused the next electron, also with a down spin, to flip its spin to up, and so on. Thus the spin traveled down the wire independently of the charge, which stayed tied to the electrons.

Source: American Committee for the Weizmann Institute of Science

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