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Cold atoms could help build 'spintronics' transistor

They can engineer them smaller and pack more in, but there will always be a limit to how fast semiconductor devices can be made to perform.

One way to improve this limit, and broaden applications, is to design "spintronic" devices that exploit electron spin as well as electron charge. Now, physicists in the United States and Lithuania have come up with an idea for a test bed that could help in the realization of one of the most important spintronic devices — the so-called Datta–Das transistor (DDT).

Like normal transistors, the DDT would control a current passing between two of its electrodes. But because the DDT is a spintronic device, it would control a "spin polarized" current — one in which most of the electrons have the same spin orientation: up or down.

The key to controlling this spin-polarized current is a spin filter, which forms part of the second electrode. The filter is set to one spin orientation — say, up — which means that a current of spin-up electrons flowing from the first electrode is always let through. To control the size of this current, the DDT has a third electrode, which emits an electric field that "twists" the spin the electrons downwards. Depending on the extent of the twist, more or less current is blocked by the filter.

That's the theory, anyway. Since U.S. physicists Supriyo Datta and Biswajit Das proposed the DDT in 1989, experimentalists have not had much success making a working version. But Charles Clarke and Jay Vaishnav from the National Institute of Standards and Technology (NIST), together with Julius Ruseckas and Gediminas Juzelunas of Vilnius University, think they have an idea that could help experimentalists on their way — an analogous system in which basic parameters can be tweaked.

Vaishnav and colleagues' system would be a beam of ultracold atoms, such as rubidium. These atoms would effectively have two possible states, which are analogous to the "up" and "down" spin states of electrons.

To control these atoms, say the researchers, the system would need the light from three laser beams that slightly overlap. As the atoms pass through the first laser beam — like electrons flowing from the first electrode in a DDT — they would be put in the same atomic "spin" state. But as the atoms pass through the region where the three laser beams overlap, their atomic states would begin to shift — like the twisting effect of the DDT's third electrode. By controlling the manner in which the laser beams switch on and off, Vaishnav and colleagues think they should be able to replicate the entire function of a DDT. "It may help understand problems in real systems," says Vaishnav.

Although the cold-atom analogue is just an idea for now, Vaishnav told physicsworld.com that it uses "common experimental techniques", which some of her colleagues would be well-equipped to implement. "There are people at NIST who are working on similar experiments," she notes.

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