Physicists Don't Flip Spin but Find Possible Electron Switch

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University of Oregon researchers trying to flip the spin of electrons with laser bursts lasting picoseconds (a trillionth of a second) instead found a way to manipulate and control the spin -- knowledge that may prove useful in a variety of new materials and technologies.

Physicists in recent years have been pursuing a variety of routes to tap electron spins for their potential use in quantum computers that can perform millions of computations at a time and store immense quantities of data or for use in emerging optic devices or spintronics.

"Spin is another dimension of electrons," said Hailin Wang, a professor of physics at the UO. "The electronics industry has depended on electron charges for more than 50 years. To make major improvements, we now need to go beyond charges to spin, which has been very important in physics but not used very often in applications."

Wang and his doctoral student Shannon O'Leary theorized that they could flip an electron's spin up to down, or vice versa, by using a nonlinear optical technique called transient differential transmission. They describe their "failure" to flip the spin and their unexpected discovery in *Physical Review B*.

The overall goal, Wang and O'Leary said, is to be able to force the spin to flip using light. Their studies involved the use of nonlinear optical processes of electron spin coherence in a modulation-doped CdTe quantum well -- semiconductor material formed from cadmium and tellurium, sandwiched in a crystalline compound between two other semiconductor barrier layers. A doped quantum well contains extra embedded electrons in a near two-dimensional state.

O'Leary initialized a spin in an experiment using a "gyro-like" arrangement with a short pulse of laser. At specific times, she hit the spin with another laser pulse with the absorption energy of an exciton (an electron-hole pair) or trion (a charged exciton). Hitting the spin with a third pulse allows them to study what impact the second pulse had on the spin.

"We know that in this particular system, excitons quickly convert into trions by binding to a free electron," O'Leary said. "One surprising aspect is that injecting trions directly does not manipulate the spin. So the manipulation effect has to do with the conversion of the excitons to trions."

The behaviors they discovered were unexpected but intriguing, Wang said. "We were not able to flip the spin, but what we found is something quite puzzling, quite unexpected, that was not supposed to happen. We now want to understand why the system works this way. This will require some more work. We wanted to get from point A to B, but we went to C."

The detour, however, "shows that we can manipulate the spin when we inject excitons at appropriate times in the precession cycle of the spin," O'Leary said. "The result gives scientists a new tool for manipulating spins, and it may prove to be a handy method because it simply requires shining a pulse of light of the appropriate energy at the right time."

Source: University of Oregon