Physicists control the flip of electron spin

May 27 2005

Today's computers and other technological gizmos operate on electronic charges, but researchers predict that a new generation of smaller, faster, more efficient devices could be developed based on another scientific concept – electronic "spin." The problem, however, is that researchers have found it challenging to control or predict spin – which keeps practical applications out of reach.
But physicists in Europe, California and at Ohio University now have found a way to manipulate the spin of an electron with a jolt of voltage from a battery, according to research findings published in the recent issue of the journal *Physical Review Letters*.

In the new study, scientists applied voltage to the electron in a quantum dot, which is a tiny, nanometer-sized semiconductor. The burst of power changed the direction of the electron's spin -- which can move either up or down. This also caused it to emit a small particle of light called a photon, explained Richard Warburton, a physicist with Heriot-Watt University in Edinburgh, Scotland, and lead author on the new paper.

"Usually you have no control over this at all – an electron flips its spin at some point, and you scratch your head and wonder why it happened. But in our experiment, we can choose how long this process takes," he said.

The experiment was based on a theory by Sasha Govorov, an Ohio University associate professor of physics and astronomy who is co-author on the current paper. Pierre Petroff, a scientist with the University of California at Santa Barbara, contributed the semiconductor used in the experiment, Indium Arsenide, which commonly is used in electronics. "It's one of those happy collaborations -- Pierre has given us some fantastic material and Sasha has come up with some really smart ideas," Warburton said.

The scientists were able to manipulate how long it would take for the electron to flip its spin and emit a photon – from one to 20 nanoseconds. But Govorov's theory suggests that 20 nanoseconds isn't the upper limit, which will lead the physicists to try out longer time periods.

Scientists' abilities to control the spin of the electron help determine the properties of the photon, which in turn could have implications for the development of optoelectronics and quantum cryptography. Photons could be encoded with secure information, which could serve as the basis for anti-eavesdropping technology, Warburton said.

The current study is one of many in the growing field of nanoscience that aims to find, understand and control physical effects at the nanoscale that could serve as the basis of a new generation of technology that is smaller and more powerful than today's electronic devices, Govorov said.

"The principles, knowledge and experience will be used for practical, real devices, we hope," he said.

The study was funded by EPSRC in the United Kingdom, Ohio University, Volkswagen, and the Alexander von Humboldt Foundations, with additional support by the Scottish Executive and the Royal Society of Edinburgh. Collaborators on the paper are Jason Smith and Paul Dalgarno of Heriot-Watt University, Khaled Karrai of the Ludwig-Maximilians-Universitat in Germany, and Brian Gerardot and Pierre Petroff with the University of California Santa Barbara.

Source: Ohio University