Article examines rare quantum physics effect

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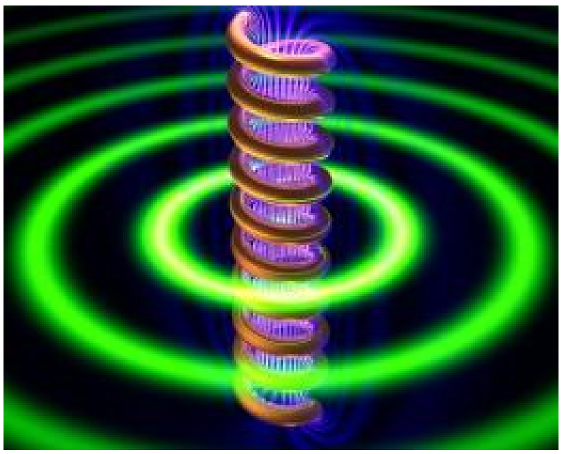

Electron waves being shot past a tiny toroidal magnet.

(PhysOrg.com) -- There's nothing University of Nebraska-Lincoln physicist Herman Batelaan likes more than a challenge. And there are few areas of science more challenging than working at the sub-atomic, or quantum, world, where the laws of physics are different from those of our macro world.

For the last four years, a little-known area within that field has captured his attention -- the Aharonov-Bohm effect. Predicted by theorists Yakir Aharonov and David Bohm in 1959, the effect is a phenomenon where electrons can be affected by electromagnetic potentials without coming in contact with actual force fields.

"It's what is called 'action-at-distance,'" said Batelaan, an associate professor of physics and astronomy. "An example of action-at-a-distance would be that you push with your finger in mid-air one foot above your table and a book that is lying on the desk moves. That would be weird -- and so is any action-at-a-distance phenomenon."

Aharanov and Bohm's prediction was originally received with skepticism, but many questions were answered by experiments in Japan and at UNL in which electron waves were shot past tiny toroidal magnets (wires rolled up in long spirals with current running through them). A 1986 experiment led by Akira Tonomura at Hitachi Ltd. and the RIKEN Frontier Research System in Japan, showed the action-at-a-distance effect is real; and a 2007 experiment by Batelaan's group at UNL showed that there is no force acting on the electrons.

That work is highlighted on the cover of the September issue of *Physics Today*, the journal of the American Institute of Physics, along with a feature article by Batelaan and Tonomura reviewing research into the little-understood phenomenon that among other things shows that some aspects of classical physics such as Newton's third law -- every action has an equal and opposite reaction -- don't always apply at the quantum level. But Batelaan and Tonomura are in good company. Even Nobel laureate Richard Feynman (1918-88), thought by many to be the greatest American physicist, pointed out in his "Lectures on Physics" that Newton's third law does not always hold.

"I feel that I'm lucky that we can tinker with physical realizations of the theoretical systems that Feyman was considering," Batelaan said.

Another puzzling thing about the Aharonov-Bohm effect, Batelaan said, is that while knowledge of the effect has been around for a half-century and is a modern cornerstone of quantum mechanics, it has not led to technological progress in developing nanometer-size devices.

"On the one hand, I have the feeling that there's something that's not quite understood there, and on the other hand, I feel there must be something we can do with this," Batelaan said. "But isn't that the heart of science, that you're at the limit of your knowledge and you're wondering what's going one there? If we knew where it was going, then it wouldn't be for me. I'm looking for fundamental stuff. I would rather open the route to something new. To me, that's very exciting and with this (*Physics Today*) article, Tonomura and I wanted to send a message to young researchers that a lot of things are still unknown and mysterious."

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