Nanoscientists Describe Electron Movement through Molecules

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Molecular electronics is the ultimate miniaturization of electronics. In this area of research, scientists have been studying the movement of electrons through individual molecules in an effort to understand how they might control and use the process in new technologies. Computers and thousands of other devices could become vastly faster, smaller and more reliable than conventional transistor-based (wire-based) electronics.

A team of Ohio University and Brazilian physicists has taken another step toward this goal. In the Rapid Communication section of the Sept. 15 issue of the journal Physical Review B, the researchers present a new theory of how electrons interact in a molecule.

In the new paper, the team describes what happens to electrons when scientists put two molecules between electrodes, which are bits of tiny conducting wire. Existing theoretical models of molecular electronics take into account that electrons avoid each other, according to Nancy Sandler, Ohio University assistant professor of physics and astronomy. The scientists report that molecular vibrations, in addition to strong electronic interactions, will produce unexpected “transport channels.” The electrons move through the molecule while the molecule vibrates, said Sergio Ulloa, co-author of the paper and Ohio University professor of physics and astronomy.

“The electrons go through the molecule like a pinball and they leave all the bells ringing (atoms moving) as they pass by,” said Ulloa, adding that

this model focuses on the general behavior of short molecules. Other scientists studying molecular electronics, he noted, are using longer molecules, such as DNA or carbon-based molecules, to serve as longer "wires" or connectors.

The collaborators on this project – which included Ulloa, Sandler, Brazilian exchange student Edson Vernek and professor Enrique Anda of the Pontifícia Universidade Católica in Rio de Janeiro, Brazil – describe another fascinating capability of the electrons: "The electrons 'remember' not only where they are, but where they have been," Ulloa said. "When the oscillations of the molecules are 'just right,' the electrons are either pushed through more efficiently or trapped momentarily in the molecule – a phenomenon physicists call 'Rabi-assisted tunneling.' The electrons can really get trapped, like in the pinball machine."

This electron "trapping" could make molecular transmission even more efficient and help develop molecular switches and other applications.

Molecular electronics is a booming field in physics right now. Scientists have been able to manipulate molecules for only last 15 years, Sandler said, and it may be at least another 20 years before consumers see molecular technology in commercially available devices.

Source: Ohio University