Spin on perovskite research advances potential for quantum computing

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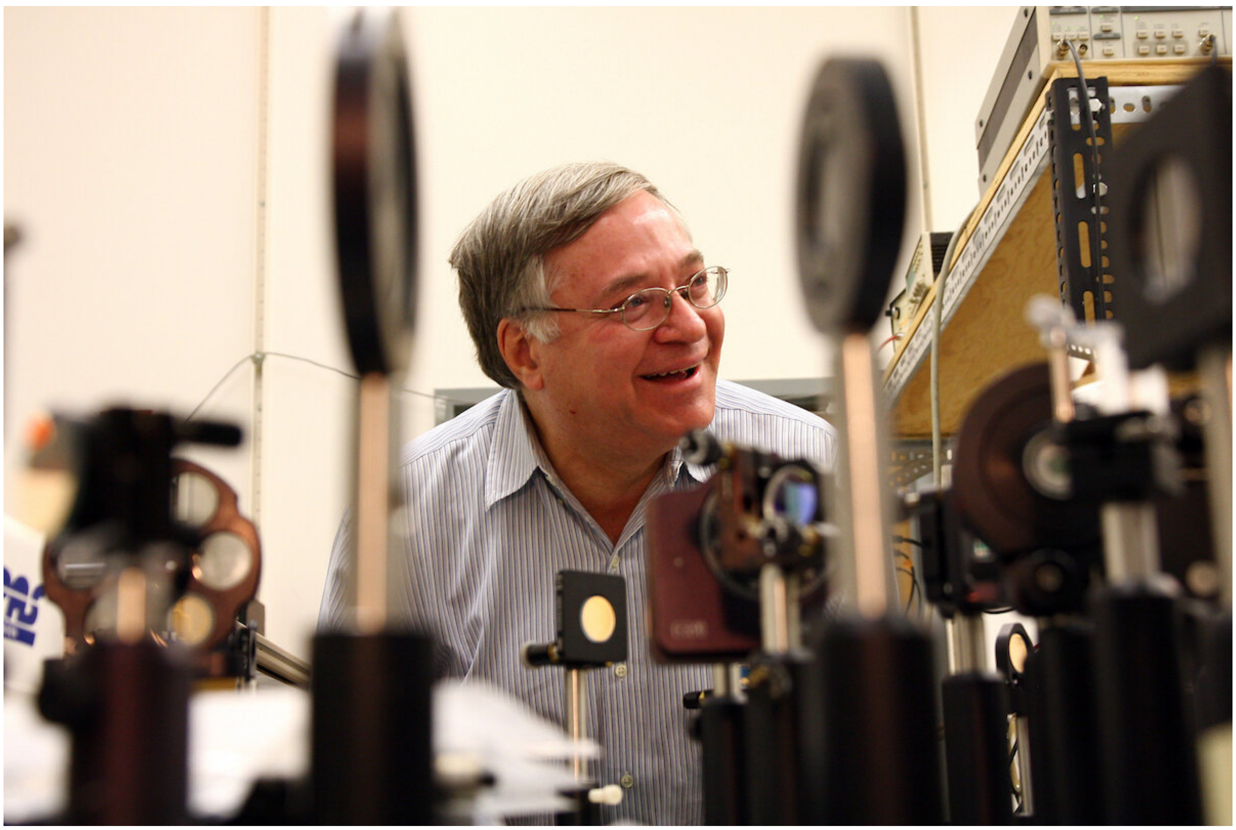

Z. Valy Vardeny, Distinguished Professor, Department of Physics & Astronomy. Credit: University of Utah

The next generation of information technology could take advantage of spintronics—electronics that use the minuscule magnetic fields emanating from spinning electrons as well as the electric charges of the electrons themselves—for faster, smaller electronic devices that use less energy.

Newly published work by scientists at the National Renewable Energy Laboratory and the University of Utah may figure into the future success of spin-based electronics. They have shown that the transport of electrons with a particular spin state through a two-dimensional hybrid organic-inorganic perovskite can be manipulated by introducing special organic molecules in the multilayer structure. These are chiral, which means they prefer one electron helicity over the other.

The new paper, "Spin-dependent charge transport through 2-D chiral hybrid lead-iodide perovskites," appears in the journal *Science Advances*. The researchers worked together under the umbrella of the Center for Hybrid Organic Inorganic Semiconductors for Energy (CHOISE), an Energy Frontier Research Center funded by the U.S. Department of Energy's Office of Science, Basic Energy Sciences.

Haipeng Lu, a postdoctoral researcher working with Matthew C. Beard, a senior research fellow at NREL and director of CHOISE, and Z. Valy Vardeny, Distinguished Professor of physics from the U, are lead authors of the paper.

"We discovered that the multilayer structure acts as a natural spin filter, which can be used to inject spin aligned electrons into active layers without the need of an external magnetic field. This is the beginning of a new paradigm of spintronics without a magnetic field," said Vardeny.

An electron can have either "up" or "down" spins, and electrons with opposite spins can occupy the same electronic state. The key challenge in a spintronic device is to control the spin-polarized electron density; that is, to manipulate the number of electrons with well-defined spin states.

Spin-based quantum computing, for example, will require the ability to control and address these individual spin states. One way to control spin-polarized currents is through "chiral-induced spin selectivity," where the transport of electrons with "up" or "down" spin states depends upon the transporting materials' chirality—a structural property of a system where its mirror image is not superimposable on itself. For example, a "left-handed" oriented chiral system may allow transport of electrons with "up" spins but block electrons with "down" spins and vice versus.

The scientists have demonstrated how to integrate a chiral organic sublattice into an inorganic framework, creating a chiral system that can transport electrons with the desired spin control. These hybrid organic/inorganic layered perovskites prefer to conduct one spin state depending on the "handedness" of chiral organic molecules. Thus, the chiral perovskite films act as a spin filter.

This work opens the door for future spintronic devices based upon chiral perovskite spin filters.

The research builds upon an accidental discovery Beard's team made several years ago that perovskite materials exhibit an efficient optical Stark effect at room temperature. The effect can be used to control or address individual spin states using optical light pulses. While spin-optoelectronic devices based on hybrid organic-inorganic perovskites have been proposed theoretically, Vardeny and his fellow researchers at the University of Utah announced earlier this year they were able to demonstrate such devices including spin-valves and spin-LEDs.

The spin-filters developed here are another component of perovskite -based spintronic applications.

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More information: Haipeng Lu et al. Spin-dependent charge transport through 2D chiral hybrid lead-iodide perovskites, *Science Advances* (2019). DOI: 10.1126/sciadv.aay0571

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