Physicist tackles atomtronics

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(PhysOrg.com) -- Atomtronics is a relatively new science devoted to creating artificial tailored materials consisting of neutral atoms held in an array with laser beams, or atoms moving along a desired track under electric or magnetic influence.

Shan-Wen Tsai, an associate professor of physics and astronomy at the University of California, Riverside, is a coauthor on a study to be published in Physical Review Letters that shows how a simple "joystick" consisting of an adjustable magnetic field can create several new phases of atomtronic matter, several of them never seen before.

"In atomtronics the forces among the atoms can be controlled," Tsai said. "The atoms can be induced to interact via a force that can be dialed up or down."

The research team, led by scientists at George Mason University, studied what happens when ultracold highly magnetic atoms are held in an optical lattice and subjected to an external magnetic field, which can be steered in various directions. This field tugs on the atom-sized magnets and, along with the direction of the field itself, leaves the atoms standing upright or pulled over on their sides at various inclinations.

Tsai explained that the atoms don't just stay put as they are being jerked around. They distort themselves into patterns.

"Each pattern can be considered a different phase of atomtronic matter," she said. "And just as water molecules can exist in phases—ice, water, steam—depending on how a joystick that controls temperature and pressure is deployed, so the magnetic atoms sort themselves into numerous phases depending on the magnetic joystick controlling the strength and orientation of the applied magnetic field."

The research impacts scientists' understanding of complex materials, and their ability to design and engineer new quantum states of matter. Various collective states of electrons in metals, such as superconducting, magnetic and charge-ordered states, are being explored as alternative vehicles for data encoding.

"Atomtronics may provide access to new quantum phases of matter that can be better controlled and manipulated for similar applications," Tsai said.

She explained that understanding the effects of interactions in a quantum many-body system is a challenging problem.

"I have been working on extensions and applications of an important technique — the 'functional renormalization group' (FRG) method — that can be used to tackle this problem," she said. "A major part of the results of this project were obtained via computational work using the FRG method."

Researchers from the University of Hamburg, Germany, and the Joint Quantum Institute at the University of Maryland collaborated on the study.

Provided by University of California, Riverside

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