One-way roads for spin currents

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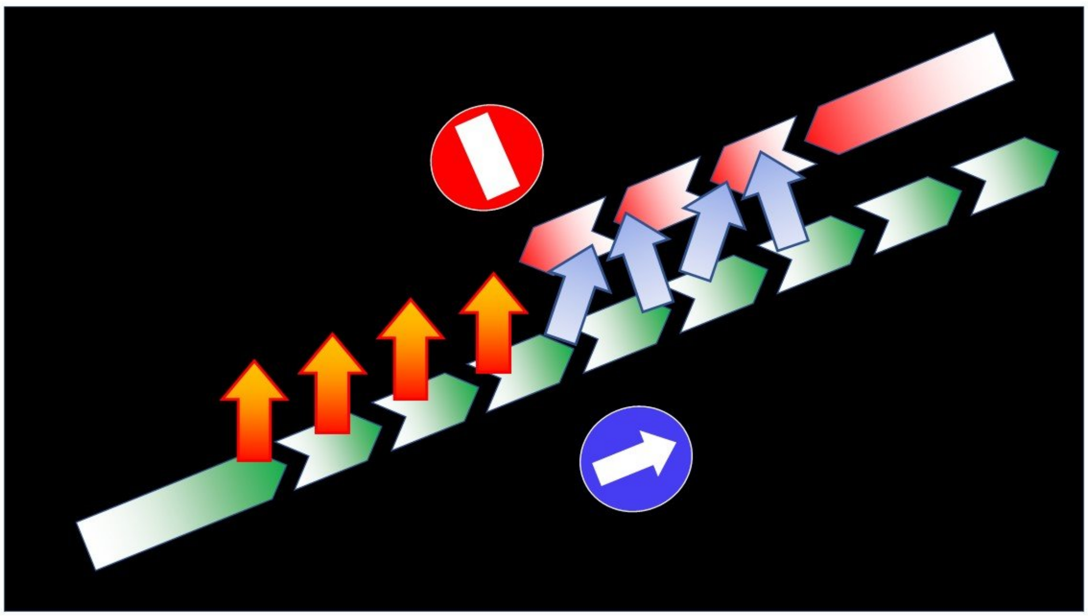

Spin chain in which spin interactions are strong in the left half (orange arrows) and weak in the right half (blue arrows). A spin current from left to right (green arrowed line) is possible, but not in the opposite direction (red arrowed line). A very large rectification is the result of this. Credit: SUTD

Spin is a type of angular momentum intrinsic to particles, roughly speaking as if they were spinning on themselves. Particles can exchange their spin, and in this way spin currents can be formed in a material. Through years of research, scientists have learned how to control such spin currents in an analogous way such that they can control the flow of electrons, the basis of a field of physics known as spintronics.

The study of the effect of strong interactions in quantum systems is particularly challenging. However, it is well known that strong interaction between quantum particles can completely change the properties of a system, making it, for instance, ferromagnetic, superconducting, etc. Strong interactions in spin systems can also allow for the generation of interesting transport properties in a material.

Researchers from Singapore University of Technology and Design (SUTD), University Insubria and Universidade Federal de Minas Gerais report a new approach to controlling spin currents based on strong spin-spin interactions, which results in diodes for spin current with a giant rectification. In this work, the researchers demonstrated analytically and via advanced numerical simulations that if the interactions are stronger than a certain magnitude, the system can drastically change and becomes an insulator, preventing currents from flowing. Interestingly, this drastic change to insulating behaviour only occurs when trying to impose the current in one direction. When trying to drive a spin current in the opposite direction, the flow is possible and the system is not an insulator.

These predictions could lead to substantial progress in material science, and new devices could be built based on this principle. The researchers propose experiments with atoms near absolute zero or with structures made of a few atoms deposited carefully on surfaces.

SUTD Assistant Professor D. Poletti, who led the research effort, says, "This is a very interesting effect we have stumbled upon. Much more interesting physics are yet to be uncovered in strongly interacting spintronic systems, and this can lead to the creation of new technologies." This research work was recently published in renowned American journal *Physical Review Letters*.

More information: Vinitha Balachandran et al, Perfect Diode in Quantum Spin Chains, *Physical Review Letters* (2018). DOI: 10.1103/PhysRevLett.120.200603

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