Heat makes electrons spin in magnetic superconductors

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Physicists have shown how heat can be exploited for controlling magnetic properties of matter. The finding helps in the development of more efficient mass memories. The result was published yesterday in *Physical Review Letters*. The international research group behind the breakthrough included Finnish researchers from the University of Jyväskylä and Aalto University.

The ability to control the huge amount of information within the Internet is largely based on the ability to use the magnetic properties of electrons for reading memory devices. The phenomenon is based on the fact that each electron spins in a certain direction. This spin is closely connected with magnetism. Since the 1990s this property has been used for a fast reading of the information in magnetic memories. That is because it was found that the direction of magnetic poles affects the electrical resistivity of magnetic materials.

Lately many research groups have aimed at finding a method for using the electric current also to modify the magnetic information, which would make the data writing process much faster than in today's magnetic memories. However, the known methods tend to produce too much heat. One of the research directions has been to exploit the heat to convert it to a spin current of the electrons, which would then be used for writing the information.

In the research published yesterday the research group showed how heat is converted to spin current in magnetic superconductors. Many metals

turn superconducting a few degrees away from the absolute zero of temperature. As a result, the electrical resistivity of the metal vanishes. Magnetic superconductors can be fabricated by placing a superconducting film on top of a magnetic insulator.

Because superconductivity is present only at low temperatures, this phenomenon cannot be directly used in memory applications.

"Our theory is based on superconductivity, but the vanishing resistance is not very essential in it. Because of that the phenomenon could be generalized to other kinds of materials, and possibly such that it would work also at room temperature," explains Prof. Tero Heikkilä from the University of Jyväskylä.

The now published work was theoretical, but the phenomenon has been already found experimentally.

"Our work explained recent experimental results on the seemingly long lifetime of spin in superconductors. The finding resulted from the conversion of heat into spin," explains Dr Pauli Virtanen from the Aalto University.

More information: "Long-Range Spin Accumulation from Heat Injection in Mesoscopic Superconductors with Zeeman Splitting." *Phys. Rev. Lett.* 114, 167002 – Published 23 April 2015, DOI: dx.doi.org/10.1103/PhysRevLett.114.167002

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