For the first time, physicists couple distant nuclear spins using a single electron

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For the first time, researchers at the University of Basel in Switzerland have coupled the nuclear spins of distant atoms using just a single electron. Three research groups took part in this complex experiment, the results of which have now been published in the journal *Nature Nanotechnology*.

In most materials, the nuclear spins of neighboring atoms have only a very weak effect on one another, as the tiny nuclei are located deep within the atoms. This is not the case in metals, however, where some of the electrons are able to move freely. The electron spins are able to couple nuclear spins at relatively large distances from one another. Named after four physicists, this RKKY interaction was discovered in the 1950s.

Nuclear spins linked by an individual electron spin

Now, an experiment by researchers from the Department of Physics at the University of Basel has for the first time succeeded in demonstrating this mechanism with a single electron, describing it using quantum theory. The team led by Prof. Richard Warburton trapped a single electron inside a quantum dot. With use of a method developed in Basel to measure nuclear spin resonance, they showed that the electron coupled the spins of nuclei up to five nanometers apart - a huge distance in the world of nuclear spins. The results are particularly relevant to the development of spin qubits: these seek to use electron spins to carry

information, but the interaction with the nuclei limits the stability of the quantum information.

Concentrated blast of physics

"This is probably the most complicated experiment our team has ever carried out," says Prof. Richard Warburton, leader of the nano-photonics research group at the Department of Physics in Basel. At the same time, he expressed his delight at the cooperation between the three research groups that made this experiment possible. "There were so many different aspects to take into account - a challenge we were able to master only thanks to the fantastic collaborations in our department."

The research group led by Prof. Martino Poggio provided the expertise in the field of nuclear spin resonance, while the team led by Prof. Daniel Loss spent months computing the quantum theory for the experiment. A vital contribution also came from Ruhr University Bochum, which manufactured the semiconductor chips for the experiment.

More information: Role of the electron spin in determining the coherence of the nuclear spins in a quantum dot, *Nature Nanotechnology*, DOI: 10.1038/nnano.2016.114

Provided by University of Basel