The ferromagnetic Kondo effect

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A group of physicists that includes scientists of the International School for Advanced Studies (SISSA) of Trieste have shown how to obtain a particular case of a physical effect – so far never observed in reality –

whose studies have earned a Nobel Prize. The scientists have also observed the response of the material subject to such effect. These observations will provide precious indications to the experimental physicists in order to verify, in the future, their theory.

The Kondo effect in 1982 earned the Nobel Prize in Physics to Kenneth Wilson – the American physicist who passed away this year – who had solved numerically such solid-state physics "problem". Now a group of scientists, including some researchers of the International School for Advanced Studies (SISSA) of Trieste have explored a lesser known variant, predicting theoretically that the phenomenon can be actually observed, and describing its behavior in detail.

The Kondo effect, described for the first time in the last century by Japanese physicist Jun Kondo, is observed when a magnetic impurity is added to metals such as gold or copper, that is, very few atoms (in some cases even only 1 out of 1,000) of a magnetic material such as iron.

"Each electron features a moment, both of rotation and magnetic, called spin. Kondo is a phenomenon linked to the spin of metal electrons," explains Erio Tosatti, a scientist of SISSA and one of the authors of the paper just published in *Physical Review Letters*. "The free metal electrons surround the impurity like a cloud and arrange themselves into a spin that screens out the impurity, to a point that it is not detectable any longer, at least as long the temperature is sufficiently low. This affects selected properties of the materials, such as an increase in resistivity and in the resistance to the flow of electrons in the metal. "

More in detail…

Tosatti, who also collaborates with ICTP and Laboratorio Nazionale Democritos of Istituto CNR-IOM, has joined forces with Michele Fabrizio and Ryan Requist of SISSA, and Paolo Baruselli, a former

student of SISSA now at Dresden University of Technology. The team has studied a particular case, that is, the"ferromagnetic Kondo effect." In this case the metal electrons will align their spins in a way that does not screen out those of the electrons of the iron atoms, but instead "anti-screens" them, preserving their magnetism. Compared to the traditional Kondo effect, this will change the resistivity properties of the material. Tosatti and his colleagues have now proposed and described a circuit, made up of three quantum dots ("puddles" of electrons trapped inside a semiconductor), where, by simply adjusting a parameter, both the ferromagnetic and the ordinary Kondo effects may be observed, distinguished by their different and opposed electrical conduction anomalies .

Now the phenomenon has to be verified. "We expect" concludes Tosatti, "that our experimental colleagues will now try to reproduce the same conditions we have indicated in order to carry out what could be the first observation of a phenomenon that has been theorized for a long time but never verified so far".

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