Kondo effect in single magnetic molecules

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The Kondo effect was first explained more than 40 years ago by a Japanese physicist. It opened a new chapter in the study of fundamental physics. Now, that door is being pushed open a little further, thanks to the efforts of a team of physicists at the Institute for Theoretical Physics in Aachen, Germany. Their paper, published May 17th in *Physical Review Letters*, is titled "Quantum-Tunneling-Induced Kondo Effect in Single Molecular Magnets," and it offers possibilities for the further study of molecular transport.

"The Kondo effect is known from a variety of systems," explains Walter Hofstetter, one of the authors of the paper. "However, this is the first time that it has been predicted in a magnetic molecule." Hofstetter and his colleagues believe this discovery can be used to create a device that can be used as a spectroscopy tool that can be used to take various measurements on a quantum level.

Jun Kondo found that as the temperature approaches 0 K, the electrical resistance of an atom will be anomalously enhanced. This is known as the Kondo effect, and it represents the first known example of a situation in physics known as asymptotic freedom. Asymptotic freedom is demonstrated by coupling that, at low energies and temperatures, become non-perturbatively strong. "Until now," Hofstetter tells *PhysOrg.com*, "the assumption was that this effect didn't take place in magnetic molecules."

Hofstetter and his peers have turned that assumption in its head. "There is an interplay between two effects of magnetic anisotropy in magnetic molecules, of which the first one is indeed detrimental to the Kondo effect. Using basic methods, we calculate the temperatures for the Kondo effect to show up. The new thing we discovered was that the second effect of anisotropy, the famous quantum tunneling of the molecular magnet, completely restores, and even enhances, the Kondo effect."

"The other interesting note about this process," Hofstetter notes, "is that the electrons involved will behave as though they have only two spin states. This is remarkable because the spin would be, in actuality, much greater. In some case the spin would be greater than 10. But even with so many spin states it behaves as if it has a spin of 1/2."

Hofstetter says that there are "lots of practical applications in the future. The main value of this discovery is that it is a very good way to get information about molecular transport." He and his colleagues have shown in more recent calculations that the discovery could lead to a spectroscopy tool that could find magnetic states.

"With such a spectroscopy tool," Hofstetter explains, "You could characterize better, and get more information. It is an important first step in eventually building other devices." He goes on to point out that when it comes to building devices of such small dimensions, such that they operate on the quantum level, a tool that can help measure such small particles is quite useful. And Hofstetter and his collaborators aren't the only scientists who think so. He says that there are already physicists working on electron transport experiments that could make use of this discovery when it comes to analyzing the characteristics and states of magnetic molecules.

"Trapping molecules is a big challenge," Hofstetter says. "There are few that have done it. So any tool that could help experimentalists understand the molecules that they do have better would be helpful."