Diabolical Nanomagnets

A quantum degeneracy named after a Chinese yo-yo boosts the magnetization lifetime of a short chain of magnetic iron atoms by a factor of 1000.

By **Charles Day**

If you line up a handful of iron atoms, their magnetic spins can arrange themselves in an alternating, antiferromagnetic pattern—or, rather, patterns. Thanks to their quantum nature, the atoms occupy a superposition of antiferromagnetic states. Ordinarily, the chain flips rapidly between the two states. But Robbie Elbertse of Delft University of Technology in the Netherlands and his collaborators have now shown that a short chain of iron atoms can be coaxed into a so-called diabolical point, whose effect is to drastically lengthen the time the chain spends in one state or the other [**1**].

A diabolical point is named after the diabolo, a Chinese yo-yo whose two opposing conical halves meet in a narrow neck. Plotted against the strength of an applied magnetic field, the energy of an antiferromagnetic spin chain yields a similar shape: One upward-pointing cone is the ground state, while the downward-pointing cone is the first excited state. At their junction—the diabolical point—the two states are degenerate.

To create their diabolical point, the researchers positioned five iron atoms on a copper nitride surface at low temperature and ultrahigh vacuum. A magnetic field applied parallel to the surface had just the right value to create almost degenerate ground and first excited states. By measuring the spin of the middle atom using a scanning tunneling microscope, the researchers found that, at the diabolical point, the antiferromagnetic pattern flipped about every 10 seconds. By varying the parallel field and applying an additional perpendicular field, they mapped conditions away from the diabolical point. At the greatest distance, the flipping time shrank by 3 orders of magnitude. The researchers say the sensitivity of the flipping time to the local magnetic field could be exploited in an atom-sized magnetometer.

Credit: R. J. G. Elbertse *et al.* [**1**]

Charles Day is a Senior Editor for ***Physics Magazine***.

REFERENCES

1. R. J. G. Elbertse *et al.*, "Long-lived magnetization in an atomic spin chain tuned to a diabolic point," **Phys. Rev. Lett. 133, 166703 (2024).**