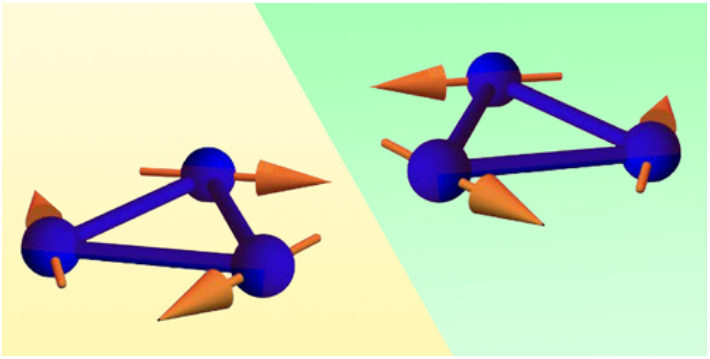
# Controlling Single-Molecule Toroics

**Researchers have proposed a feasible way to manipulate the ring-like magnetic configurations of certain molecules.**

By **Marric Stephens**

Some molecules include magnetic atoms whose individual magnetic moments are arranged in a closed loop, canceling each other out. These "single-molecule toroics" could be used in future computer memories, but they have proved difficult to manipulate. Now Kieran Hymas of the Commonwealth Scientific and Industrial Research Organisation in Australia and Alessandro Soncini of the University of Padua in Italy have proposed a set of techniques by which information-encoding states of such molecules could be prepared, flipped, and read [**1**].

Single-molecule toroics have two degenerate ground states—one with the magnetic moments oriented clockwise, and the other counterclockwise. This degeneracy makes the two orientations potentially useful as 1s and 0s in a computer memory, while the molecules' lack of net magnetization makes the states robust against bit flips by stray magnetic fields. Unfortunately, the lack of net magnetization also makes the bits hard to flip intentionally. In principle, states could be switched using extremely sharp field gradients, but such gradients are hard to achieve.



Credit: K. Hymas and A. Soncini [**1**]; adapted by APS

Seeking an alternative, Hymas and Soncini modeled the application of microwave pulses to molecules that include two triangular magnetic units, each containing three dysprosium atoms arranged in a triangle. The researchers found that pulses with precisely shaped temporal profiles could selectively initialize the molecular states or could switch between them. Reading such states would remain difficult because of the lack of a net magnetic moment, but Hymas and Soncini showed in a related study that they could make the states magnetically distinguishable by using an electric field to first distort the molecules' electron clouds [**2**]. In that study, the researchers proposed a method to prepare toroidal polarization states using ultrafast near-infrared pulses. Their newer microwave-based approach is potentially more efficient and could be realized using current experimental techniques, although it is limited to molecules that lack inversion symmetry.

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## REFERENCES

1. K. Hymas and A. Soncini, "Preparation and coherent control of toroidal moments in molecules," **Phys. Rev. B 114, 274426 (2026).**
2. A. Soncini *et al.*, "Finite-temperature toroidal moment amenable to direct observation in an $Fe_{10}Dy_{10}$ molecular ring," **Nat. Commun. 17, 9030 (2026).**