# A strange monopole observed in diamond: When string theory inspires quantum simulation

March 22 2022

Credit: Pixabay/CC0 Public Domain

Theoretical physicists routinely introduce fictitious particles and fields in their calculations, in view of completing a theory or simply to make it more elegant. A striking example concerns the magnetic monopole imagined by Dirac in 1931: a point-like source of magnetic

field, which is absent in classical electromagnetism. While the Dirac monopole was never observed in nature, it appears artificially in various physical settings, in particular, in the solid state.

In 2018, Giandomenico Palumbo and Nathan Goldman (Science Faculty, ULB) proposed an experimental scheme by which exotic "tensor" monopoles, initially introduced in string theory, can be created and observed in the lab. These tensor monopoles are point-like sources of generalized magnetic fields (known as Kalb-Ramond fields) living in a four-dimensional space, and they naturally appear in the mathematical framework of string theory. The central result of Palumbo-Goldman, published in the *Physical Review Letters* in 2018, is that tensor monopoles can be created artificially by manipulating a simple quantum system, such as a three-level atom coupled by lasers.

In a new publication in *Science*, the team of Paola Cappellaro (MIT) describes the experimental implementation of the Palumbo-Goldman model, as well as the observation and characterization of the associated tensor monopole. In this experiment, the team manipulates an artificial atom realized by a defect in diamond (a nitrogen-vacancy center or NV center). Using this highly controllable quantum setup, the experimentalists prepared the synthetic monopole, measured the emanating Kalb-Ramond field and determined the quantized charge of the monopole (an integer set by topology).

This work illustrates how a quantum simulator can be exploited in view of studying abstract and complex physical structures, initially introduced in the context of mathematical physics.

**More information:** Mo Chen et al, A synthetic monopole source of Kalb-Ramond field in diamond, *Science* (2022). DOI: 10.1126/science.abe6437