

Small magnets reveal big secrets

25 October 2019



Igor Barsukov is an assistant professor of physics at UC Riverside. Credit: Barsukov lab, UC Riverside

An international research team led by a physicist at the University of California, Riverside, has identified a microscopic process of electron spin dynamics in nanoparticles that could impact the design of applications in medicine, quantum computation, and spintronics.

Magnetic nanoparticles and nanodevices have several applications in medicine—such as drug delivery and MRI—and [information technology](#). Controlling spin dynamics—the movement of electron spins—is key to improving the performance of such nanomagnet-based applications.

"This work advances our understanding of spin dynamics in nanomagnets," said Igor Barsukov, an assistant professor in the Department of Physics and Astronomy and lead author of the study that appears today in *Science Advances*.

Electron spins, which precess like spinning tops, are linked to each other. When one spin begins to precess, the precession propagates to neighboring spins, which sets a wave going. Spin waves, which are thus collective excitations of spins, behave differently in nanoscale magnets than they do in large or extended magnets. In nanomagnets, the

spin waves are confined by the size of the magnet, typically around 50 nanometers, and therefore present unusual phenomena.

In particular, one spin wave can transform into another through a process called "three magnon scattering," a magnon being a quantum unit of a spin wave. In nanomagnets, this process is resonantly enhanced, meaning it is amplified for specific magnetic fields.

In collaboration with researchers at UC Irvine and Western Digital in San Jose, as well as theory colleagues in Ukraine and Chile, Barsukov demonstrated how three magnon scattering, and thus the dimensions of nanomagnets, determines how these magnets respond to spin currents. This development could lead to paradigm-shifting advancements.

"Spintronics is leading the way for faster and energy-efficient information technology," Barsukov said. "For such technology, nanomagnets are the [building blocks](#), which need to be controlled by spin currents."

Barsukov explained that despite its technological importance, a fundamental understanding of energy dissipation in nanomagnets has been elusive. The research team's work provides insights into the principles of energy dissipation in nanomagnets and could enable engineers who work on spintronics and information technology to build better devices.

"Microscopic processes explored in our study may also be of significance in the context of quantum computation where researchers currently are attempting to address individual magnons," Barsukov said. "Our work can potentially impact multiple areas of research."

More information: "Giant nonlinear damping in nanoscale ferromagnets" *Science Advances* (2019). DOI: [10.1126/sciadv.aav6943](https://doi.org/10.1126/sciadv.aav6943) , advances.sciencemag.org/content/5/10/eaav6943

Provided by University of California - Riverside

APA citation: Small magnets reveal big secrets (2019, October 25) retrieved 24 September 2021 from <https://phys.org/news/2019-10-small-magnets-reveal-big-secrets.html>

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