An effective strategy for protecting skyrmions in quantum computing devices

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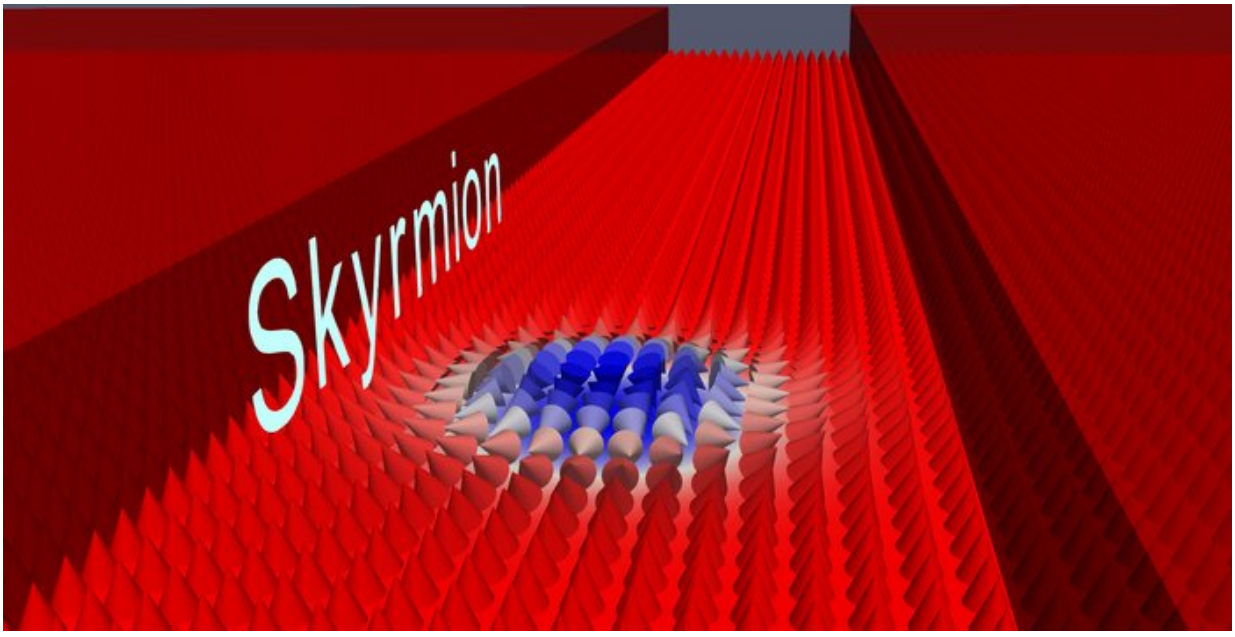

A magnetic skyrmion confined in a designed channel within a ferromagnetic film, where the skyrmion is protected from being touching the film edge. Credit: Shinshu University

A magnetic skyrmion is a versatile topological object that can be used to carry information in future spintronic information processing devices. As potential non-volatile information carriers, excellent endurance and robust retention are desired properties of skyrmions in spintronic devices. However, previous studies have suggested that skyrmions can be

easily destroyed at device edges during high-speed operations due to the so-called skyrmion Hall effect.

For these reasons, one focus of current skyrmion research is to find effective ways to protect skyrmions from being destroyed by touching device edges. Typical solutions include the elimination of the skyrmion Hall effect in antiferromagnetic and synthetic antiferromagnetic systems.

In a study published in *Nano Letters*, the group led by Prof. Xiaoxi Liu from the Department of Electrical and Computer Engineering, Shinshu University, Japan and their collaborators demonstrate in experiments that skyrmions can be effectively confined in channels and protected from being destroyed at device edges in more commonly used ferromagnetic systems. The confinement of skyrmions in designed channels is fundamental for any practical applications based on the accumulation and transport of skyrmions. The authors find that the position of skyrmions in ferromagnetic materials can be controlled by engineered energy barriers and wells.

Therefore, they experimentally fabricated a magnetic multilayer film with many energy barriers and wells formed by patterns with modified magnetic properties, where they find that skyrmions can be attracted or repelled by the boundaries of patterns. By fabricating square and stripe patterns with modified magnetic properties in a large ferromagnetic film, the authors show the possibility of building reliable channels for confinement, accumulation, and potential transport of skyrmions as information carriers.

In addition, this method reported in this research also offers the possibility for future study of the skyrmions interacting with one-dimensional and two-dimensional substrates, which are important dynamic problems that have been investigated theoretically in past

decades.

"Our research demonstrated that a robust topological protection of skyrmions can be achieved by a simple but effective approach, which has practical application importance," explains experimentalist Prof. Xiaoxi Liu of Shinshu University, who led this research study.

Senior JSPS researcher Dr. Xichao Zhang says that "the research results suggest that we can use patterns of modified magnetic properties to control the static and dynamic behaviors of skyrmions." He then adds, "In our future work, we will investigate the current-induced dynamics of skyrmions in designed channels, which will be another important step toward skyrmion-based spintronic devices."

More information: Kentaro Ohara et al, Confinement and Protection of Skyrmions by Patterns of Modified Magnetic Properties, *Nano Letters* (2021). DOI: 10.1021/acs.nanolett.1c00865

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