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MULTISTABLE SKYRMIONS: ENHANCED STABILITY OF SKYRMIONS BY THE MAGNETOSTATIC FIELD OF FERROMAGNETIC RINGS

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We demonstrate a novel approach to control and manipulate magnetic skyrmions in ultrathin multilayer systems using spatially engineered magnetostatic fields generated by ferromagnetic rings. Using both analytical modelling and micromagnetic simulations, we show that the stray fields from a Co/Pd ferromagnetic ring with perpendicular magnetic anisotropy can significantly enhance skyrmion stability in an Ir/Co/Pt nanodot, even in the complete absence of Dzyaloshinskii-Moriya interaction.

We observe a multistability phenomenon where skyrmions can be stabilised at two or three different diameters depending on the magnetization orientation of the ring (see Fig. 1).

The resulting high energy barriers between these states, suggesting potential applications for binary or multibit data storage. We demonstrate that transitions between these stable states can be reliably controlled through the application of modest magnetic field pulses (100-300 mT) with short durations (0.5-1.0 ns).

By varying the geometric parameters of the ring structure (thickness, inner and outer radii), we demonstrate precise control over skyrmion size and stability, opening pathways for advanced spintronic devices that do not rely solely on conventional DMI-based stabilization mechanisms. Our approach provides a comprehensive framework for designing skyrmion-based spintronic devices with tailored stability properties by engineering the magnetostatic energy landscape.

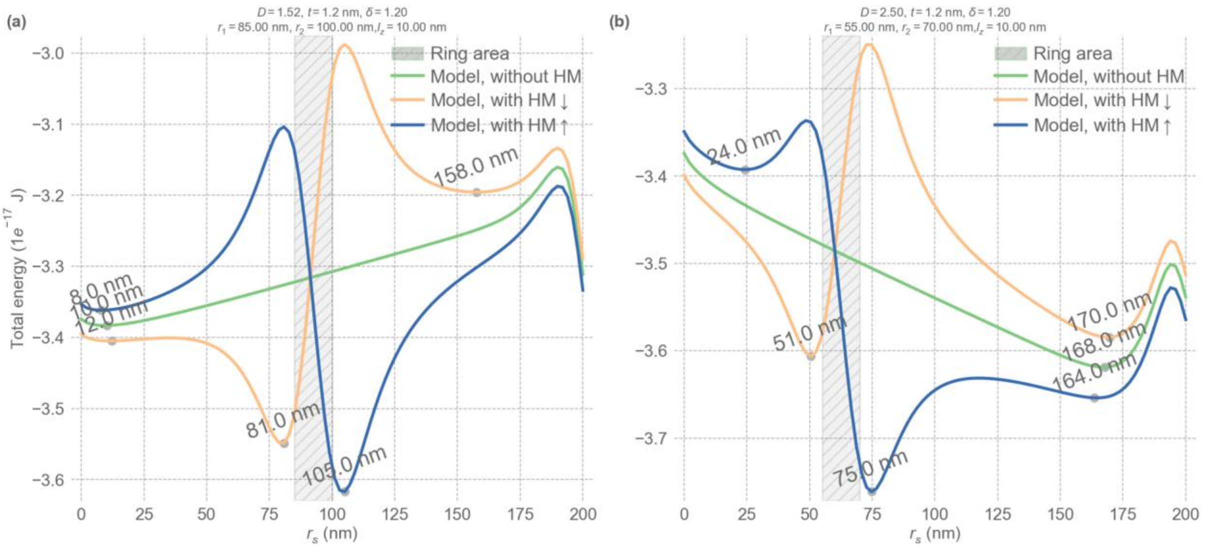

Fig. 1. Total energy of the Néel skyrmion as a function of its radius. The analytical calculations were performed in the absence of DMI for a nanodot of thickness t = 1.2 nm and radius 200 nm. The shaded region indicates the spatial extent of the HMR, with inner and outer radii of r1 = 75.0 nm and r2 = 90.0 nm, respectively. Solid lines represent the analytical model, while dashed lines correspond to micromagnetic simulations. The green curve denotes the reference case without the HMR. The blue and orange curves correspond to cases where the HMR is magnetized perpendicularly

downward and upward, respectively.