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Chirality control and vortex manipulation in asymmetric Co dots[1]

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Magnetic vortices in sub-micron sized dots have gained considerable interests in recent years due to their fascinating physics and potential applications in information storage, spin-torque oscillators, and magnetic memory and logic devices. Reproducible control of the vortex chirality is of critical importance for these studies. Here we report on two distinctly different chirality control mechanisms in asymmetric Co dots. Arrays of Co dots were fabricated using electron beam lithography and the circular symmetry was broken by introducing a flat edge. Below a critical diameter and/or thickness, chirality control is achieved by the nucleation of a single vortex within each dot, as conventionally observed. The vortex can be manipulated to annihilate at particular sites under different field orientations and cycle sequences. Interestingly, above these critical dimensions a new chirality control mechanism is realized by the nucleation and subsequent coalescence of double vortices, resulting in a single vortex at remanence with the *opposite* chirality as found in smaller dots. Magneto-optical Kerr effect and magnetic force microscopy measurements confirm this new process. Micromagnetic simulations not only reproduce the experimentally observed behavior, but also elucidate the delicate interplay between exchange, demagnetization, and Zeeman energies and the role of fractional vortices bound to the dot edge.

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