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Time-resolved X-ray imaging of a magnetic bubble's gyrotropic motion

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Skyrmions are winding vector fields with a characteristic spherical topology. One example for such a vector field is the winding spin structure of a magnetic bubble in thin-film material with out-of-plane magnetization. Recent theoretical investigations predict a GHz gyrotropic motion of such a topological configuration after excitation in a restoring potential, analogous to vortex gyration. However, in contrast to vortices, bubbles are predicted to exhibit inertial effects, manifesting themselves in a second gyrotropic mode of reverse chirality and in additional degrees of freedom. Here, we present time-resolved images of the gyration of a magnetic bubble recorded using soft-X-ray Fourier-transform holography (FTH). The motion is triggered by a magnetic field pulse and the pump-probe image sequence is acquired with 50 ps time resolution using the single-bunch mode of the BESSY II storage ring. The microcoil to administer the magnetic field pulses has been lithographically integrated into the mask defining the FTH geometry. From the images, we extracted the relaxation trajectory of the bubble with a position precision of 3 nm. We find that two eigenfrequencies are required to describe the bubble's motion leading to the conclusion that the bubble possesses a quasi-particle inertial mass. We attribute the comparatively large mass to the non-local energy reservoir of the bubble's breathing mode.

Primary authors: Dr PFAU, Bastian (Max-Born-Institut); Dr BÜTTNER, Felix (Massachusetts Institute of Technology); Dr GEILHUFE, Jan (Max-Born-Institut)

Co-author: Prof. EISEBITT, Stefan (Max-Born-Institut)

Presenter: Dr PFAU, Bastian (Max-Born-Institut)

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