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Ultrafast dynamics of chiral spin structure in synthetic antiferromagnet

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In synthetic antiferromagnetic multilayers (SAFs), chiral magnetic structures such as spin spirals and skyrmions have been stabilized at room temperature by precisely tuning the effective perpendicular magnetic anisotropy, the Dzyaloshinskii-Moriya interaction, and the Ruderman-Kittel-Kasuya-Yoshida (RKKY) interlayer coupling [1-3]. In this study, we investigate the dynamics of chiral spin spirals on ultrashort timescales after femtosecond laser pumping in SAFs. The access to ultrafast magnetization dynamics, inaccessible by standard techniques due to zero net magnetization, has been enabled by the use of time-resolved circular dichroism in x-ray resonant magnetic scattering (CD-XRMS) [4]. A pair of two-dimensional X-ray scattering patterns for left and right elliptical polarization (EL and ER) have been recorded for each delay. In contrast to our previous findings in ferromagnetic multilayers, the magnetization (EL+ER) and dichroism (EL-ER) signals exhibit notably similar ultrafast dynamics, with demagnetization occurring on a timescale of ~180 fs, followed by rapid remagnetization within ~500 fs. This similarity in ultrafast dynamics can be attributed to the continuous rotation of magnetization in the spin spiral of SAFs, which evolves smoothly in space without forming sharp domains or alternating domain walls. The ultrafast response and stability in its topological character highlight the potential of SAF-based chiral magnetic structures for future high-speed, energy-efficient data storage and processing applications.

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