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Ultrafast Spin-Wave Soliton Coupling To Lattice Dynamics

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Spin waves are the fundamental excitations in magnetic systems. At low densities, they behave as independent quasiparticles that can mediate solid-state interactions such as superconducting pairing or can be used to transport information in technology. At sufficiently high densities, spin waves can condense into solitons that derive their stability from nonlinear spin precession. Nonequilibrium conditions via demagnetization with a femtosecond (fs) laser pulse provide an alternative generation mechanism for spin-wave solitons [1] and skyrmions [2] as seen by time-resolved soft x-ray magnetic scattering [1,2]. Spin-wave solitons nucleated in FePt nanoparticles of ~16nm size are characterized by an in-plane spin precession at the soliton boundary. We have recently shown that this spin precession perturbs the lattice by means of the magneto-elastic coupling [3]. Here we show new experiments performed at the European XFEL that identify the formation of spin-wave soliton in the smaller FePt particles with the average size of 7 nm. Such a spin-wave soliton would have the smallest size of 5 nm, and the fastest precession frequency of 0.12 THz, observed so far. This new information allows us to address the scaling of spin-wave soliton in the FePt nanoparticles, as well as the aspects of spin-lattice coupling and other related non-equilibrium magnetic phenomena in material with exchange length approaching the atomic scale.

REFERENCES
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