Ultrafast spin fluctuations and random telegraph noise in antiferromagnetic $Sm_{0.7}Er_{0.3}FeO_3$

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Owing to their THz magnon frequencies, antiferromagnets are now being viewed as a promising material system for next-generation high-speed spintronic/magnonic applications. Such a perspective has led to extensive research on their ultrafast dynamics in the last decade [1]. Since the THz frequency range goes far beyond the reach of existing electronics technology, their investigation has been based on optical pump-probe techniques and thus inherently limited to nonequilibrium processes. In contrast, magnetically ordered systems also exhibit spontaneous fluctuations of the magnetic order, due to either thermal or quantum mechanisms [2]. Although, high-frequency magnetic fluctuations in (anti) ferro-magnets are fundamentally important for a variety of topics in modern spintronics research such as, e.g., phase transitions and spintronic computing, not much information exists due to a lack of experimental tools to access them.

In this work, we demonstrate the first time-domain observation of incoherent sub-THz antiferromagnetic magnon fluctuations in the orthoferrite $Sm_{0.7}Er_{0.3}FeO_3$ and reveal their critical dynamics (Fig. 1a) close to the spin reorientation transition (SRT). We exploit a novel experimental principle, inspired by the emerging field of sub-cycle quantum optics [3], where we detect the magnon fluctuations by measuring the statistical correlations of polarisation noise imprinted on two femtosecond probe pulses. We find two distinct modes [4], a high-frequency mode (green arrows, Fig. 1b) corresponding to the quasi-ferromagnetic mode in $Sm_{0.7}Er_{0.3}FeO_3$ and a low-frequency mode (purple arrows, Fig. 1b), which has not been previously reported in pump-probe experiments. Comparison to an atomistic spin dynamics simulation reveals that this new mode is ascribed to ultrafast spontaneous spin switching within the double-well magnetic anisotropy potential. The corresponding random spin switching speed is the fastest ever marked and may provide a key ingredient for ultrafast probabilistic computing working at THz frequencies in the future. Furthermore, our results shed new light on THz magnonics, where the AFM spin switching by intense THz pulses is seen as an important milestone, but the influence of incoherent spin dynamics on this context has largely been ignored.

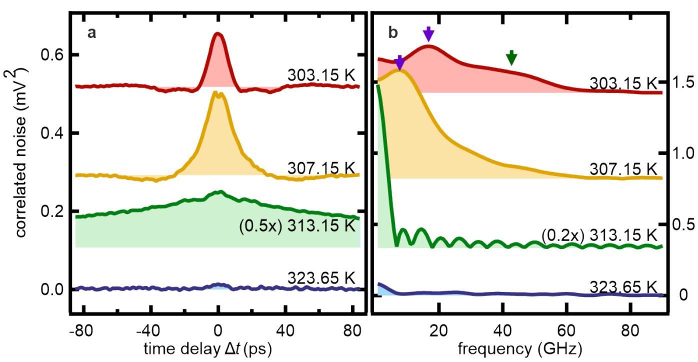

Fig. 1: a, *Correlated noise versus time delay Δt for multiple temperatures near SRT in* $Sm_{0.7}Er_{0.3}FeO_3$. **b**, *Corresponding spectra.*

References:

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