Narrow-band resistance noise and mode-locking phenomena of a skyrmion lattice in a microfabricated MnSi

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Using resistance fluctuation spectroscopy (Fig. a), we observe current-induced narrow-band noise (NBN) in the magnetic skyrmion-lattice phase of micrometer-sized MnSi. The NBN appears only when electric-current density exceeds a threshold value (Fig. b), indicating that the current-driven motion of the skyrmion lattice triggers the NBN. The observed NBN frequency is 10^2–10^4 Hz at ~10^9 A/m^2, implying a skyrmion steady-flow velocity of 1–100 μm/s, 3–5 orders of magnitude slower than previously reported. The temperature evolution of the NBN frequency, f_{NBN}, suggests that the steady flow entails thermally activated processes, which are most likely due to skyrmion creation and annihilation at the sample edges [1]. f_{NBN} monotonously increases with the d.c. current, j_{dc} (Fig. c). When an a.c. electric current is further added, however, the f_{NBN}– j_{dc} profile becomes nonmonotonous, and a so-called mode-locking is observed; that is, f_{NBN} becomes much less dependent on the d.c. current if it satisfies a simple integer ratio to the a.c. current frequency (Fig. c) [2]. We also discuss the relation between the skyrmion dynamics and the thermodynamic stability of the skyrmion lattice.

[1] T. Sato *et al.,* Phys. Rev. B **100,** 094410 (2019).
[2] T. Sato *et al.,* Phys. Rev. B **102,** 180411(R) (2020).
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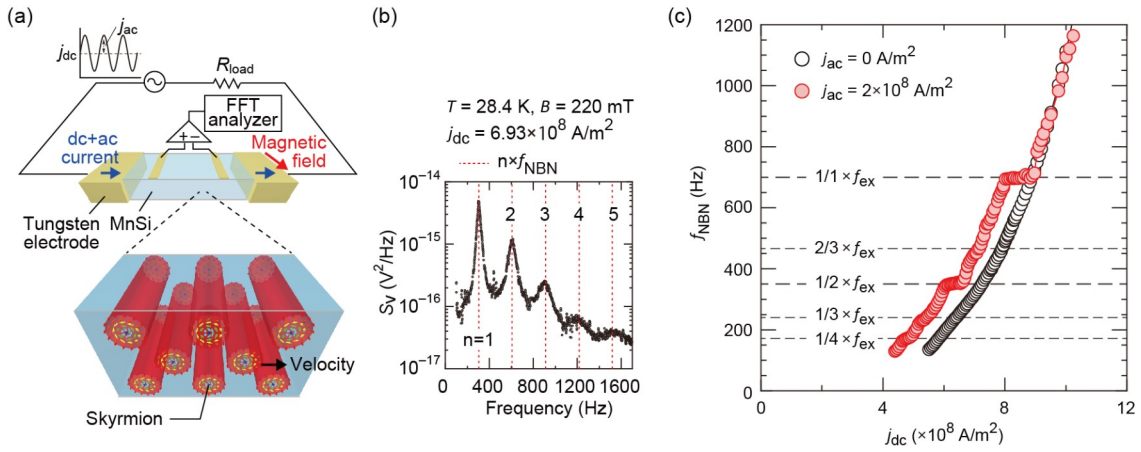

FIG: (a) Schematic of the experimental configurations. (b) Typical power spectral density of voltage fluctuations for the narrow-band noise (NBN) in the skyrmion lattice phase under the application of a d.c. electric current above a threshold value. The spectrum exhibits several higher harmonic bands, of which frequencies agree with the integral multiple of the fundamental NBN frequency, f_{NBN}. (c) d.c. current density dependence of f_{NBN} with and without externally applied a.c. current at f_{ex} =700 Hz (red and black plot, respectively). The staircase structures, a hallmark of the mode-lock phenomena, are labeled with a set of small integers.