Topological spin-wave edge modes in a moiré magnonic crystal

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1. Introduction

When two lattices are stacked and twisted at a small angle relative to one another, a new periodic pattern known as a moiré lattice appears [1]. Moiré physics has recently led to extraordinary discoveries such as unconventional superconductivity and magic-angle lasers. But despite advances in electronic and photonic in moiré systems, there has been no experimental work on magnonics, a promising avenue for low-power computing and data processing that uses magnons, or spin waves, as information carriers. To date, moiré physics in magnonic systems has only been studied from a theoretical point of view [2]. Here, we provide the first experimental evidence of magnons in a moiré system.

2. Results and discussion

In our study, we fabricated a nanostructured magnetic moiré lattice on an yttrium iron garnet thin film. From micro-focused Brillouin light scattering measurements we observe emergent spin-wave modes propagating at the edge of a moiré unit cell. The magnon edge mode becomes best defined at an optimal twist angle between the two sublattices of 6 degrees and is controllable with an applied magnetic field. We observe an additional mode, cavity mode, localized at the center of a moiré unit cell with a different resonance frequency from the edge mode. The asymmetric propagation observed for the edge mode indicates that its chirality is associated with the moiré magnon band structure as confirmed by micromagnetic simulations. Our theoretical estimates of the magnon-magnon coupling between two twisted lattices via dipolar interactions reveal the topological nature of the chiral edge modes.

Our findings provide a key initiative in the emergent research field of moiré magnonics, in which the use of topologically protected magnon edge modes could significantly enhance the capabilities of magnonic devices for information processing.

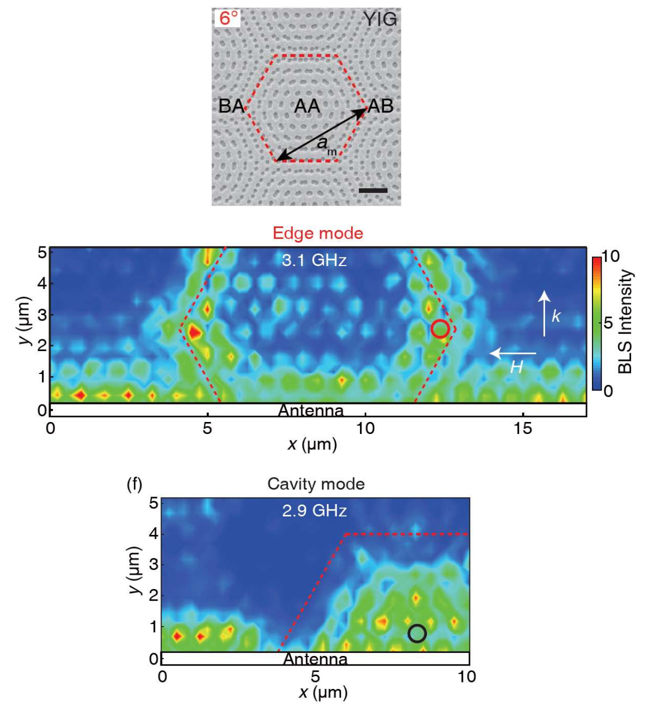

Figure 1: Top row: Scanning electron microscope (SEM) image of a moiré magnonic lattice based on YIG grown on a GGG substrate with a twist angle of 6°. The red dashed line indicates a moiré unit cell with commensurate AA region at its center and incommensurate AB (BA) region at its edge. Moiré lattice constant am is marked by the black arrow. Scale bar 2.0 microns.

Middle row: Two-dimensional spin-wave intensity map of the edge mode measured by micro-BLS at 3.1 GHz.

Bottom row: Two-dimensional spin-wave intensity map of the cavity mode measured by micro-BLS at 2.9 GHz.

References

[1] Cao, Y. et al. *Nature* **556**, 43-50 (2018).
[2] Li, Y.-H. & Cheng, R. *Phys. Rev. B* **102**, 094404 (2020).

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