

Lasing Reporting Summary

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• Experimental design

Please check: are the following details reported in the manuscript?

1. Threshold

Plots of device output power versus pump power over a wide range of values indicating a clear threshold

Yes
 No

Our in-situ detection solely observes changes in the Lorentz phase images of the magnetic structure. The laser serves only for its thermal effect, and parameters such as the threshold are not significant.

2. Linewidth narrowing

Plots of spectral power density for the emission at pump powers below, around, and above the lasing threshold, indicating a clear linewidth narrowing at threshold

Yes
 No

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Resolution of the spectrometer used to make spectral measurements

Yes
 No

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3. Coherent emission

Measurements of the coherence and/or polarization of the emission

Yes
 No

Our in-situ detection solely observes changes in the Lorentz phase images of the magnetic structure. The laser serves only for its thermal effect, and parameters such as coherent emission are not significant.

4. Beam spatial profile

Image and/or measurement of the spatial shape and profile of the emission, showing a well-defined beam above threshold

Yes
 No

Our in-situ detection solely observes changes in the Lorentz phase images of the magnetic structure. The laser serves only for its thermal effect, and parameters such as beam spatial profile are not significant.

5. Operating conditions

Description of the laser and pumping conditions
Continuous-wave, pulsed, temperature of operation

Yes
 No

We have provided detailed descriptions of the operating conditions in both the main text and the Methods section. "The fs laser system was triggered externally with a digital delay generator which outputted single-shot fs laser pulses with 520 nm wavelength, 300 fs pulse duration and 11 mJ/cm² fluence, where the laser spot size was adjusted to be 50 μm to ensure homogeneous illumination on the sample."

Threshold values provided as density values (e.g. W cm⁻² or J cm⁻²) taking into account the area of the device

Yes
 No

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6. Alternative explanations

Reasoning as to why alternative explanations have been ruled out as responsible for the emission characteristics
e.g. amplified spontaneous, directional scattering; modification of fluorescence spectrum by the cavity

Yes
 No

Our in-situ detection solely observes changes in the Lorentz phase images of the magnetic structure. The laser serves only for its thermal effect, and parameters such as amplified spontaneous and directional scattering are not significant.

7. Theoretical analysis

Theoretical analysis that ensures that the experimental values measured are realistic and reasonable
e.g. laser threshold, linewidth, cavity gain-loss, efficiency

Yes
 No

The dynamic curves based on the two-temperature model can be found in Figure S22 and Supplementary Note 8.

8. Statistics

Number of devices fabricated and tested

- Yes
- No

The samples subjected to a total of five Hall measurements, one LTEM, and five MFM tests are illustrated in the graphs presented in the main text Figures 1a, Figure 2a, Figure 4, Figure S13, Figure S16, etc.

Statistical analysis of the device performance and lifetime (time to failure)

- Yes
- No

We characterize the fundamental properties of the material, independent of any specific devices.