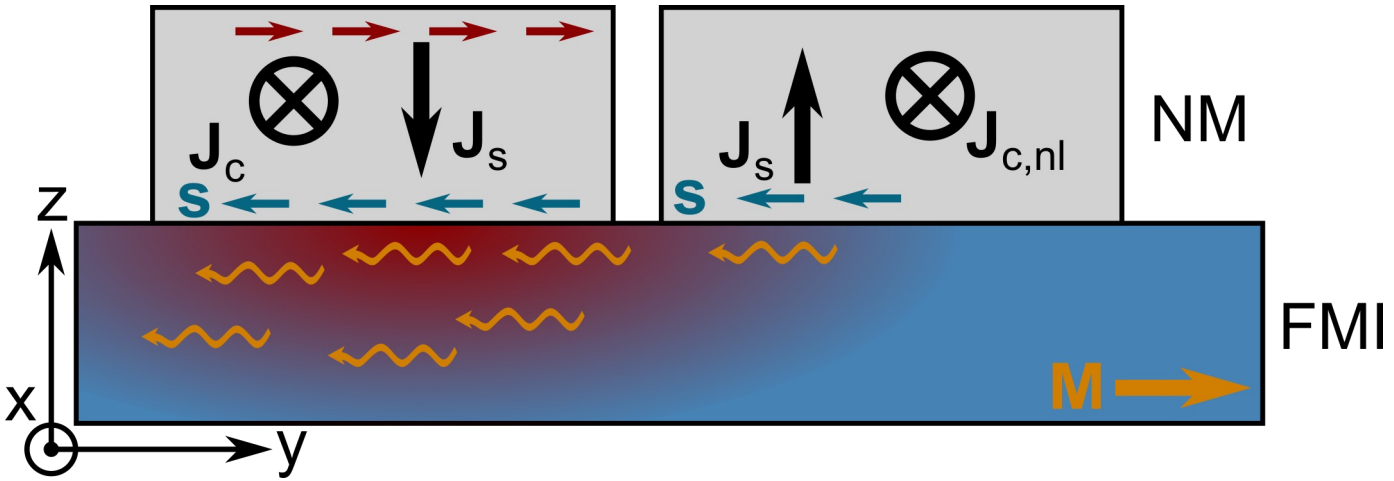
Universität Konstanz

SFB 1432

DFG



Controlling Magnons and Their Transport by Electronic Spin Injection

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J. Hu
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H. Peng
J. Chen
S. Liu
D. Yu
J.-P. Ansermet
H. Yu

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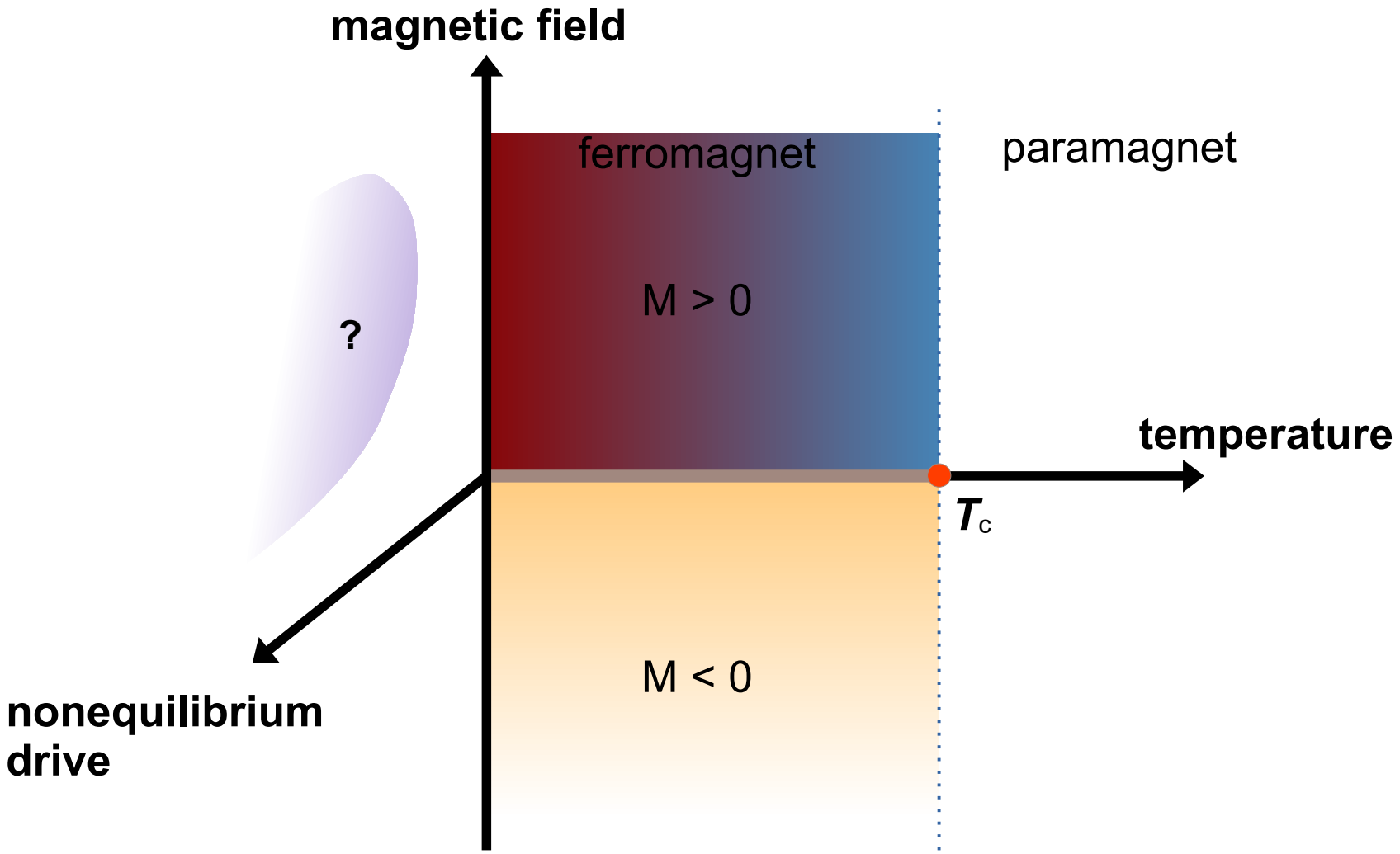
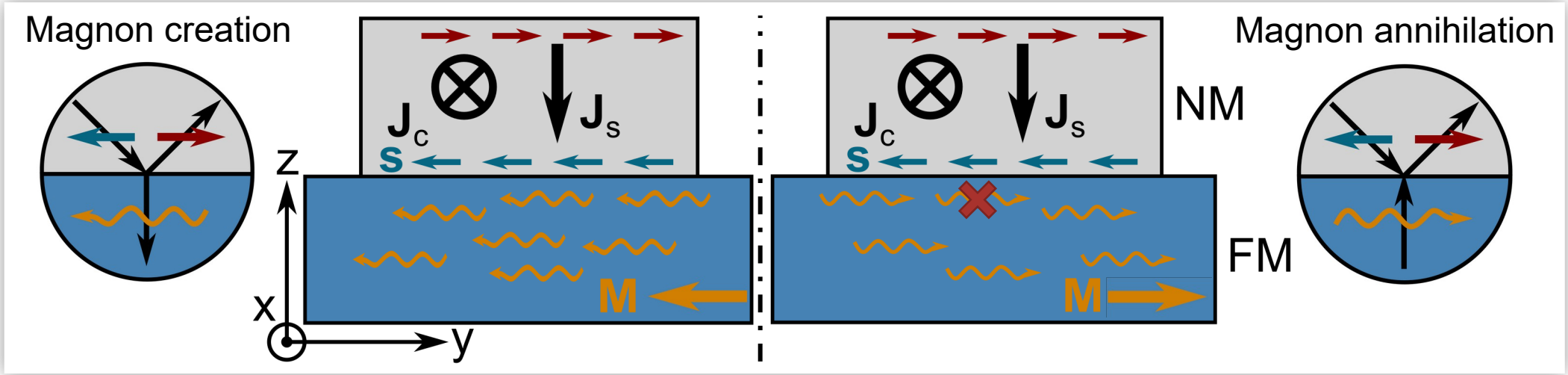
A. L. Bassant
R. A. Duine

Nonequilibrium magnetic systems

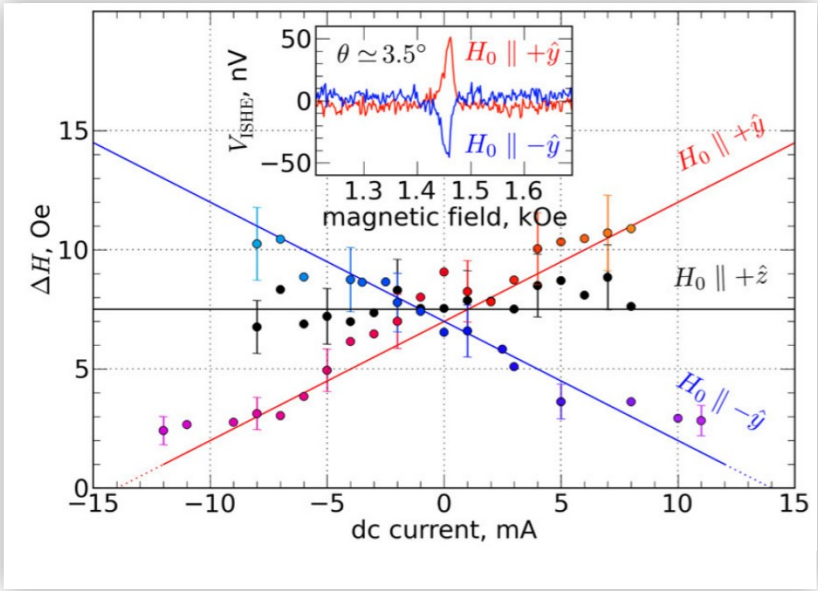


what physics happens along the nonequilibrium axis?

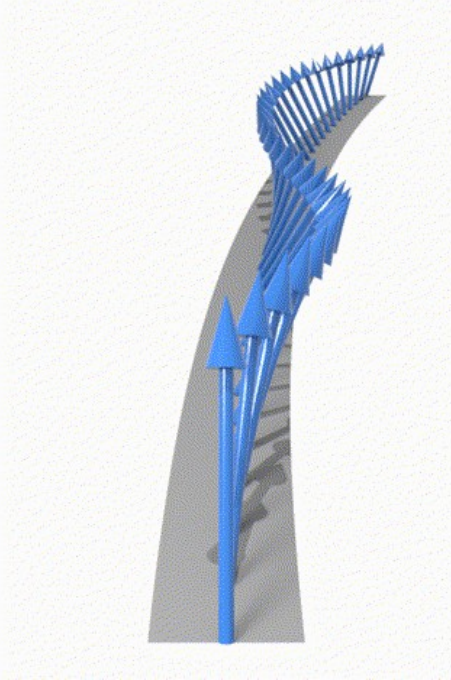
Magnonic spin currents in insulators



Electrical control of magnetization damping

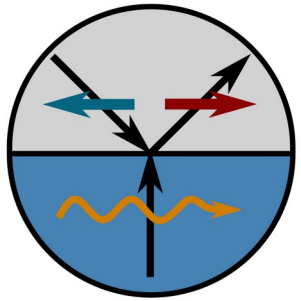


Hamadeh et al., Phys. Rev. Lett. **113**, 197203 (2014)

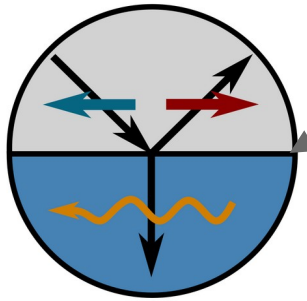


What happens at the interface? Electron-magnon coupling

Magnon annihilation



Magnon creation

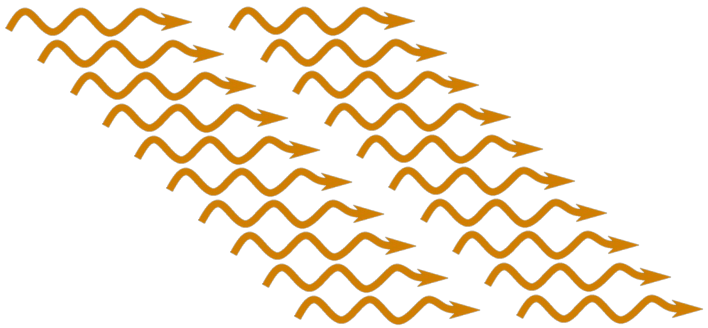


Exchange coupling of metal electrons and localized spins in MI

Bose-Einstein statistics

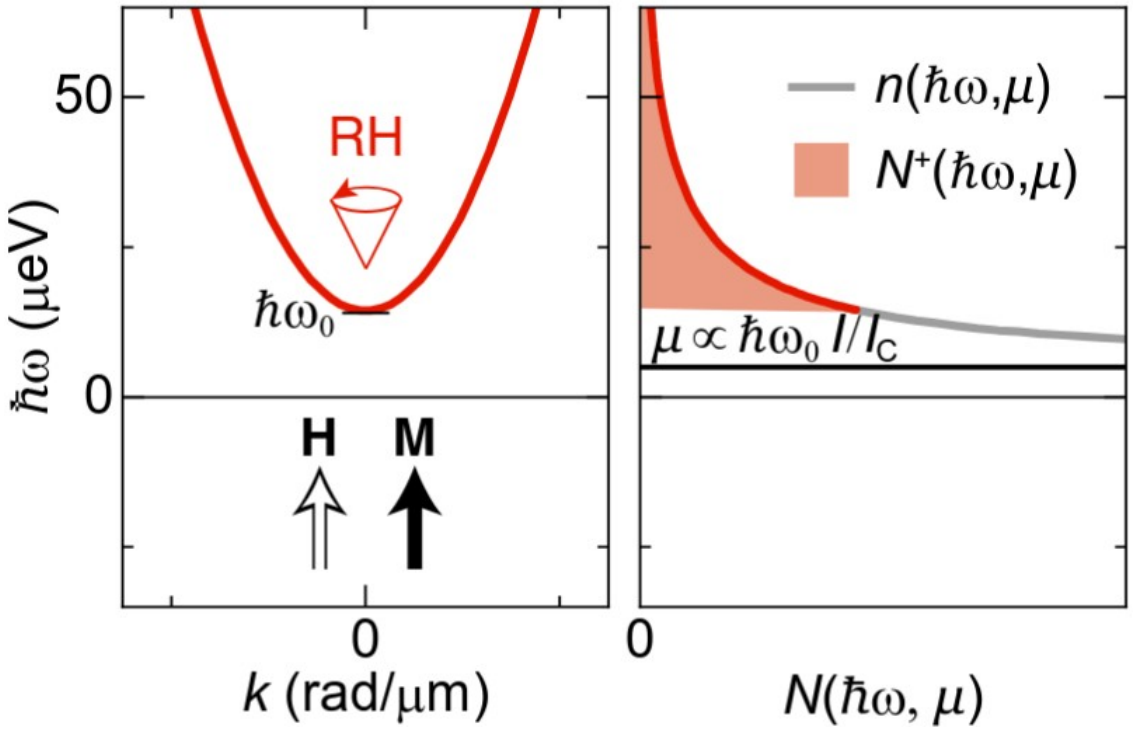
$$n(E) = \frac{1}{\exp\left(\frac{E-\mu}{k_B T}\right) - 1}$$

High probability to couple



low probability to couple

Higher magnon mode occupancy enhances coupling



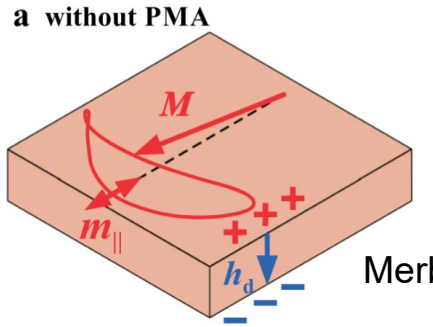
Agarwal, Phys. Rev. Lett. **53**, 1732 (1984)
Goennenwein et al., Appl. Phys. Lett. **107**, 172405 (2015)
Kohno et al., Phys. Rev. B **108**, 144410 (2023)

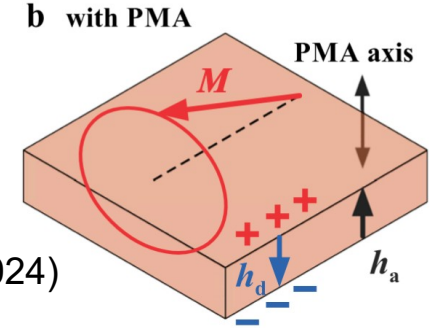
Karadza, Wang et al., arXiv 2601.09569 (2026)

Controlling the spin current in magnetic insulators

critical point

nonequilibrium drive → μ

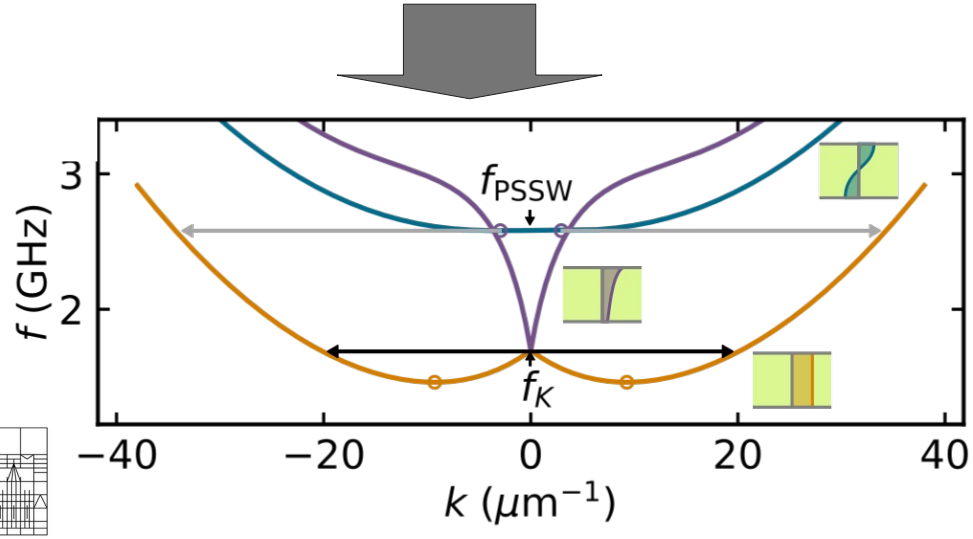


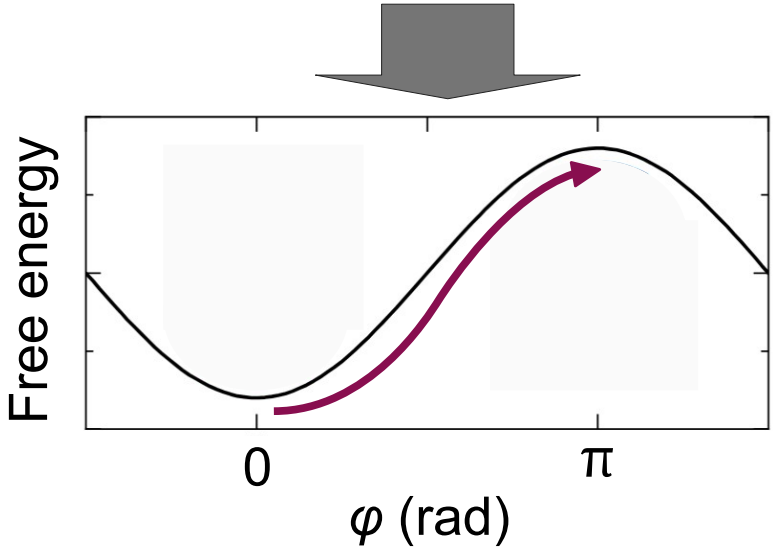


Merbouche et al., Nat. Commun. **15**, 1560 (2024)

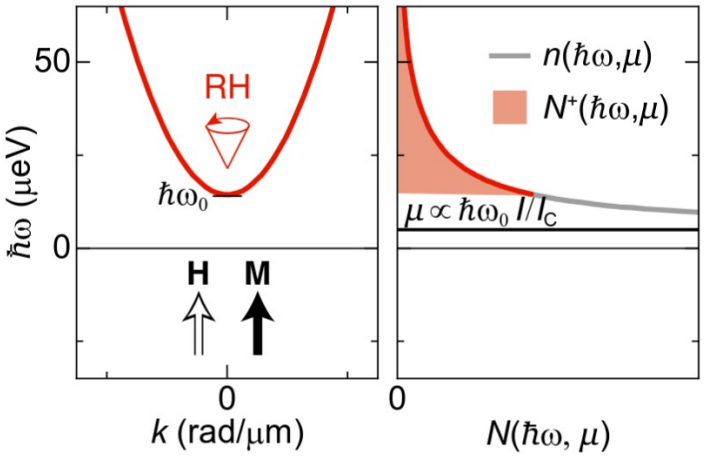
P1: nonlinear scattering limits the magnon number

P2: suppressed nonlinear scattering → growth to infinity?





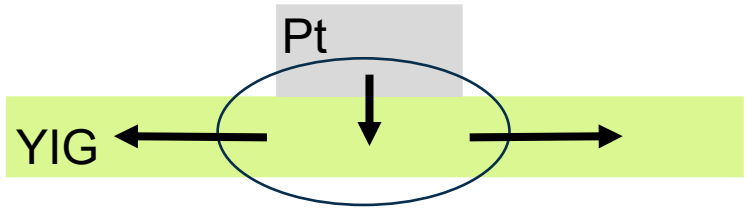
Controlling the spin current in magnetic insulators



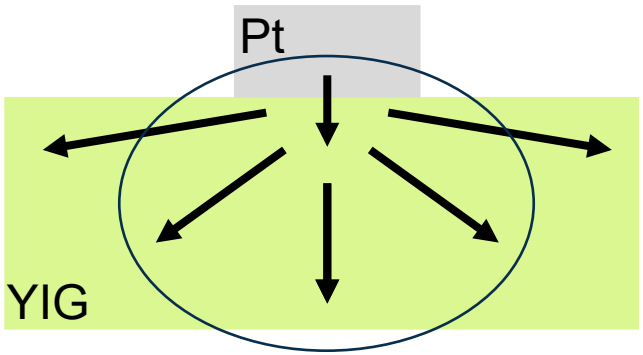
What defines I_c?

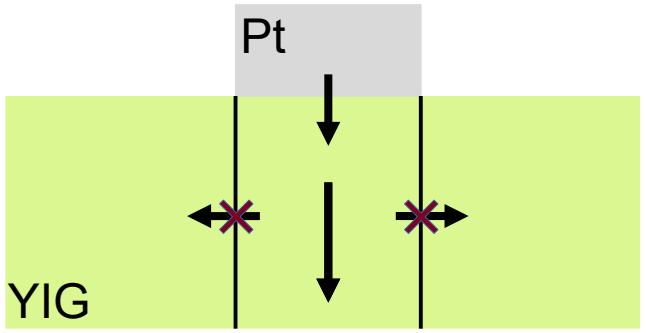
→ **spin injection rate = relaxation rate**

→ **Is there a thickness limit?**



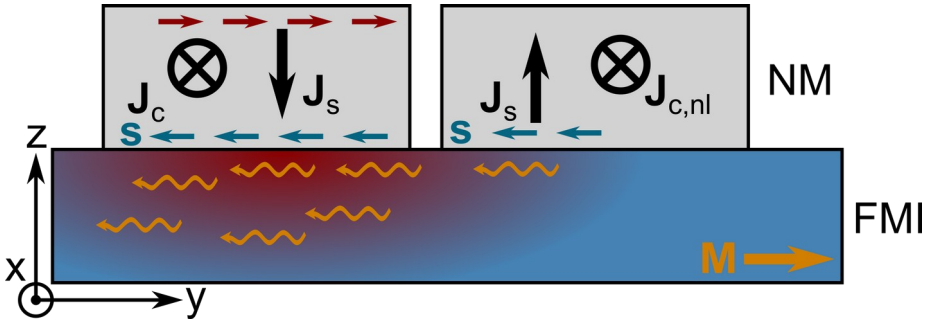
$N_{\mathrm{spins,thin}} \ll N_{\mathrm{spins,thick}}$

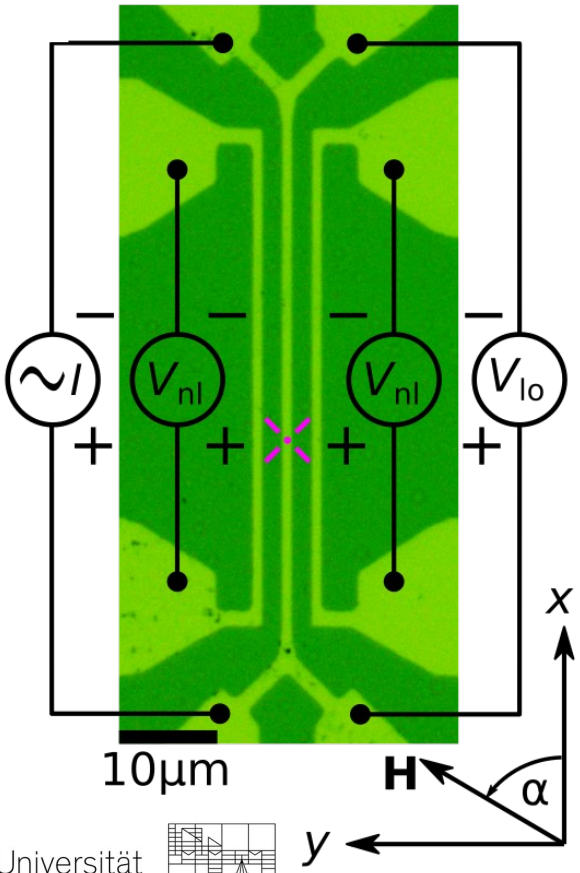


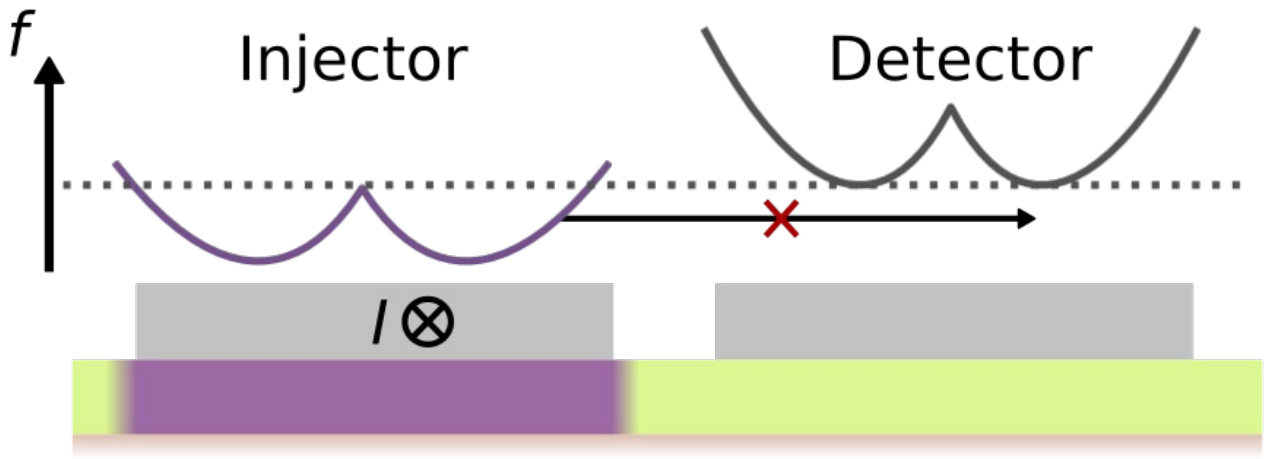


Use a cavity to prevent radiation?

Nonlocal transport in the nonlinear regime



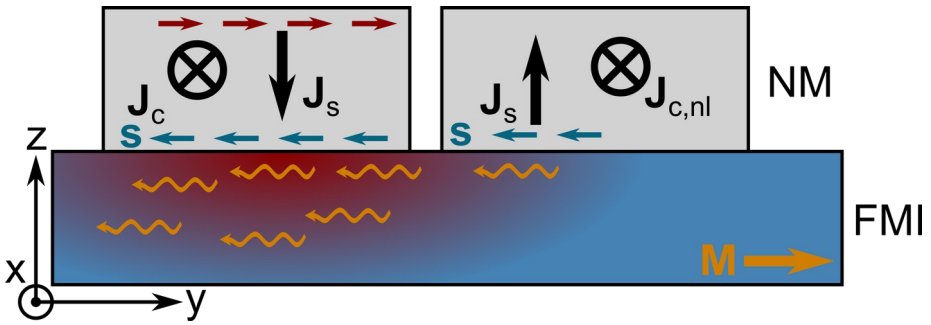


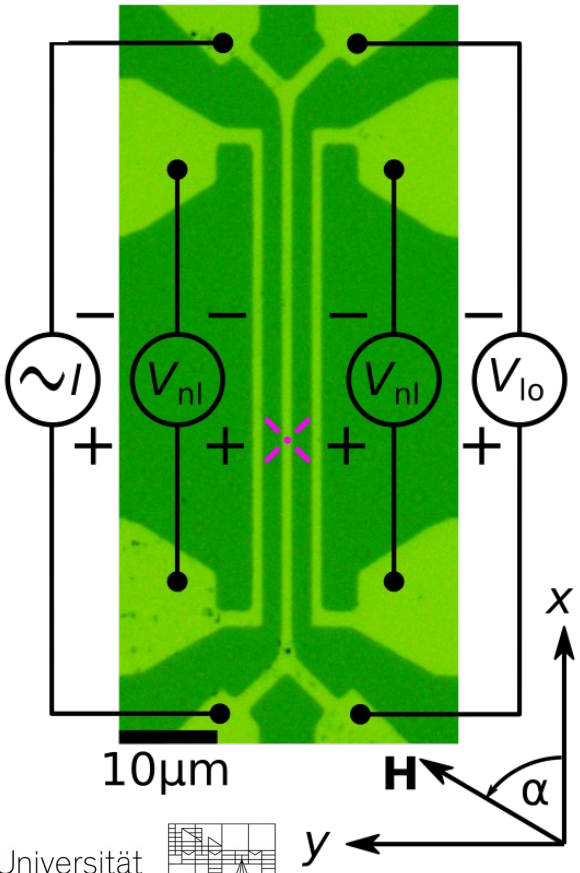


➔ Injector is hotter = more magnons = lower magnetization
➔ Energy is reduced by nonlinear frequency shift
➔ Mode confinement

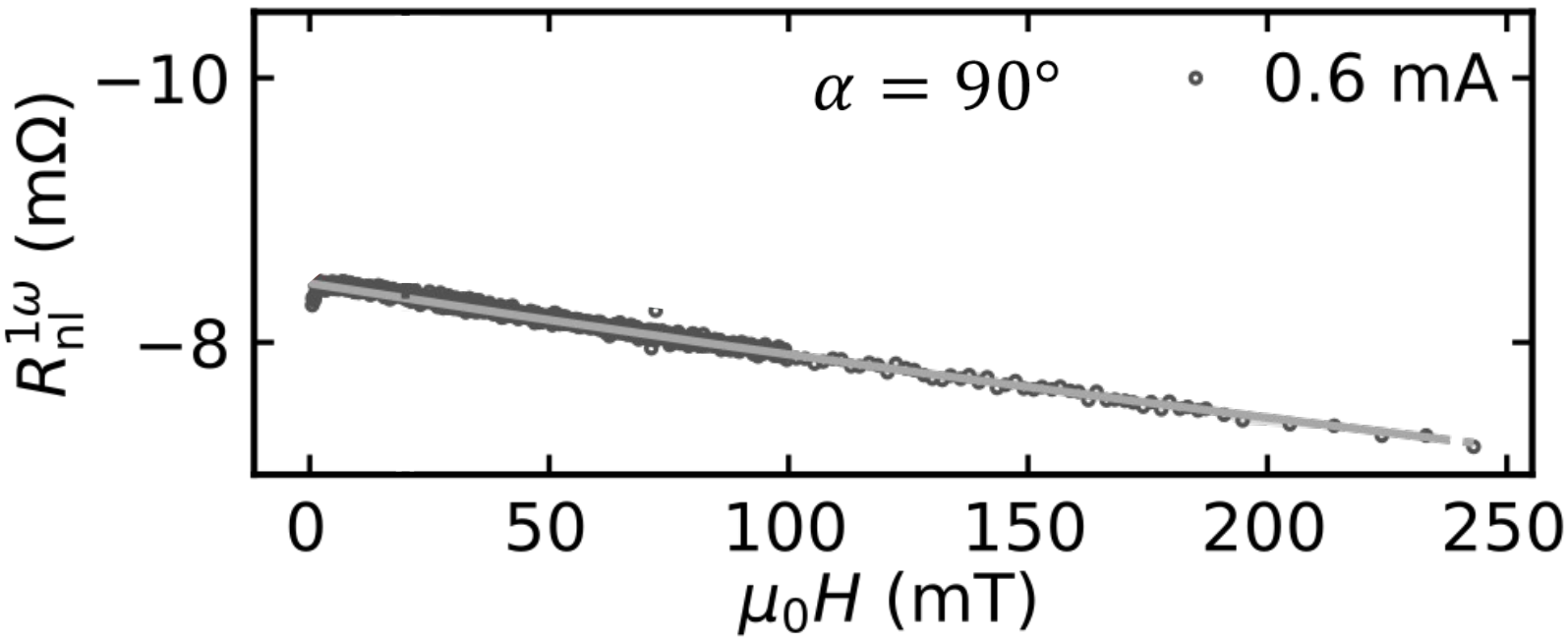
Schlitz et al., Nat. Commun. **16**, 8472 (2025)

Nonlocal transport in the nonlinear regime



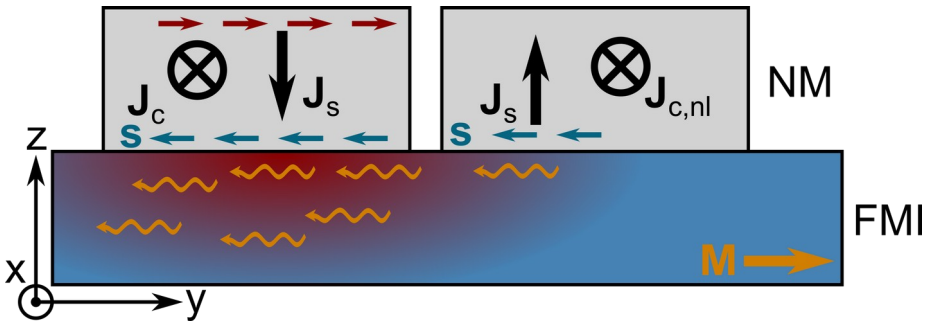


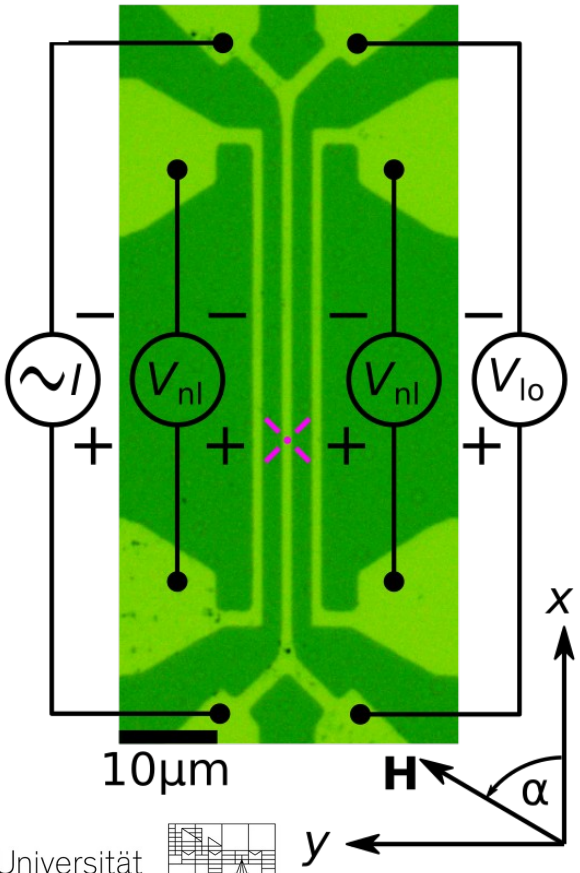
sample made by Michaela Lammel
150 nm YIG / 5 nm Pt



Schlitz et al., Nat. Commun. **16**, 8472 (2025)

Nonlocal transport in the nonlinear regime





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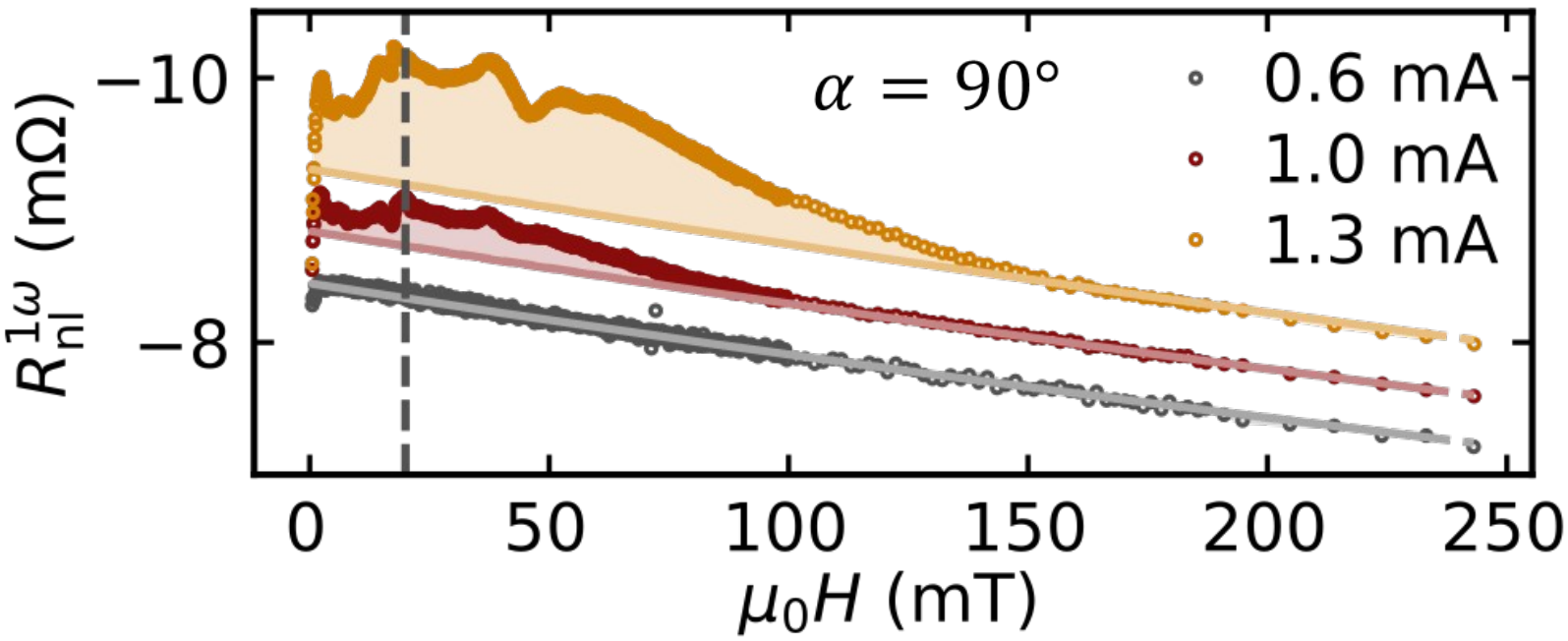
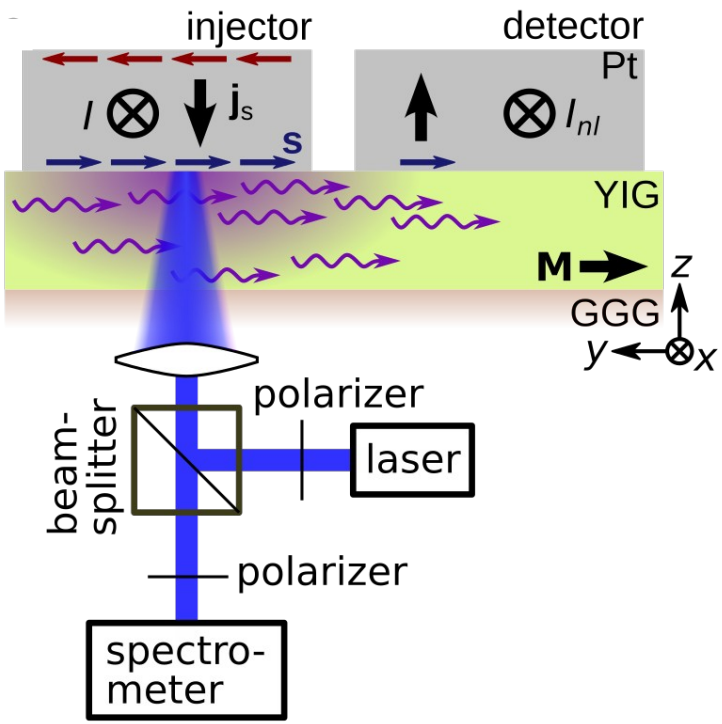
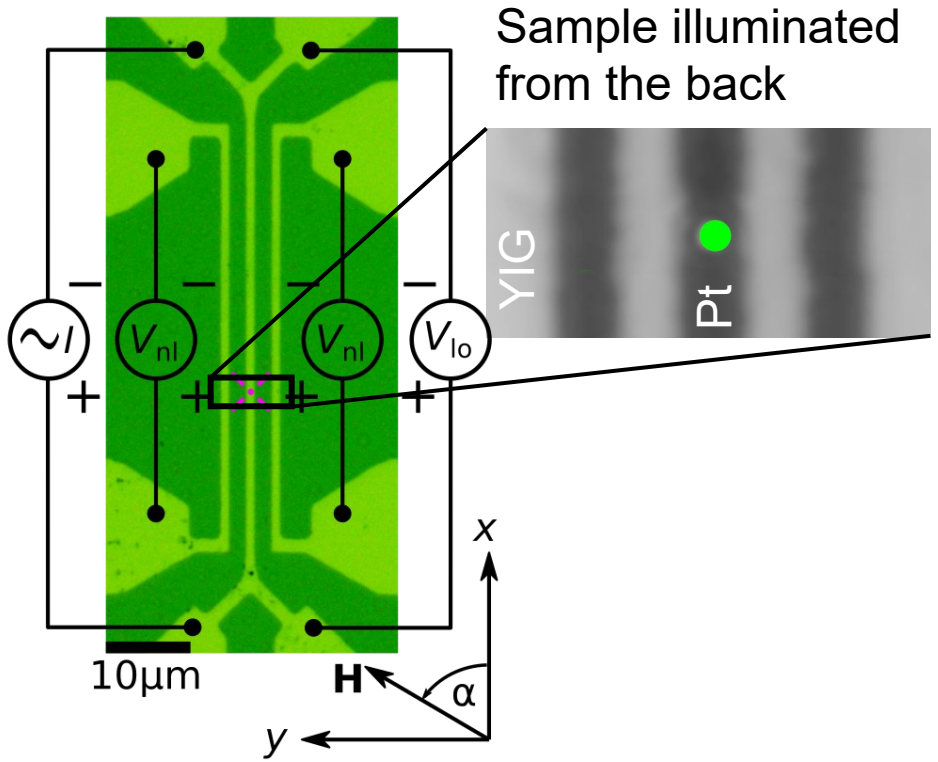


Prominent and nonmonotonous field dependence → signature of confinement?

Schlitz et al., Nat. Commun. **16**, 8472 (2025)

Brillouin light scattering of the excited magnons



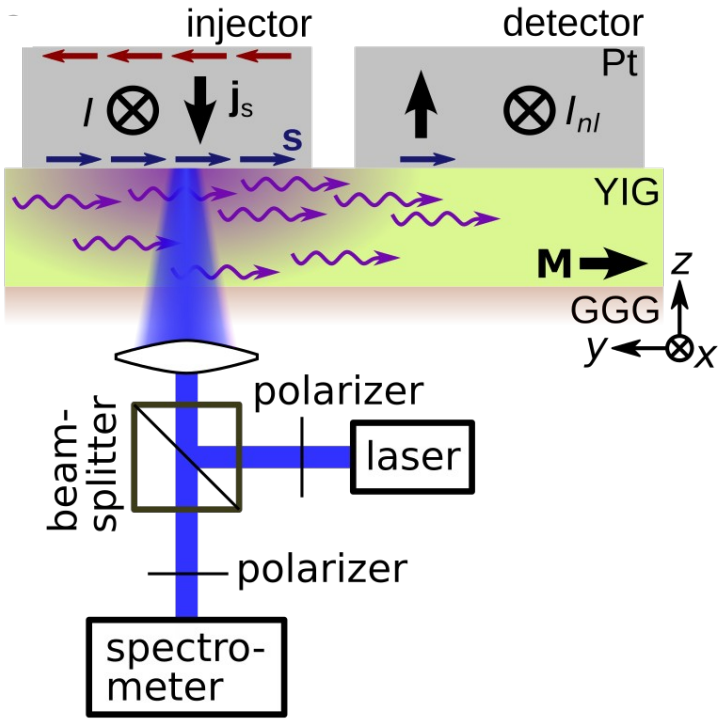


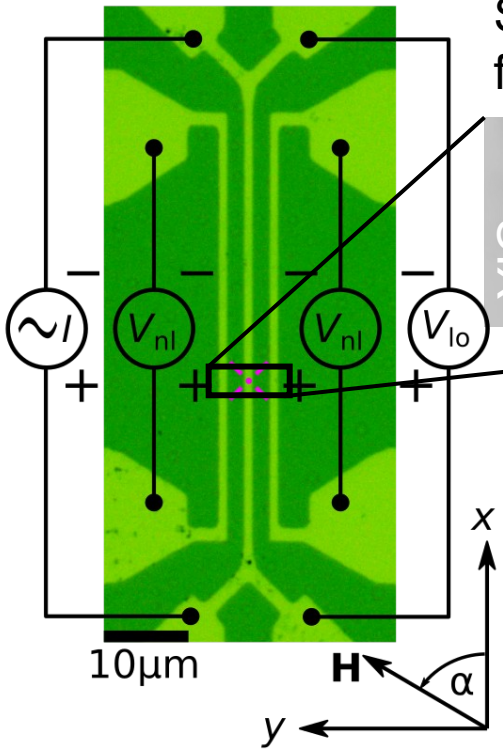
Sample illuminated from the back

Universität Münster

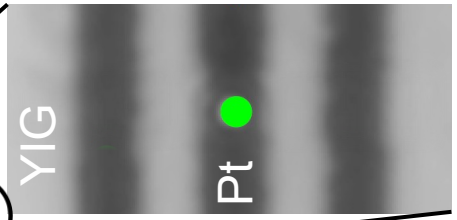
Brillouin light scattering measurements done by V. E. Demidov and S. O. Demokritov

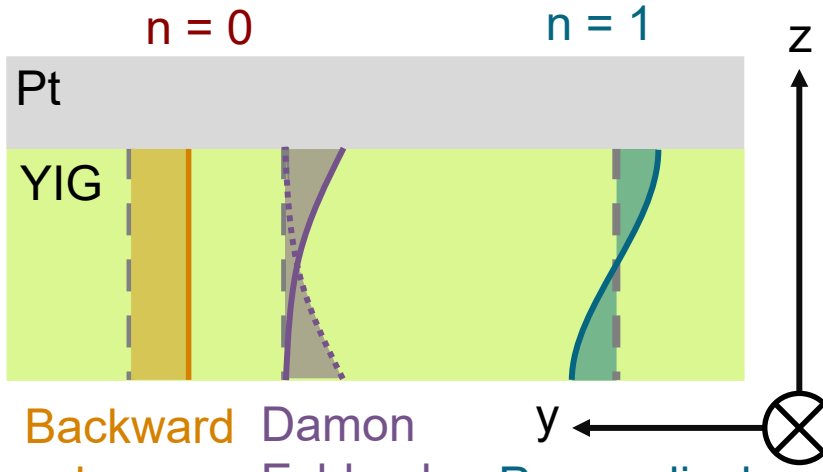
Brillouin light scattering of the excited magnons

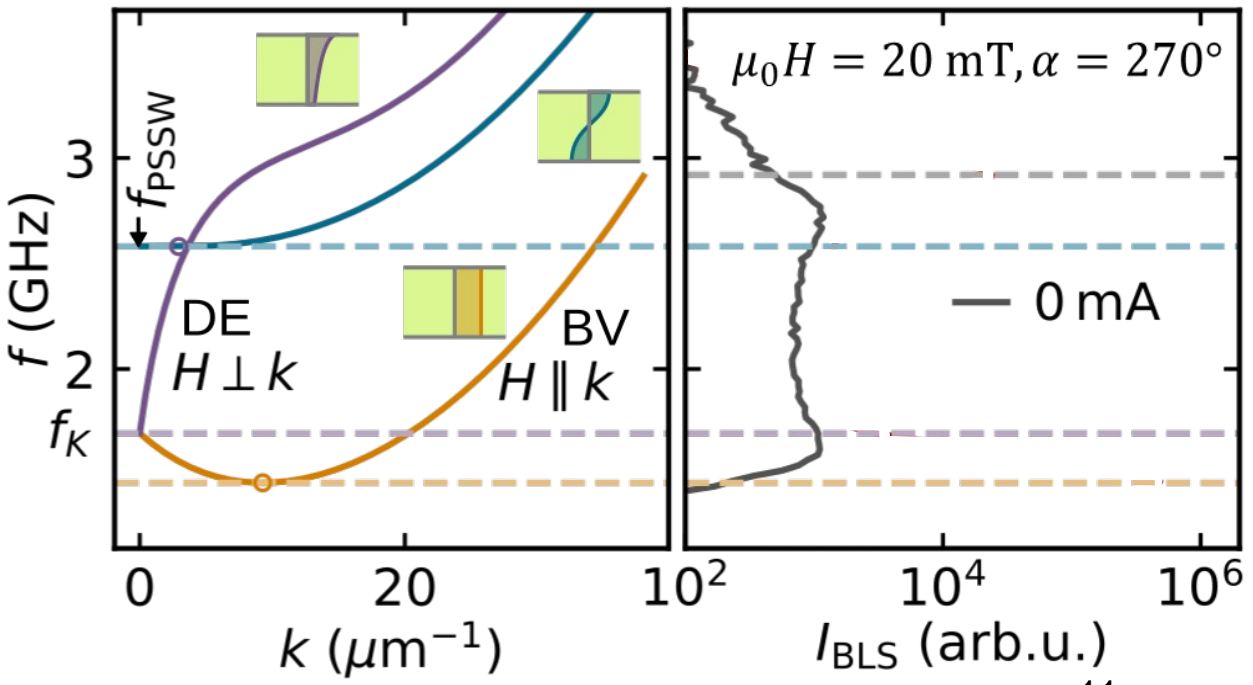




Sample illuminated from the back







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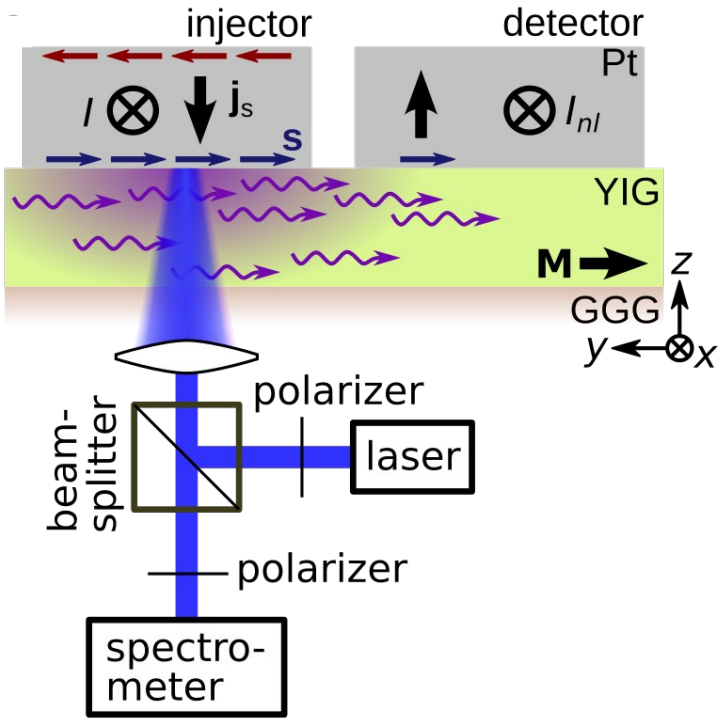
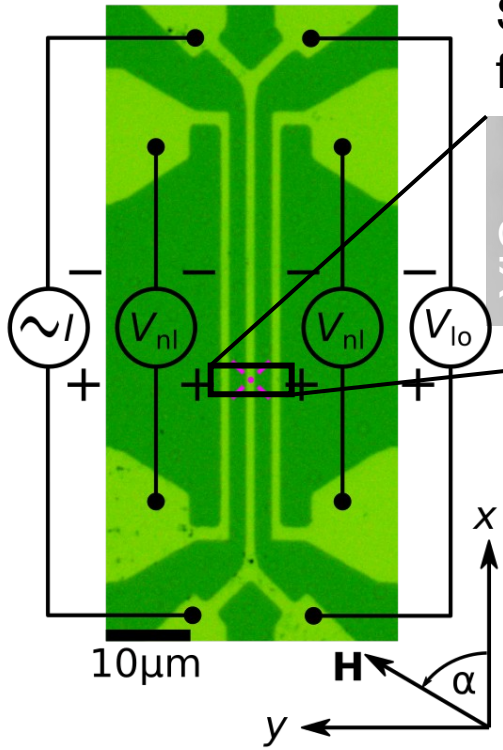
Brillouin light scattering measurements done by V. E. Demidov and S. O. Demokritov

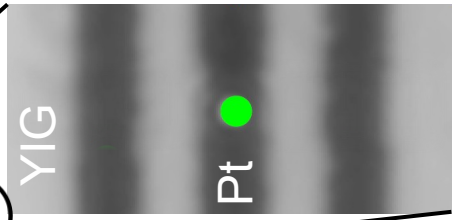
Schlitz et al., Nat. Commun. **16**, 8472 (2025)

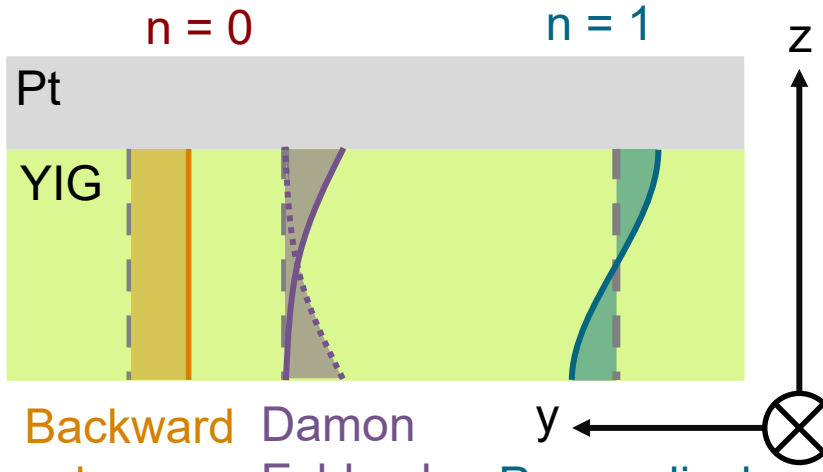
Brillouin light scattering of the excited magnons

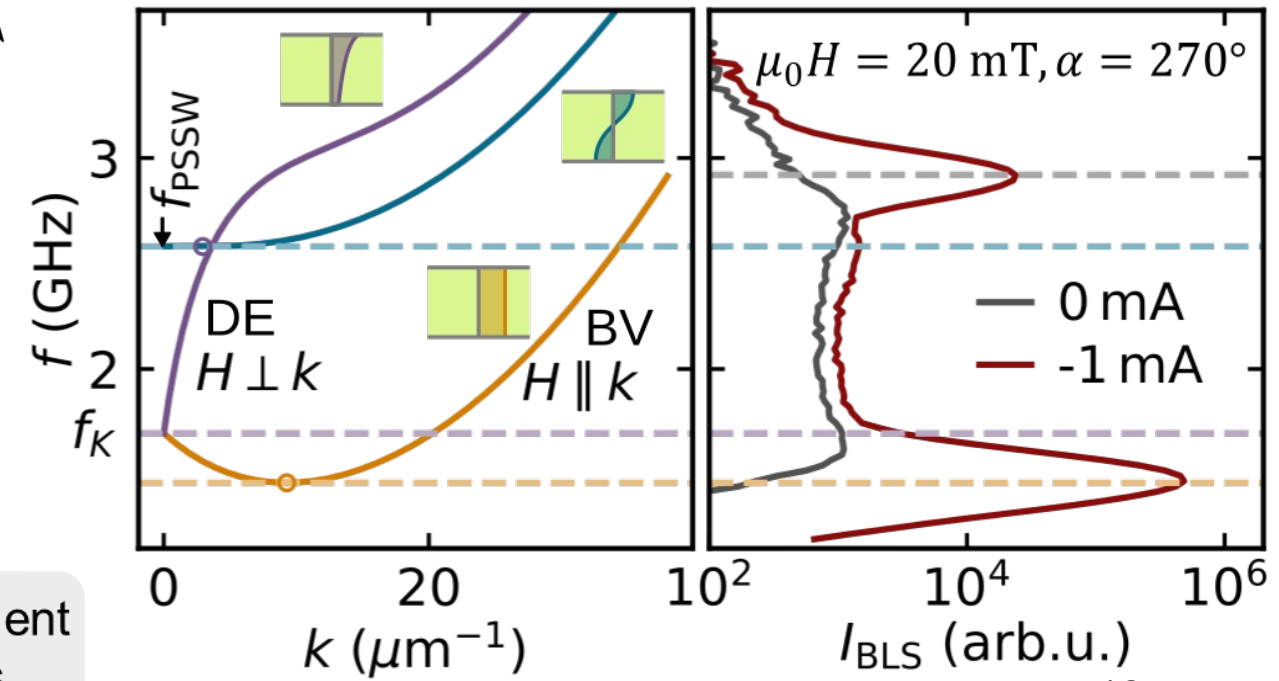




Sample illuminated from the back







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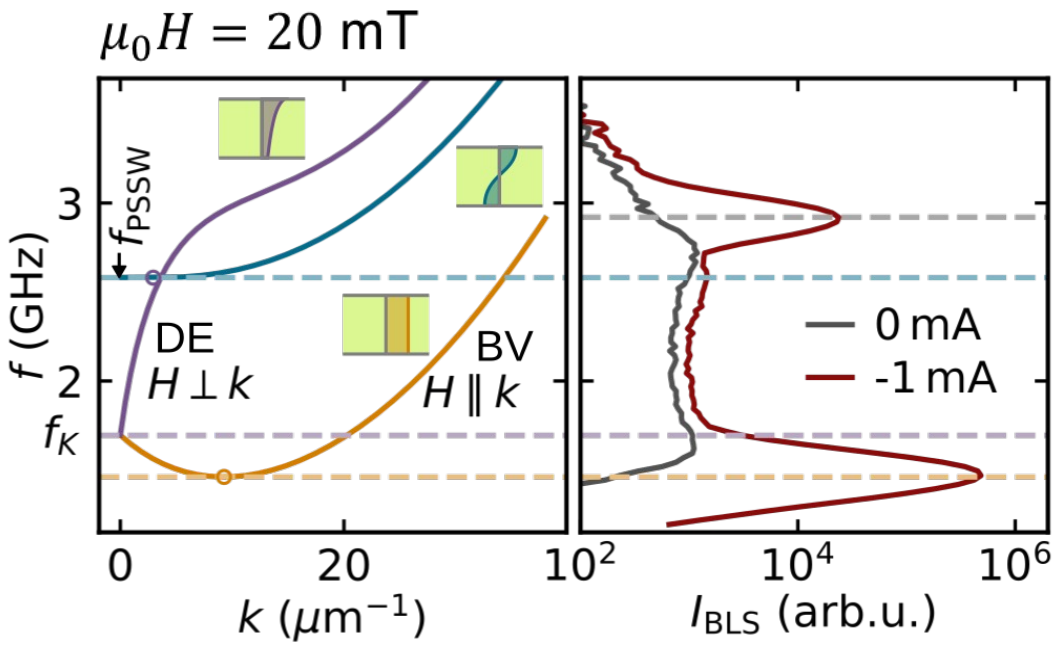
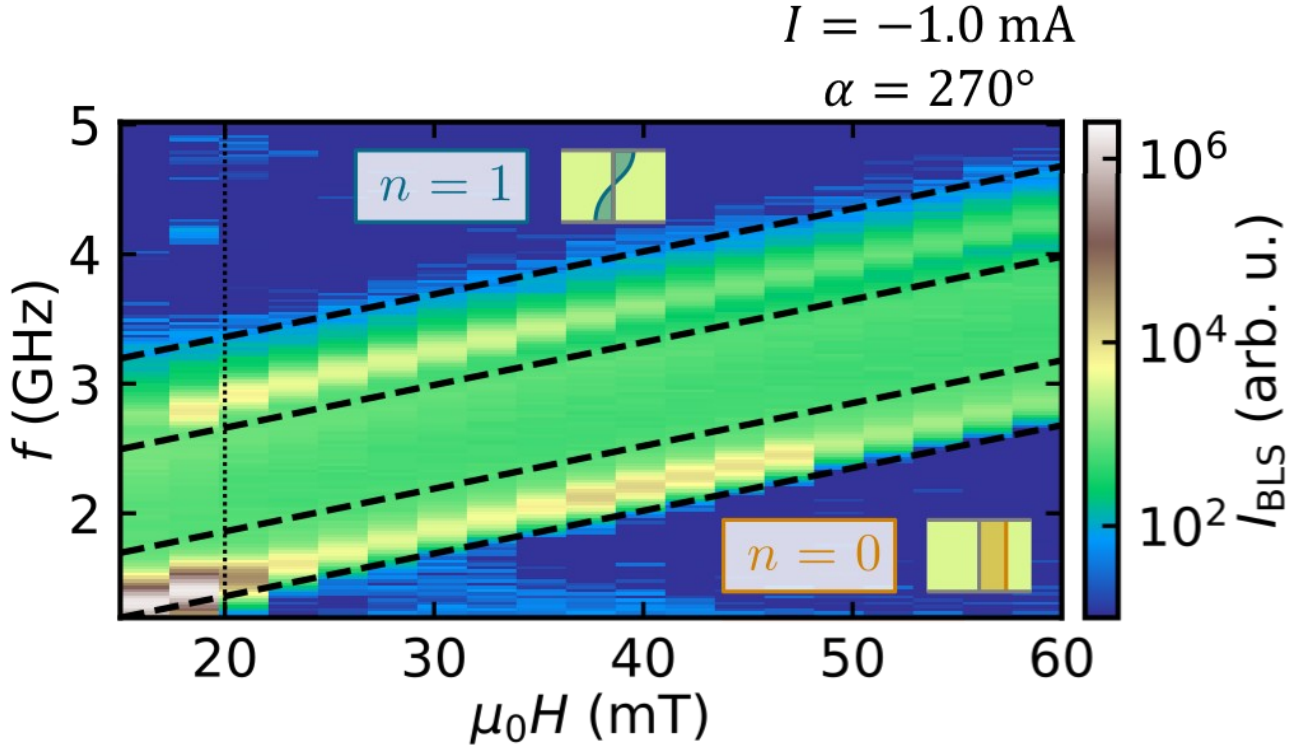
Brillouin light scattering measurements done by V. E. Demidov and S. O. Demokritov

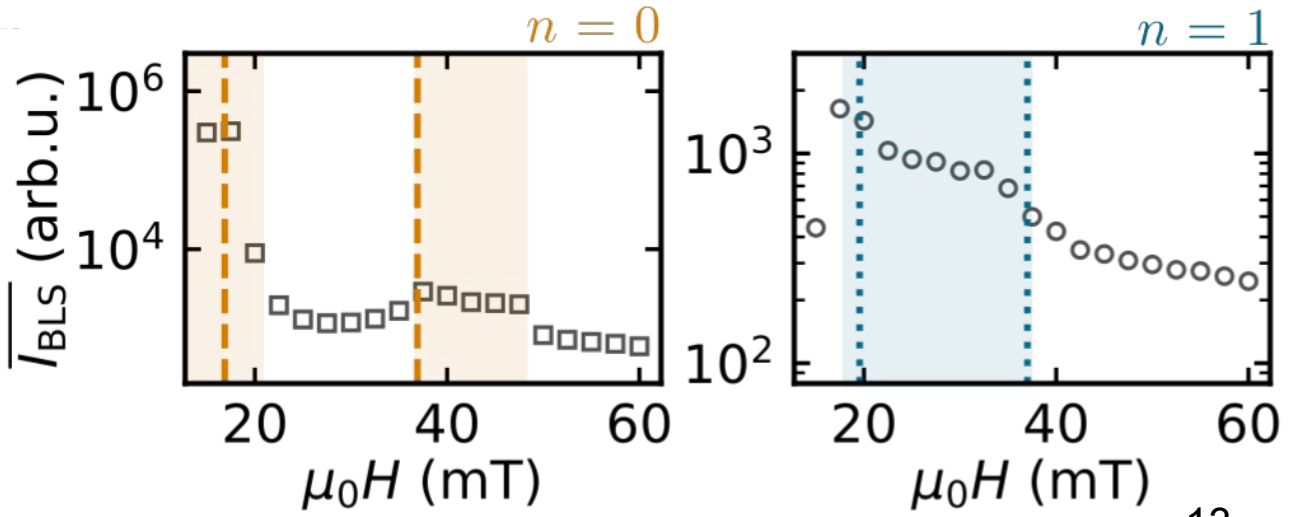
3 order of magnitude enhancement of BLS signal → autooscillations

Schlitz et al., Nat. Commun. **16**, 8472 (2025)

Oscillations in the Brillouin light scattering response

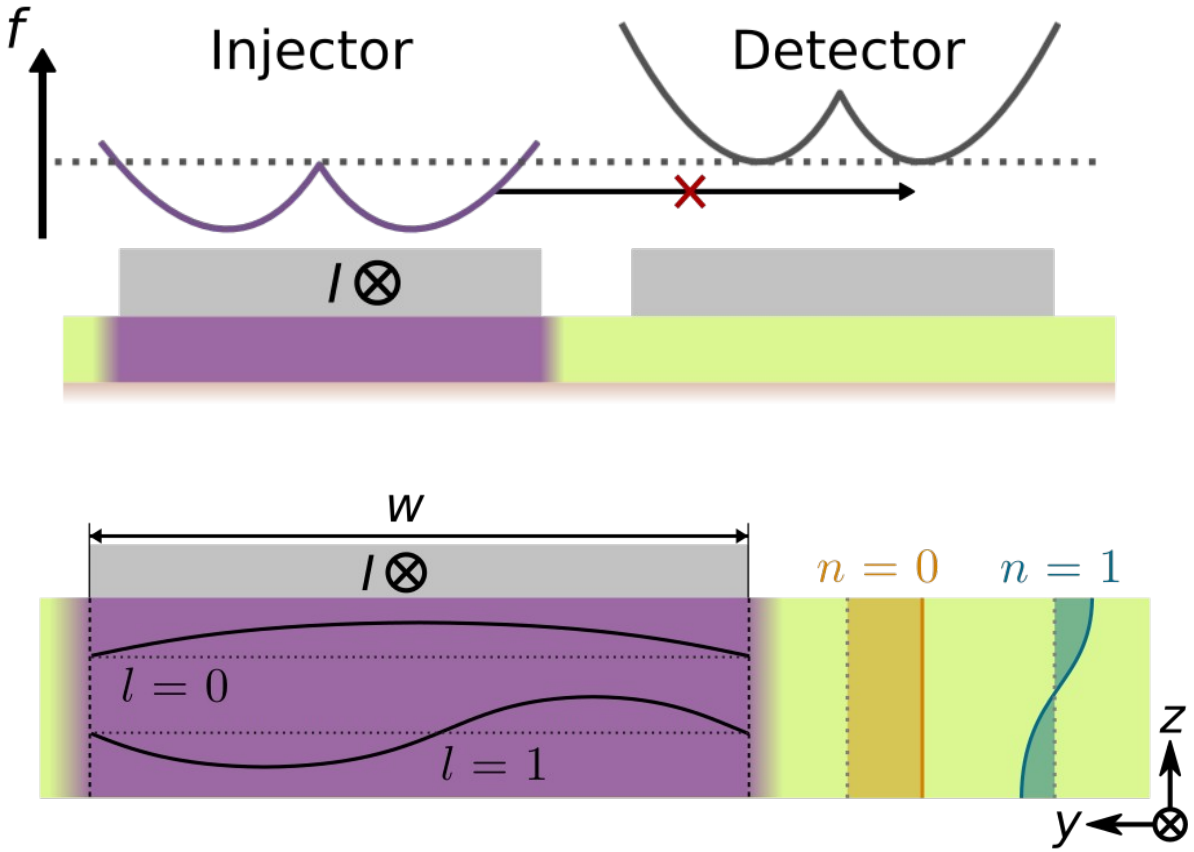




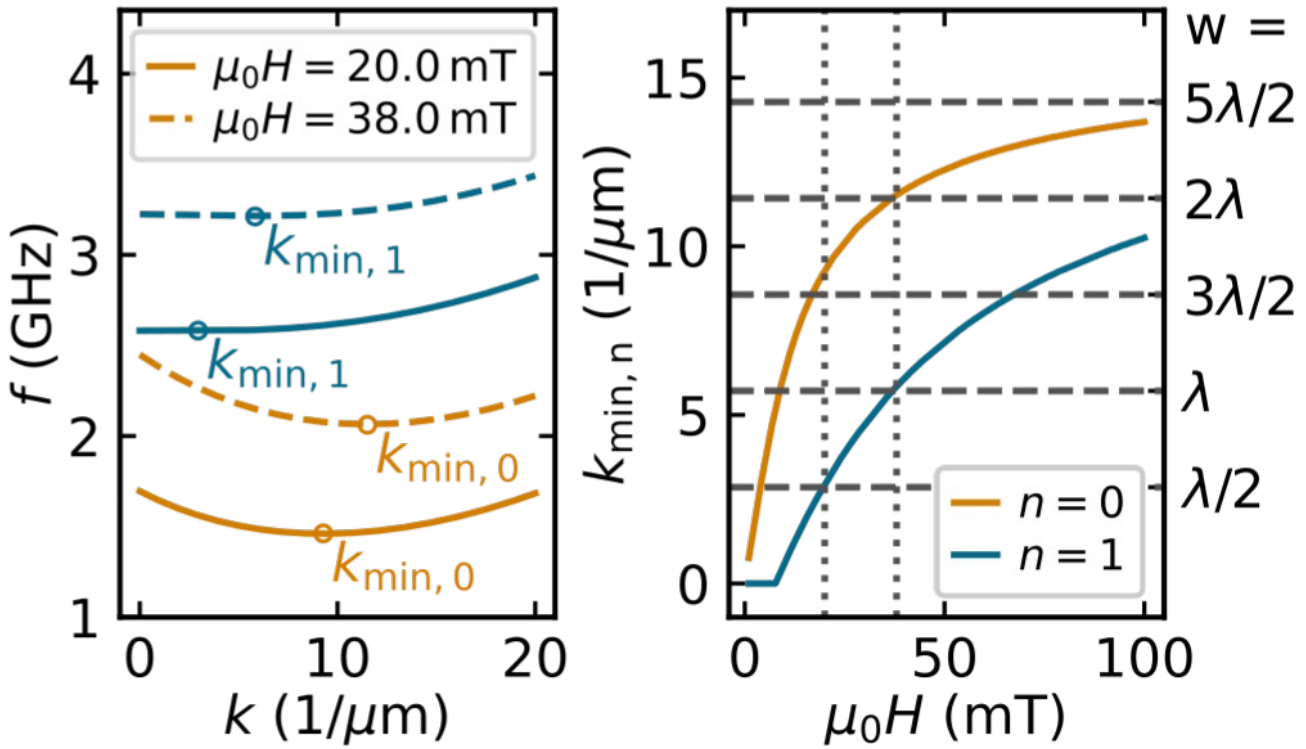


Schlitz et al., Nat. Commun. **16**, 8472 (2025)

Nonequilibrium magnon confinement

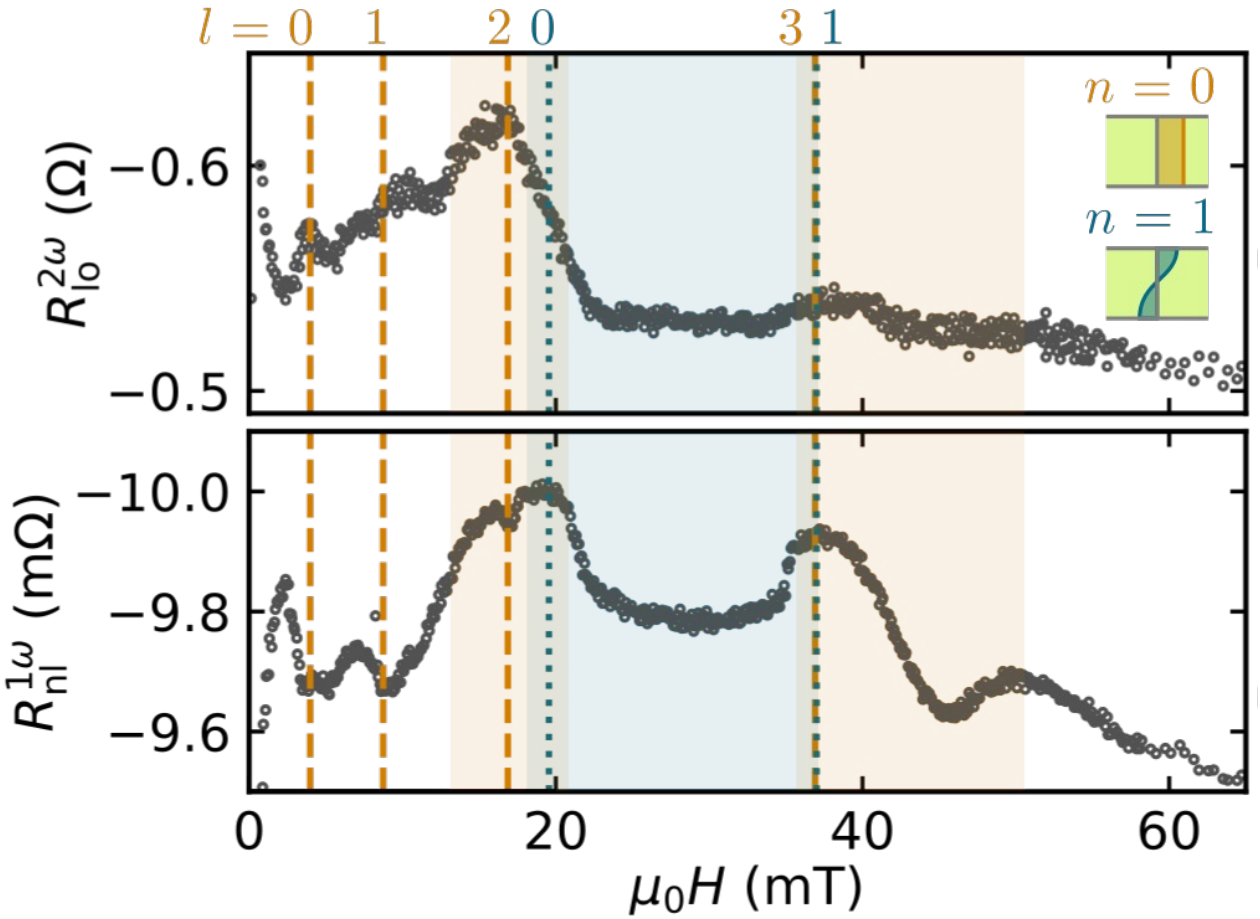


$$\lambda_l = \frac{2\pi}{k_l} = \frac{2w}{l+1} \rightarrow k_l = (l+1)\frac{\pi}{w}$$

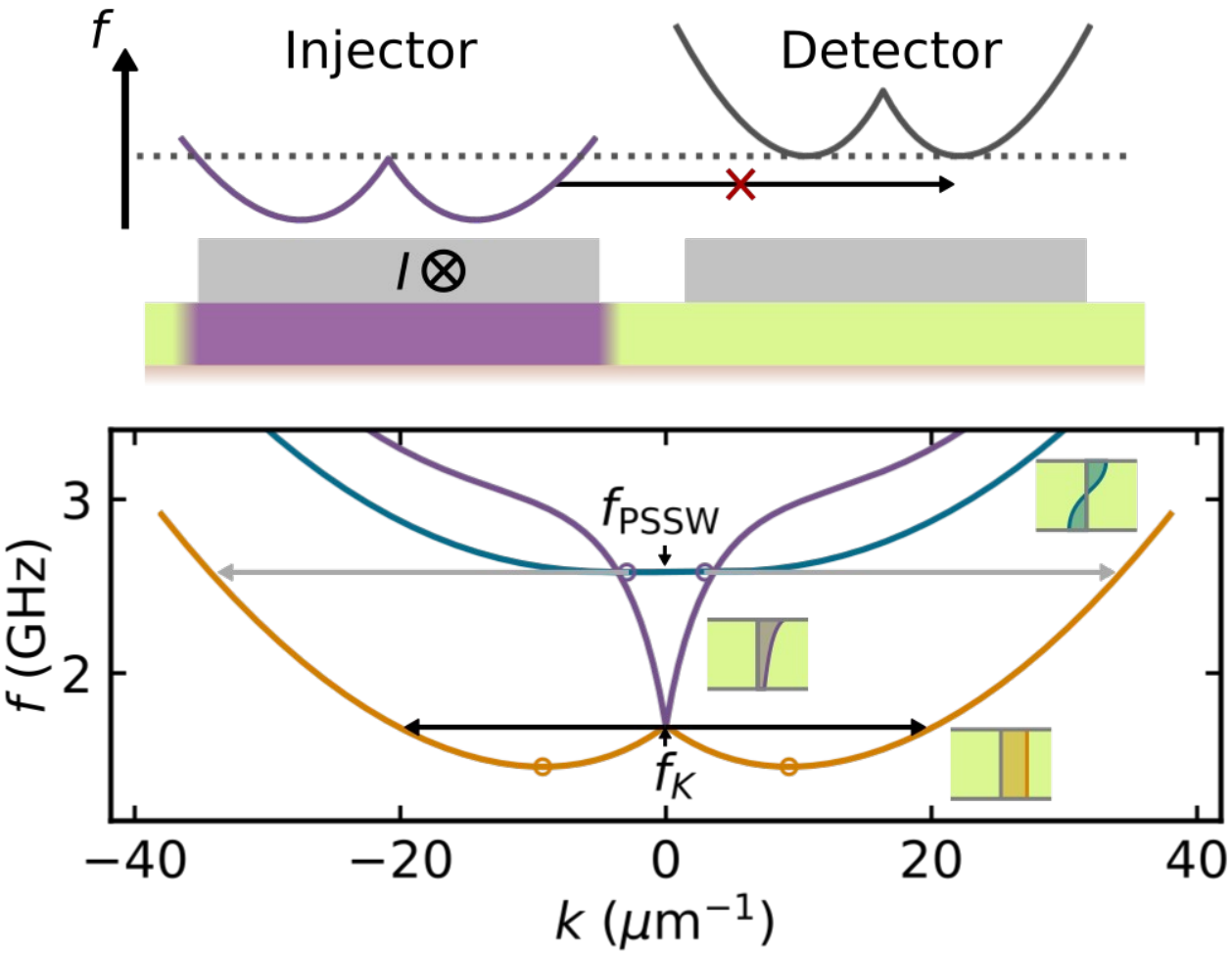


Schlitz et al., Nat. Commun. **16**, 8472 (2025)

Mechanism of radiation in the nonlinear regime



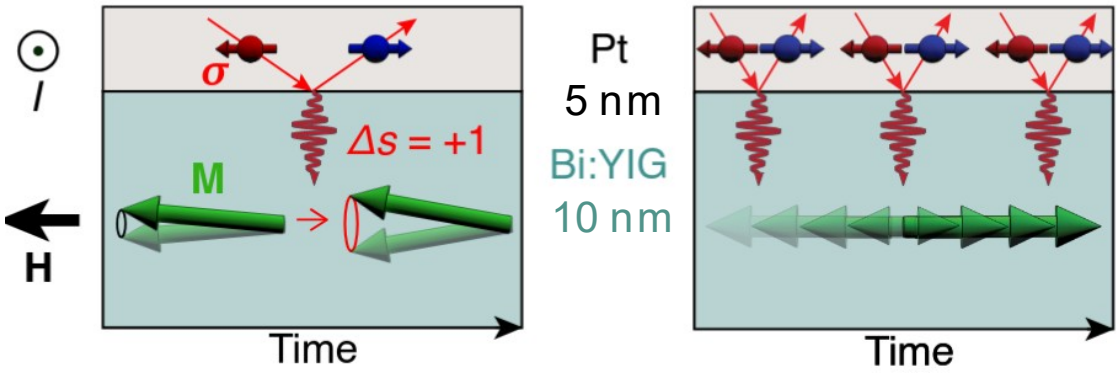
transport response motivated by nonlinear scattering



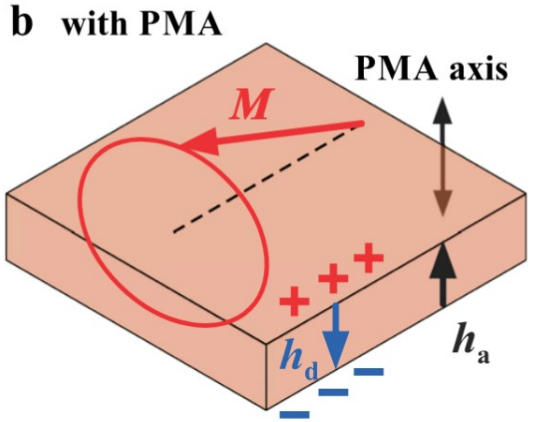
Schlitz et al., Nat. Commun. **16**, 8472 (2025)

Optical detection of magnon creation and annihilation

Emir Karadza (with Paul Noël)

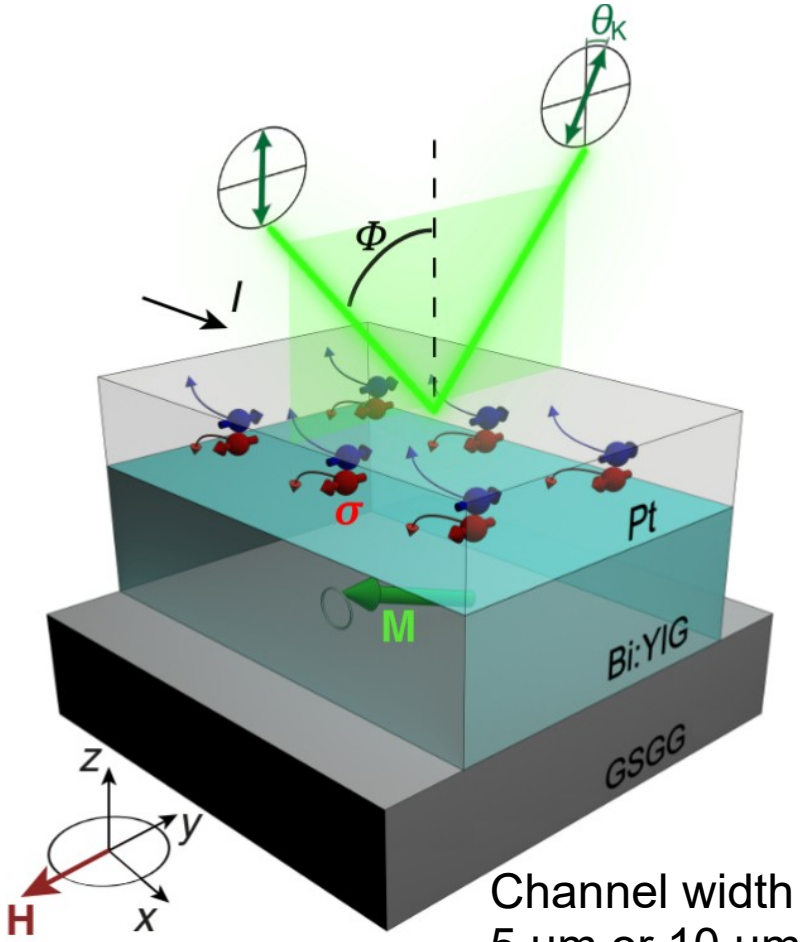


Bi:YIG on GSGG features almost net-zero magnetic anisotropy – **sample made by William Legrand**

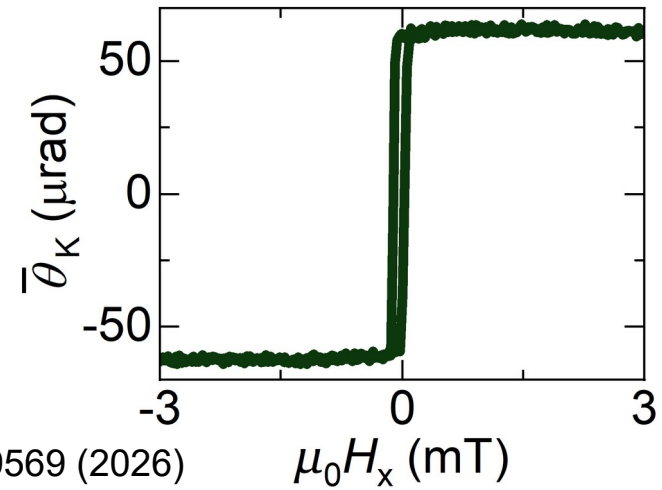


Nonlinear scattering suppressed

Merbouche et al., Nat. Commun. **15**, 1560 (2024)

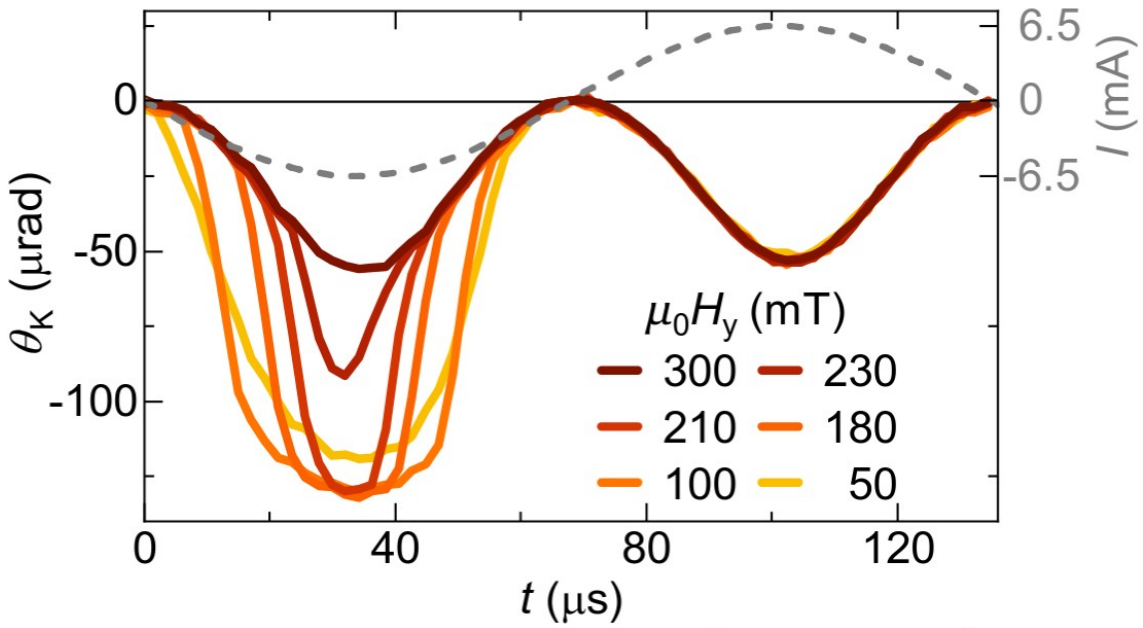


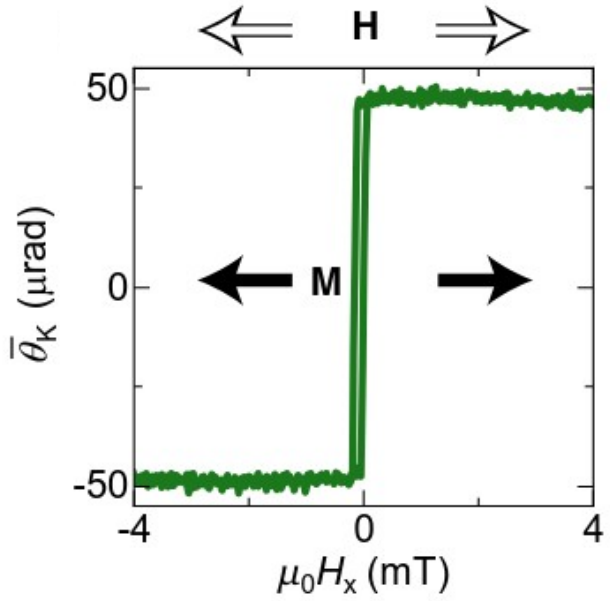
Channel width of 5 µm or 10 µm

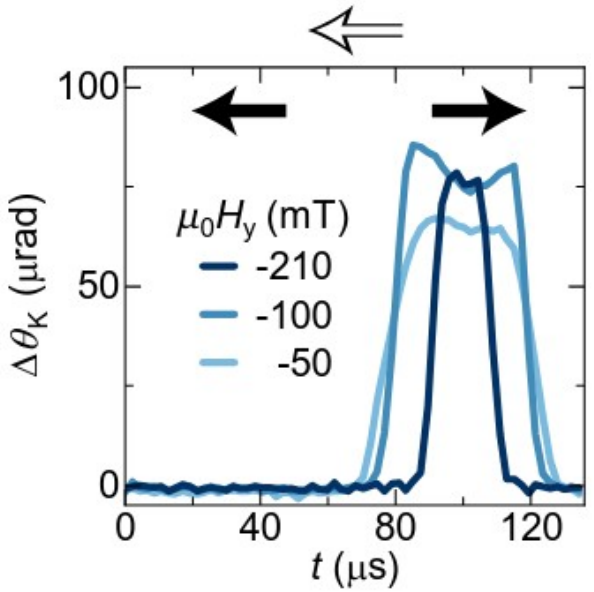


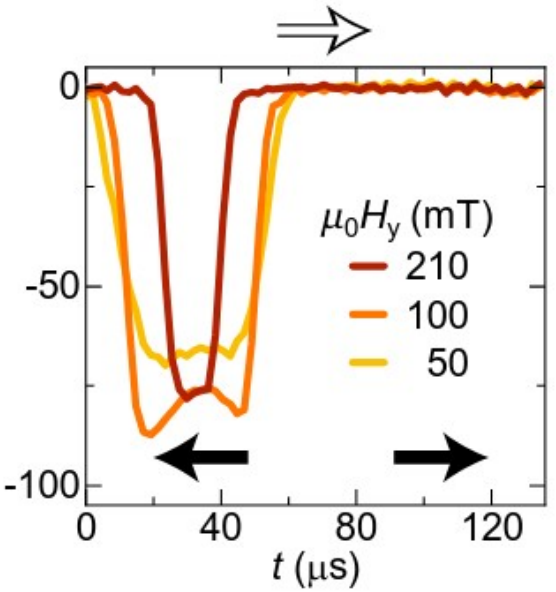
Karadza, Wang et al., arXiv 2601.09569 (2026)

Optical detection of magnon creation and annihilation



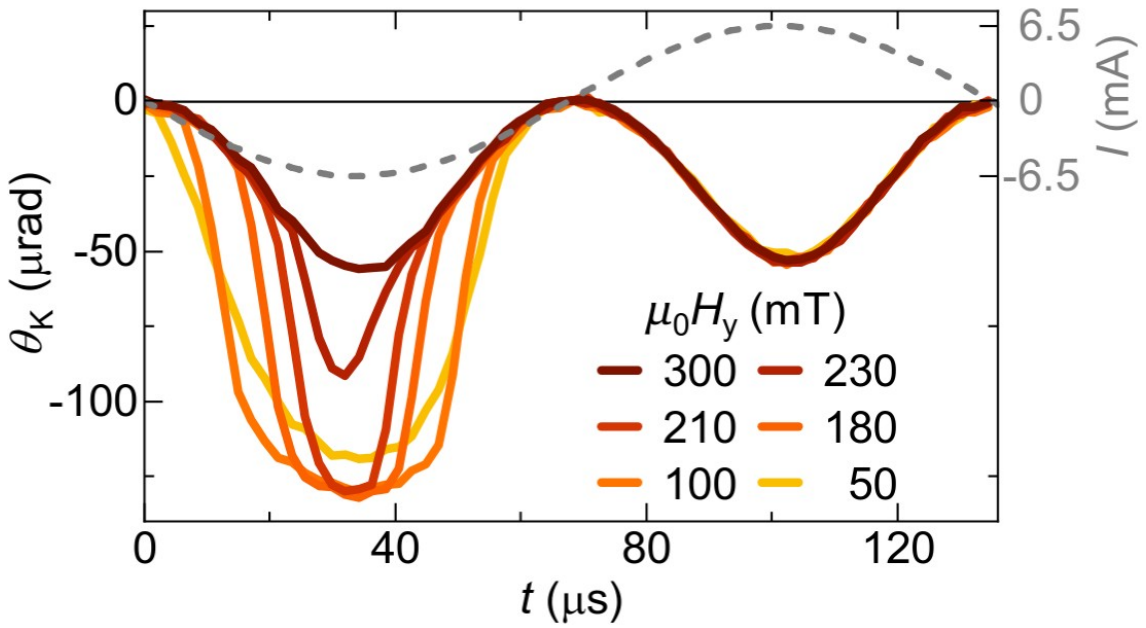


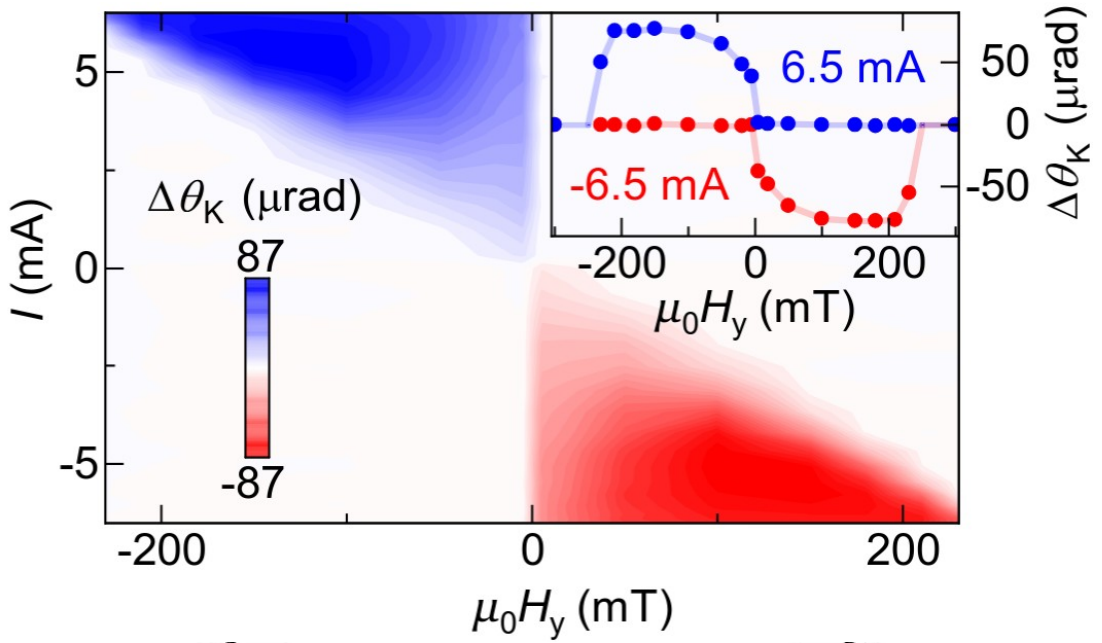


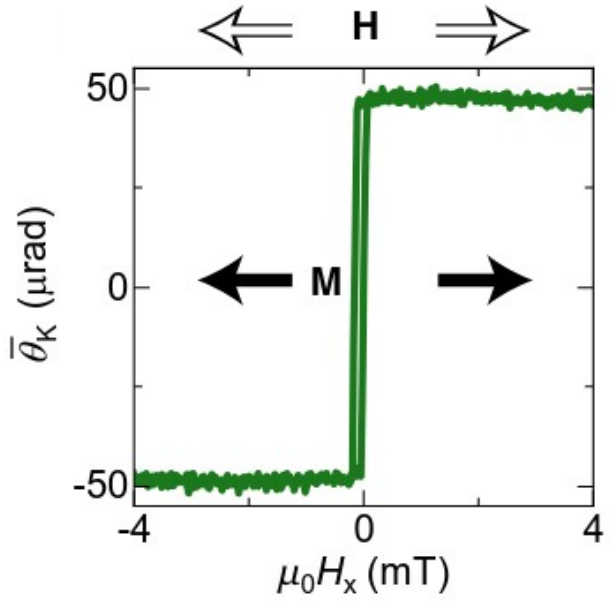


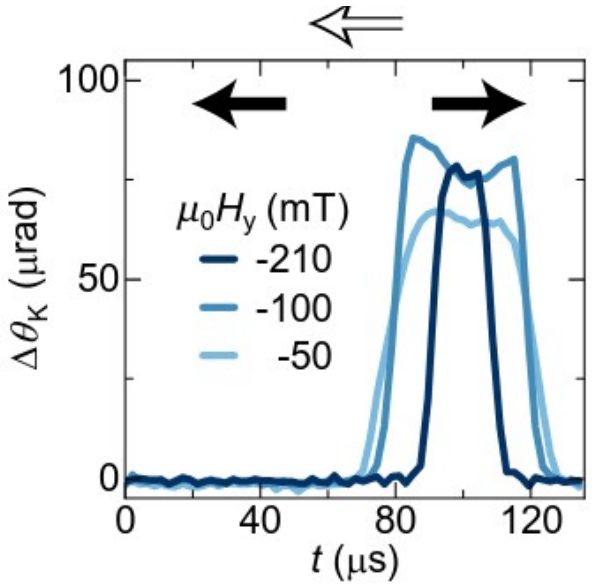
Karadza, Wang et al., arXiv 2601.09569 (2026)

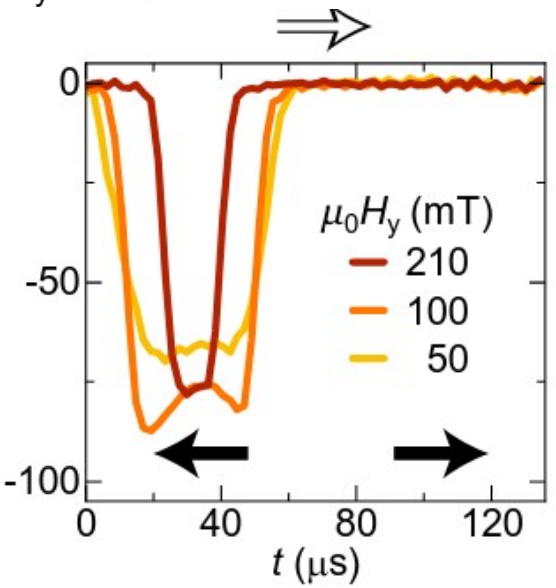
Optical detection of magnon creation and annihilation







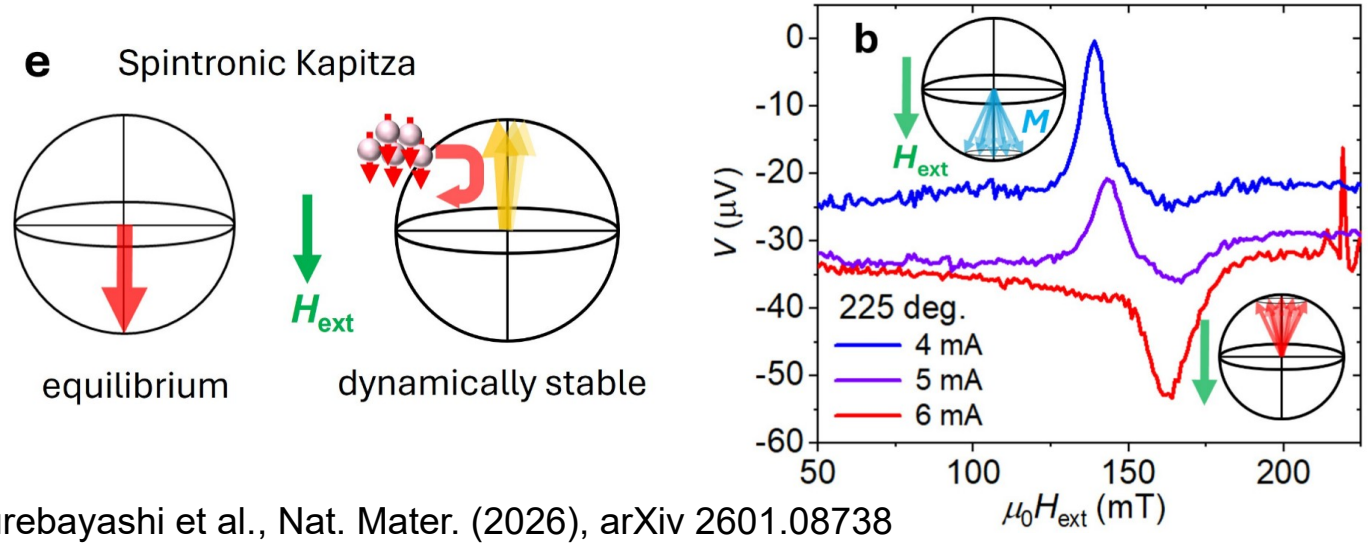




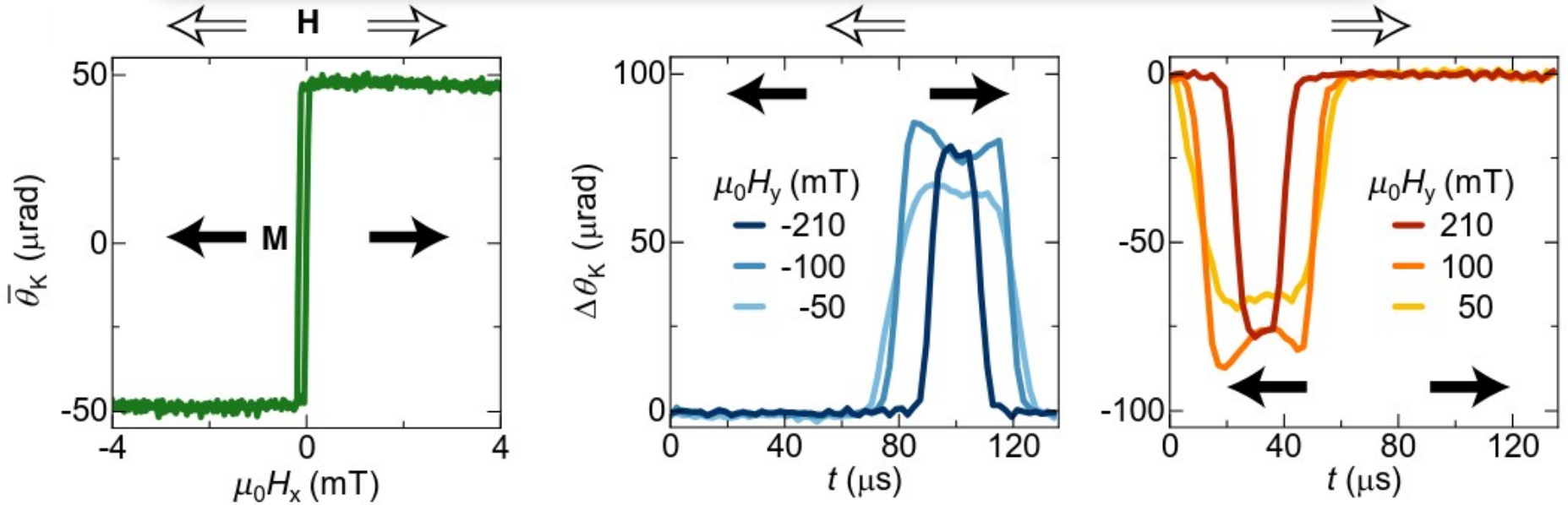
Karadza, Wang et al., arXiv 2601.09569 (2026)

Optical detection of magnon creation and annihilation

Other demonstration using MgO/CoFeB/W and ST-FMR

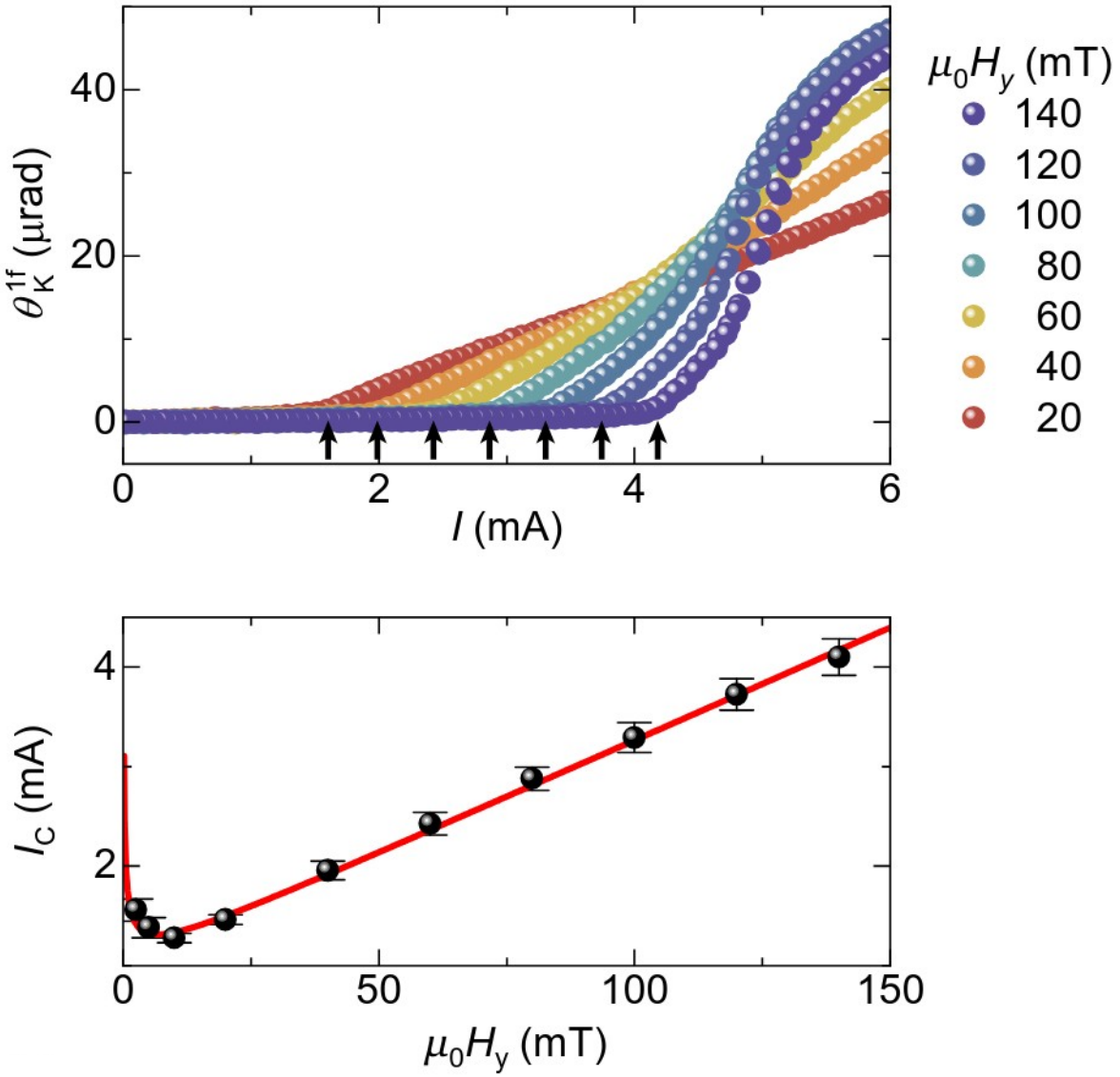


Kurebayashi et al., Nat. Mater. (2026), arXiv 2601.08738

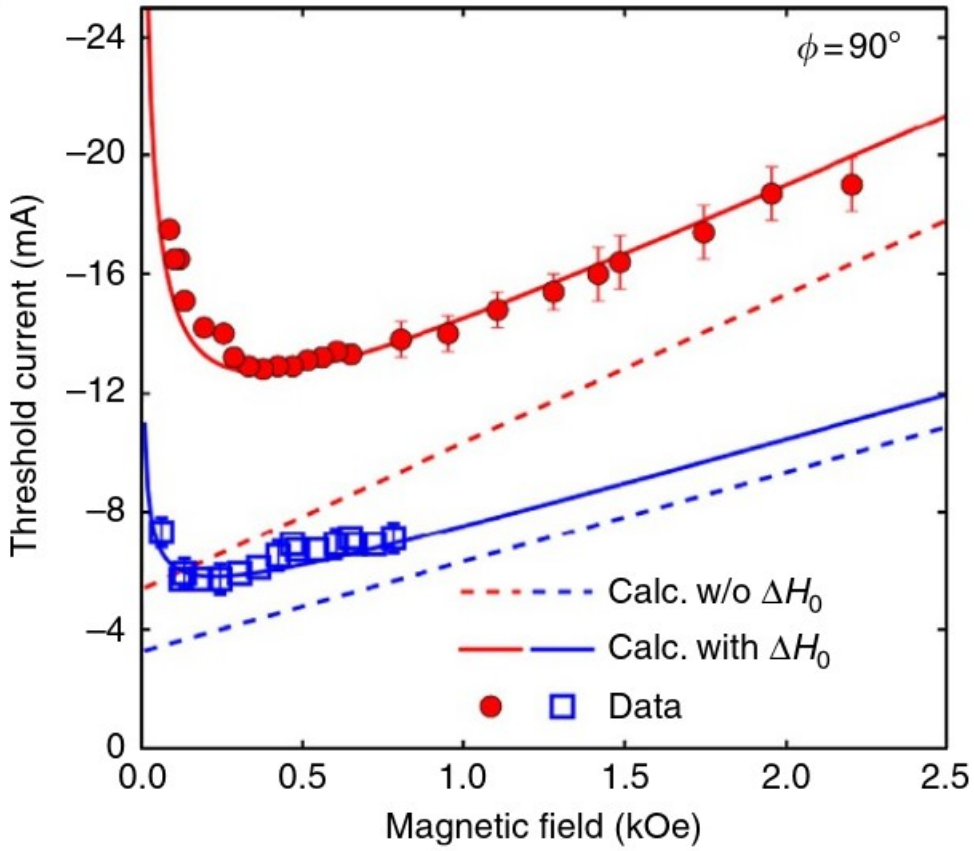


Karadza, Wang et al., arXiv 2601.09569 (2026)

Optical detection of magnon creation and annihilation



Critical current for auto-oscillations in YIG(20)/Pt(5)



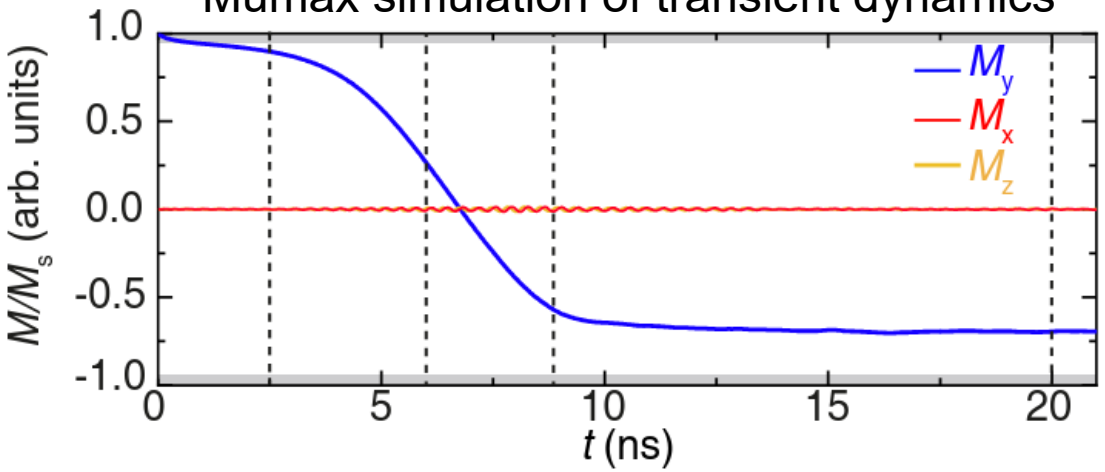
Collet et al., Nat. Commun. **7**, 10377 (2016)

Karadza, Wang et al., arXiv 2601.09569 (2026)

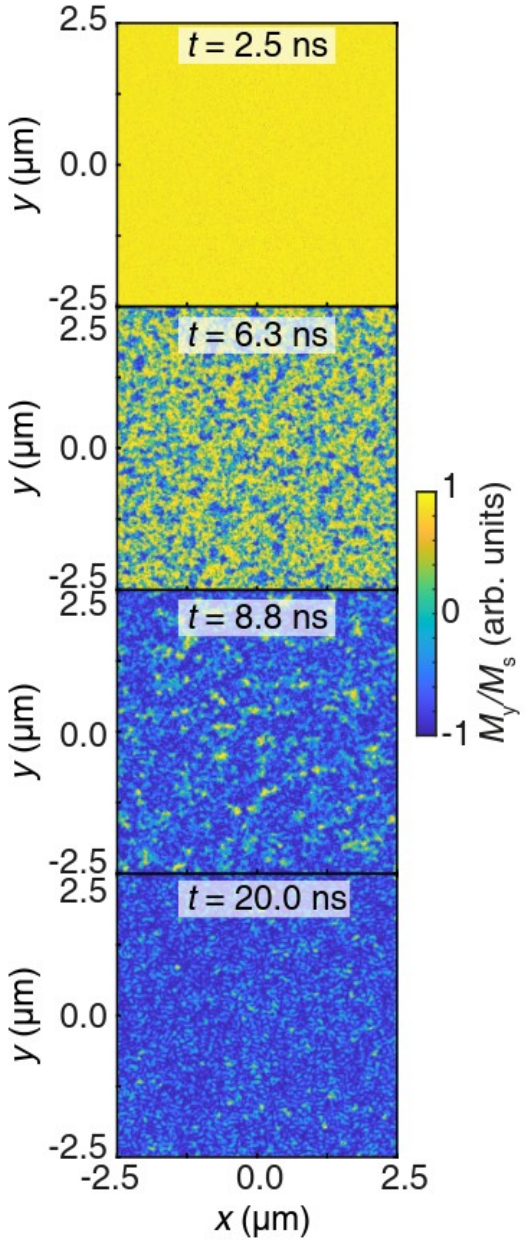
Optical detection of magnon creation and annihilation

Hanchen Wang

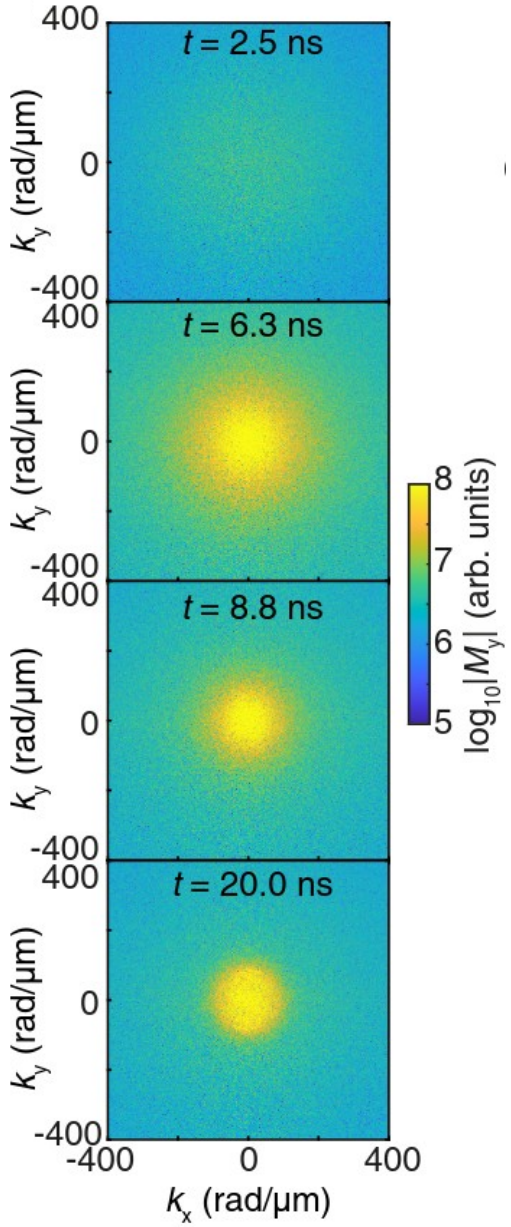
Mumax simulation of transient dynamics



Magnetization reversal does not take place via coherent reversal (spatially average *M* disappears)

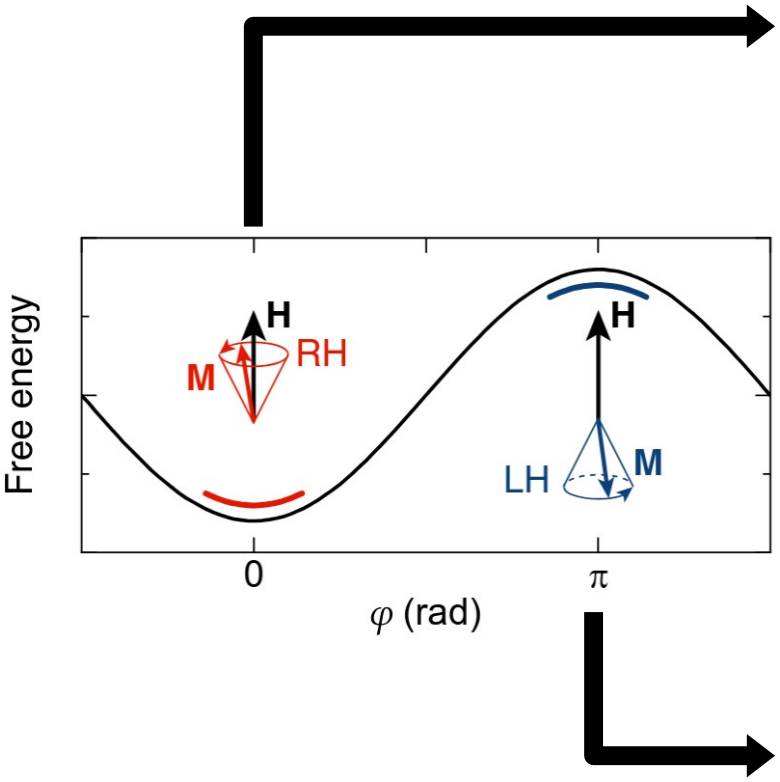


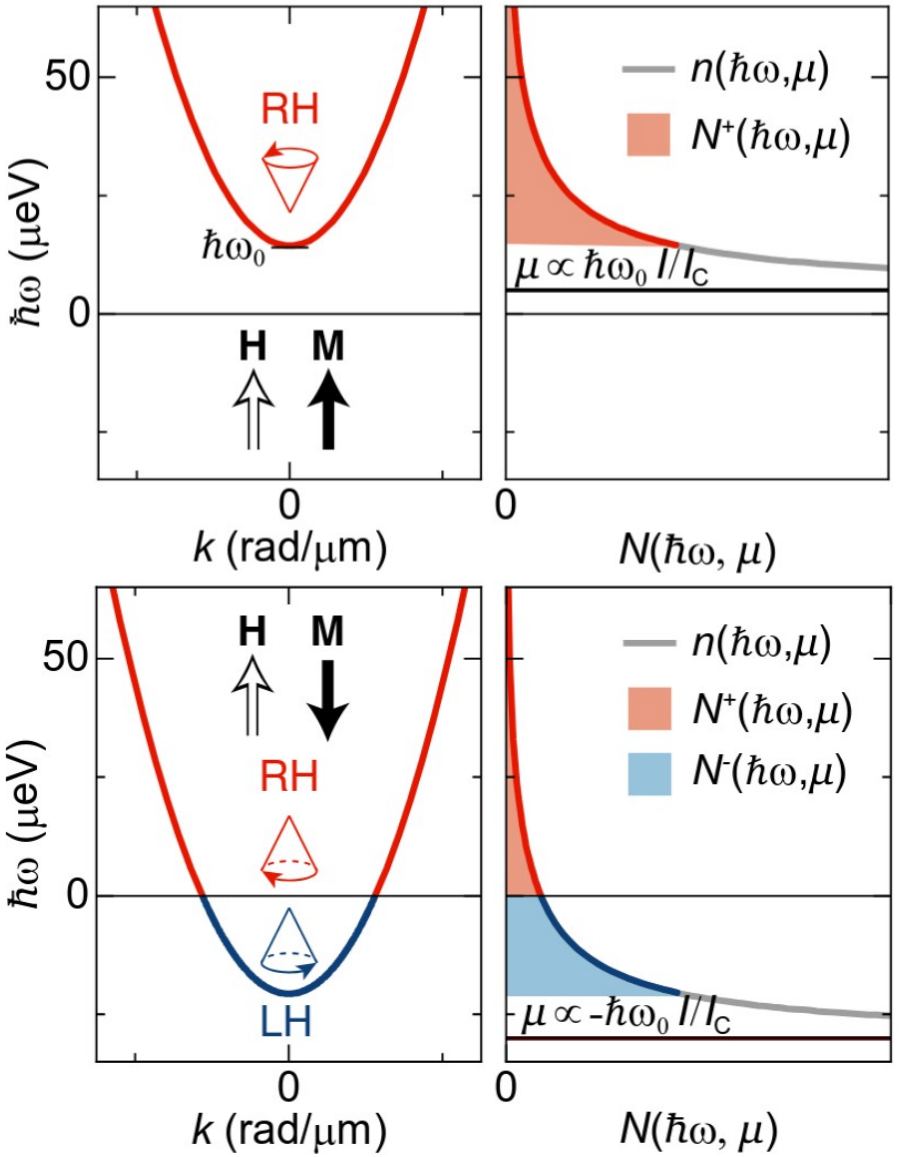
FFT



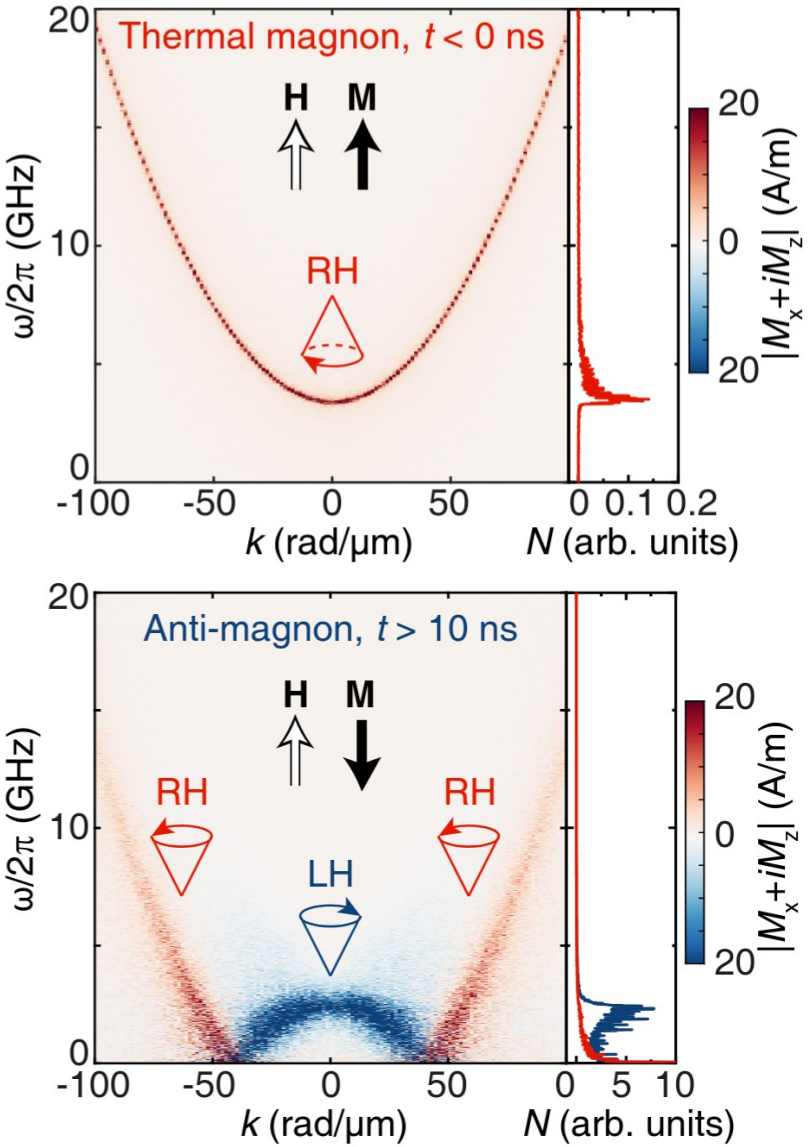
Karadza, Wang et al., arXiv 2601.09569 (2026)

The inverted state in the Bose-Einstein picture





mumax³



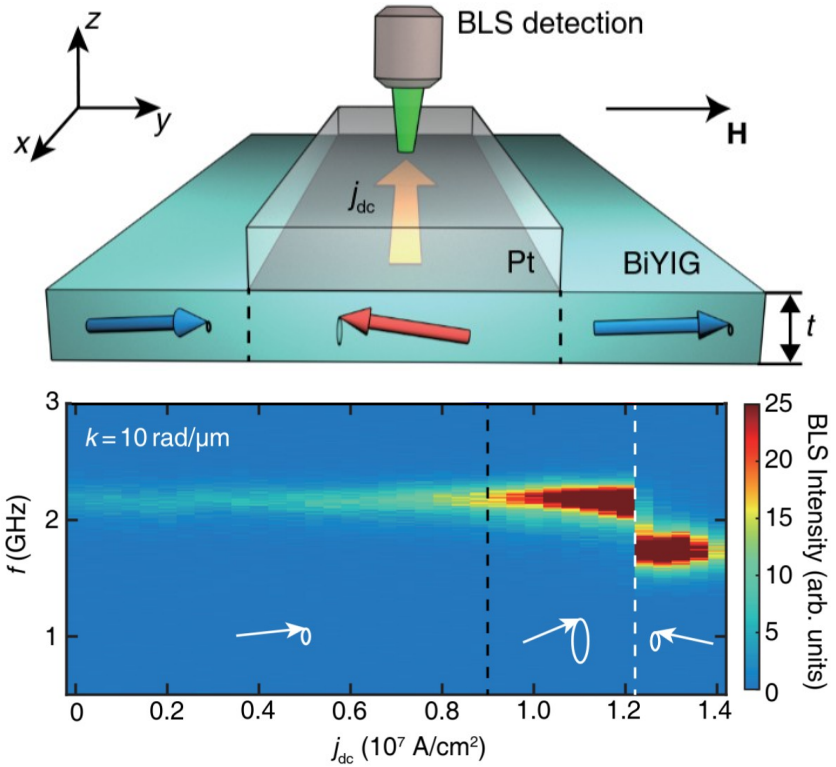
Karadza, Wang et al., arXiv 2601.09569 (2026)

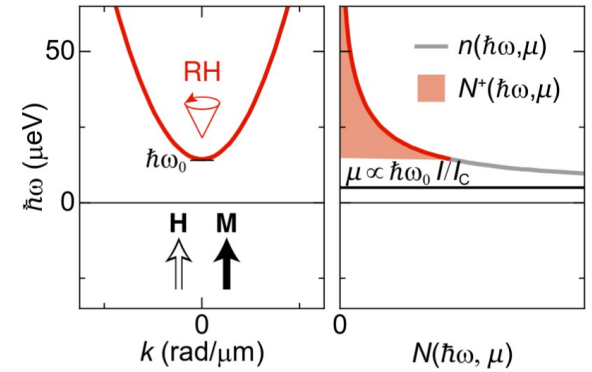
Direct spectroscopic evidence of negative band curvature

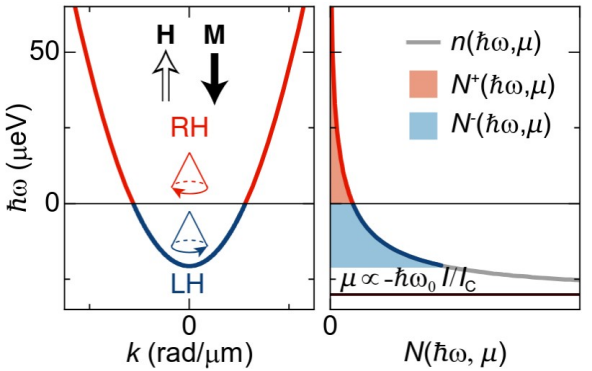
北京航空航天大學
BEIHANG UNIVERSITY

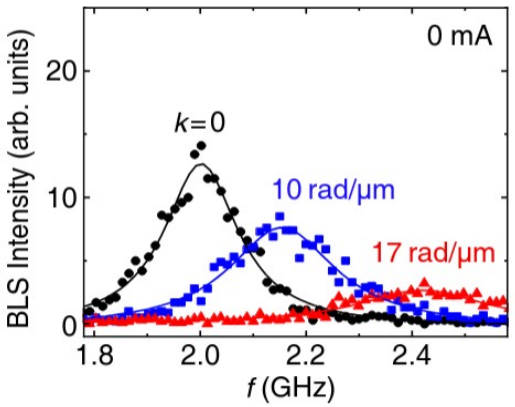
Experiments performed by the group of Haiming Yu

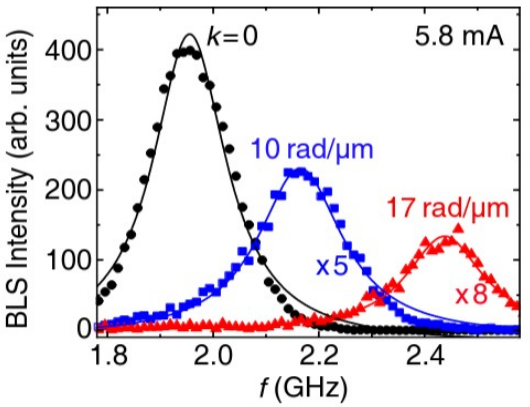
J. Hu H. Peng D. Yu
W. Song J. Chen J.-P. Ansermet
J. Wang S. Liu

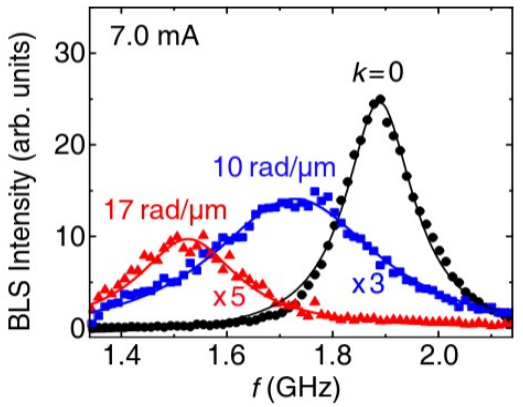


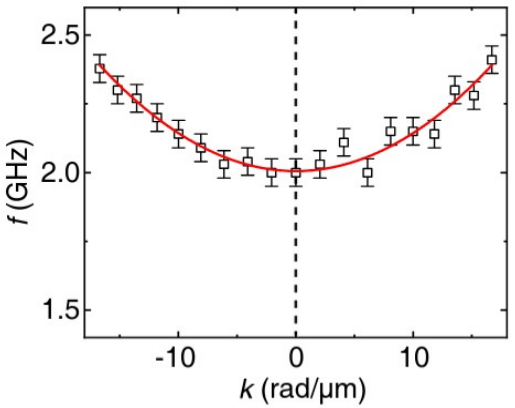


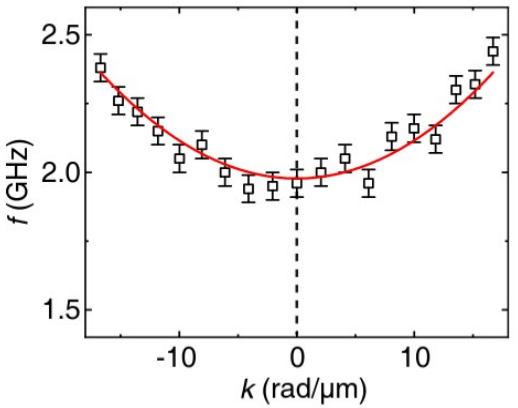


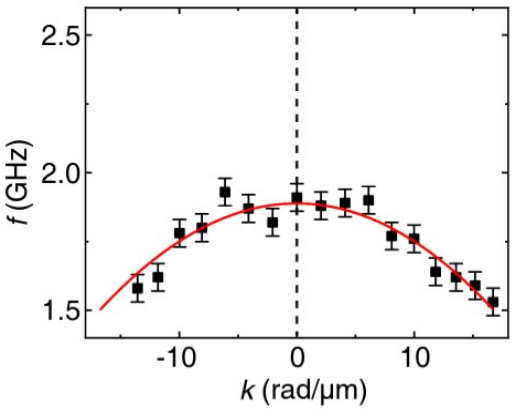












Wang, Hu, Song, Bassant et al., arXiv 2601.15231 (2026)

Acknowlegments

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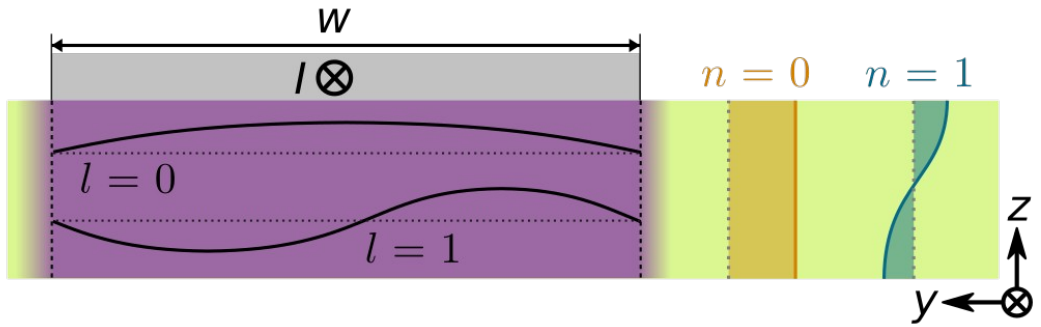
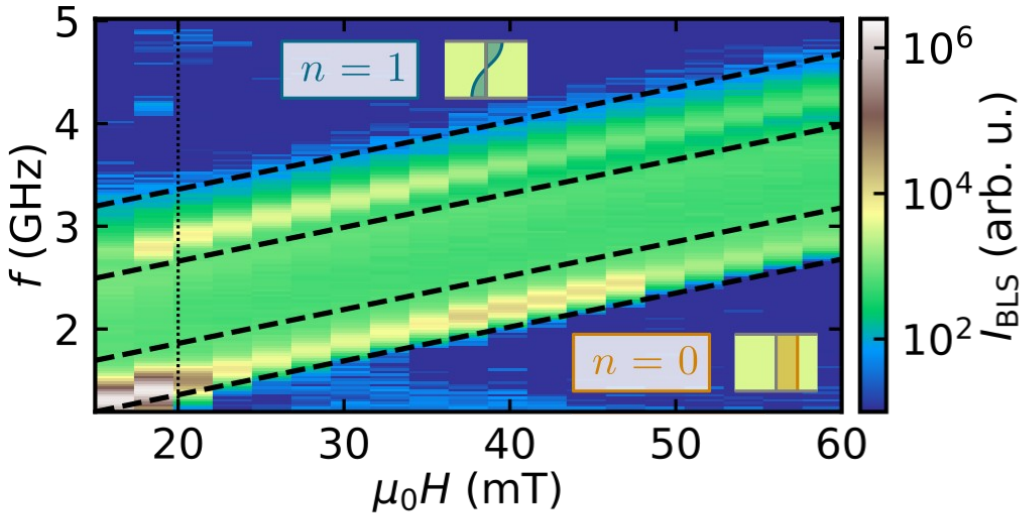
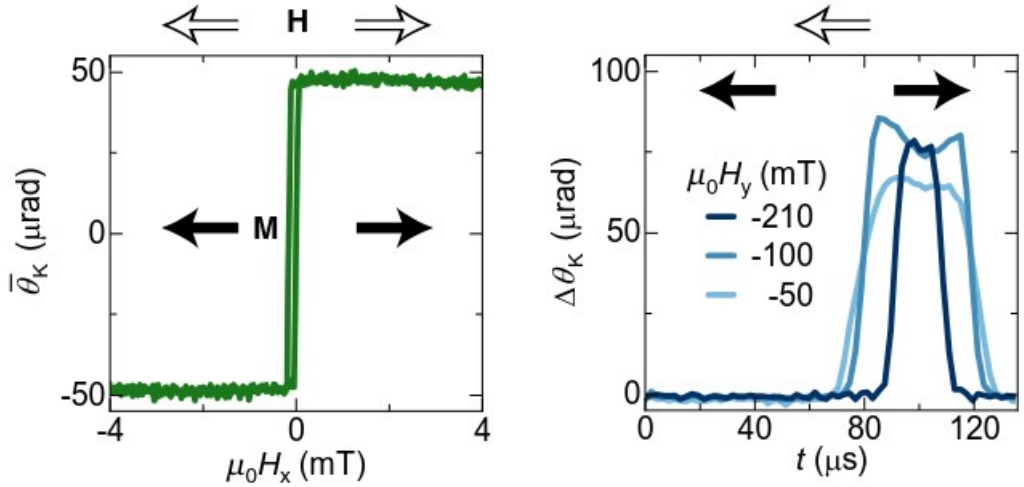
Summary and Outlook



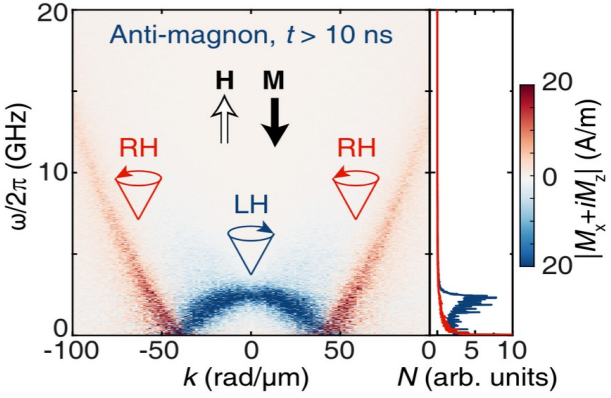
Self-confinement of magnons allows to reach damping compensation also in thick YIG films

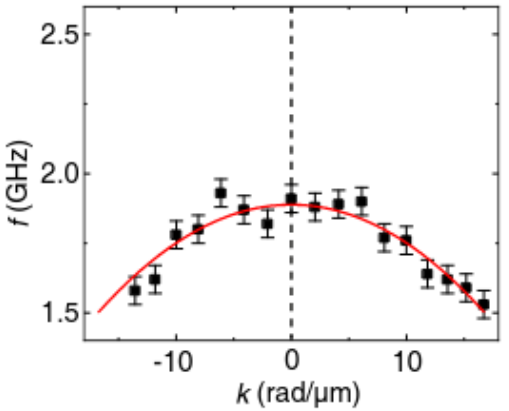


Confinement induced quantization leads to oscillatory magnetic field dependence



Experimentally demonstrated dynamical stabilization of inverted magnetization hosting a new type of excitation





Schlitz et al., Nat. Commun. 16, 8472 (2025)

Karadza, Wang et al., arXiv 2601.09569 (2026)
Wang, Hu, Song, Bassant et al., arXiv 2601.15231 (2026)
see also: Kurebayashi et al., arXiv 2601.08738 (2026)