

High wave vector non-reciprocal spin wave beams

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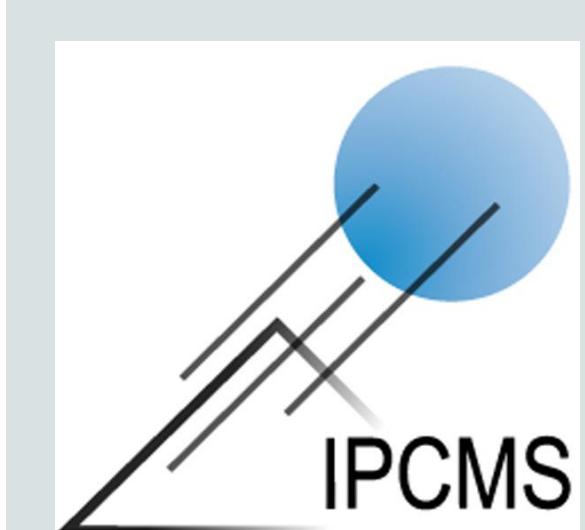
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Fundings



Project "SOSMAG"

References

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- [3] J. Chen, et al., Rev. B **100**, 104427 (2019)
- [4] V. Vlaminck, and M. Bailleul, Phys. Rev. B **81**, 14425 (2010)
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Motivations

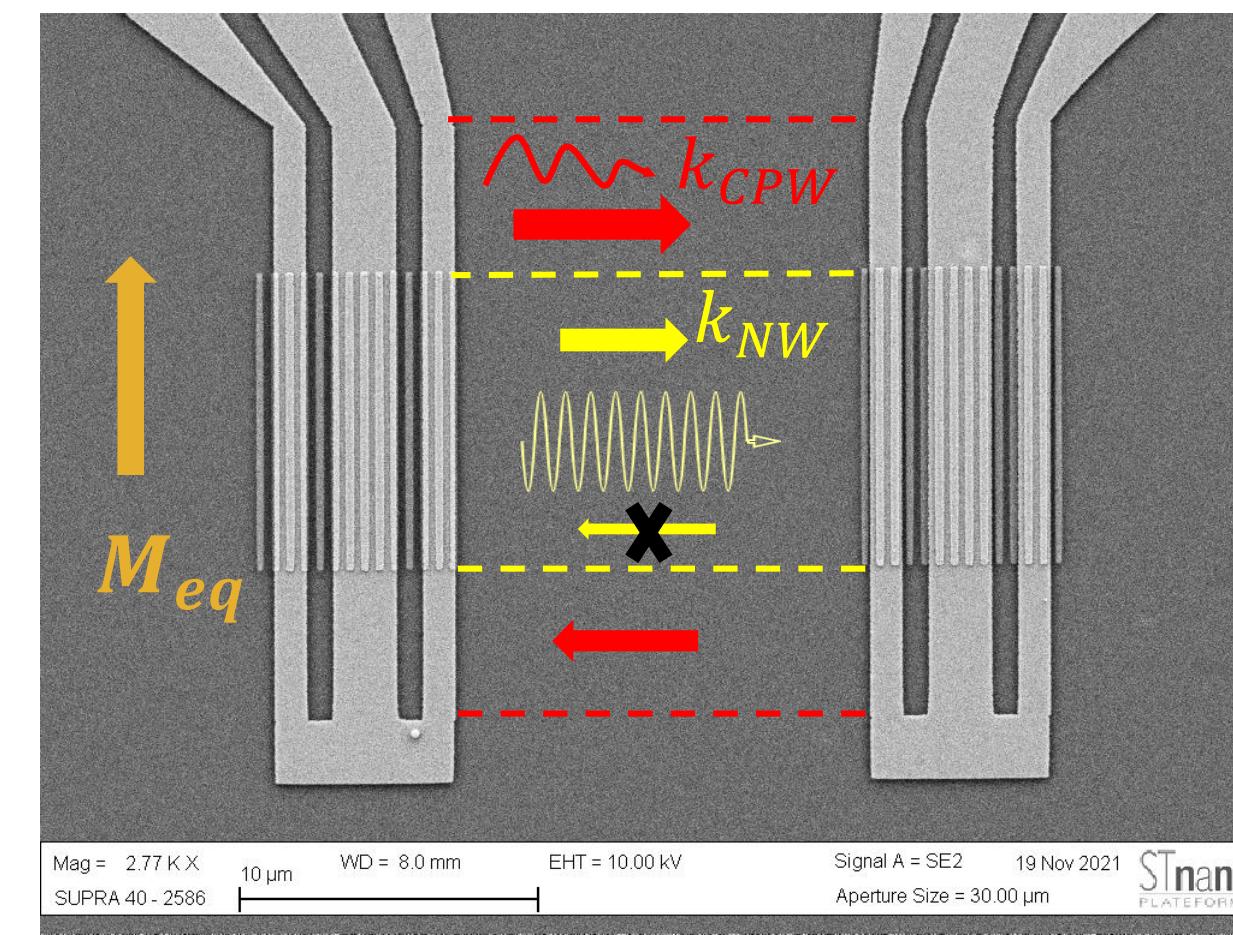
► Miniaturization of non-reciprocal devices

Integrate circulators, isolators, and phase shifters in today's communication systems [1,2]

► Shaping non-reciprocal spin wave beams

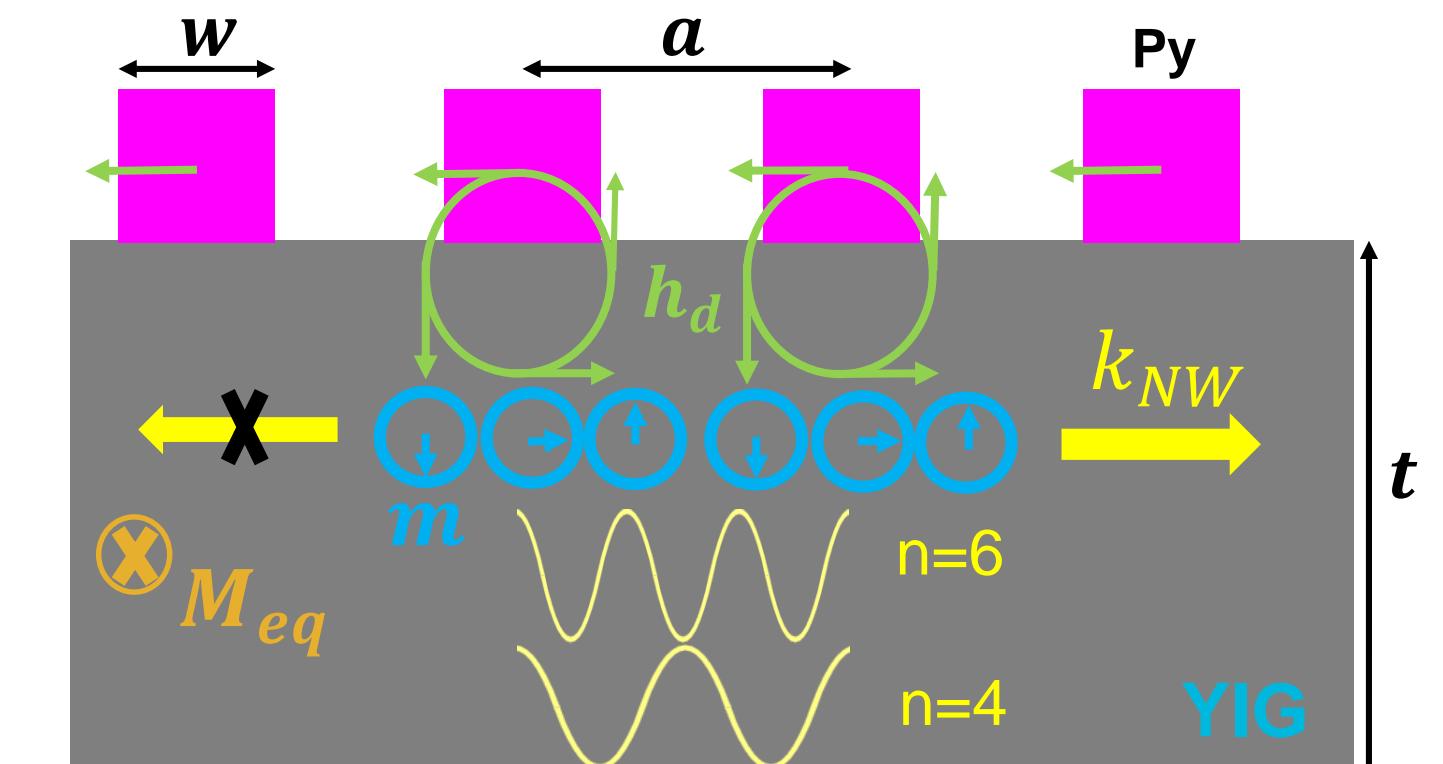
in a continuous thin YIG film using chiral coupling from nanowire arrays [3]

► High k-vector magnon spectroscopy



t=55nm thin YIG film / Ni₈₀Fe₂₀ nanowires (NW):

L=10μm, w=300nm, a=500nm / 80nm Au-antennas

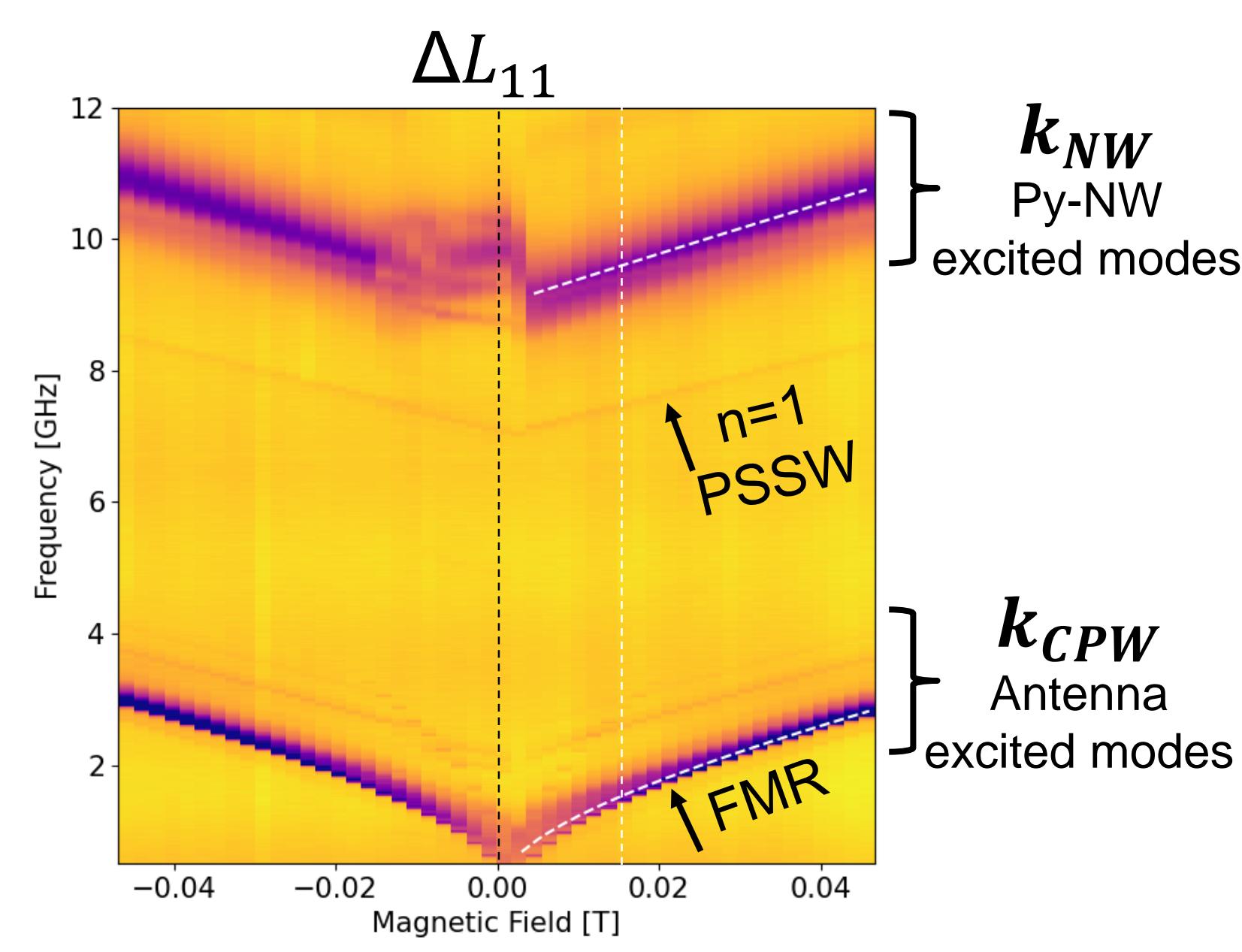


Chiral coupling between FMR-dynamic dipolar field of Py-NW (h_d) and high k-vector magnon modes ($k_n = \frac{2\pi n}{a}$) in YIG:
Chirality due to circular polarization of h_d

Perfect non-reciprocal transmission of spin wave beams

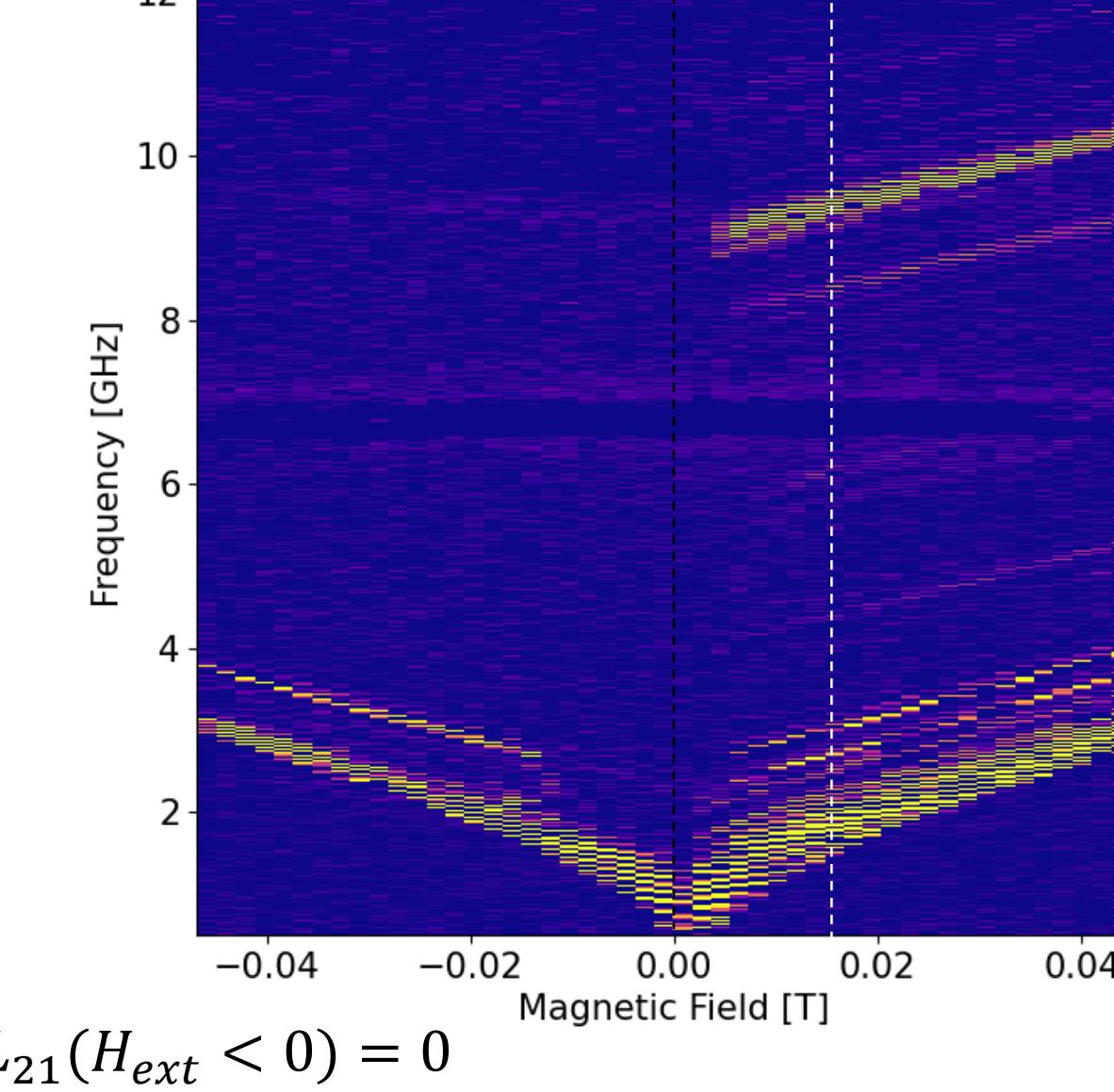
► VNA SW Spectroscopy [4,5]

Mapping (f,H) of self- and mutual inductance spectra



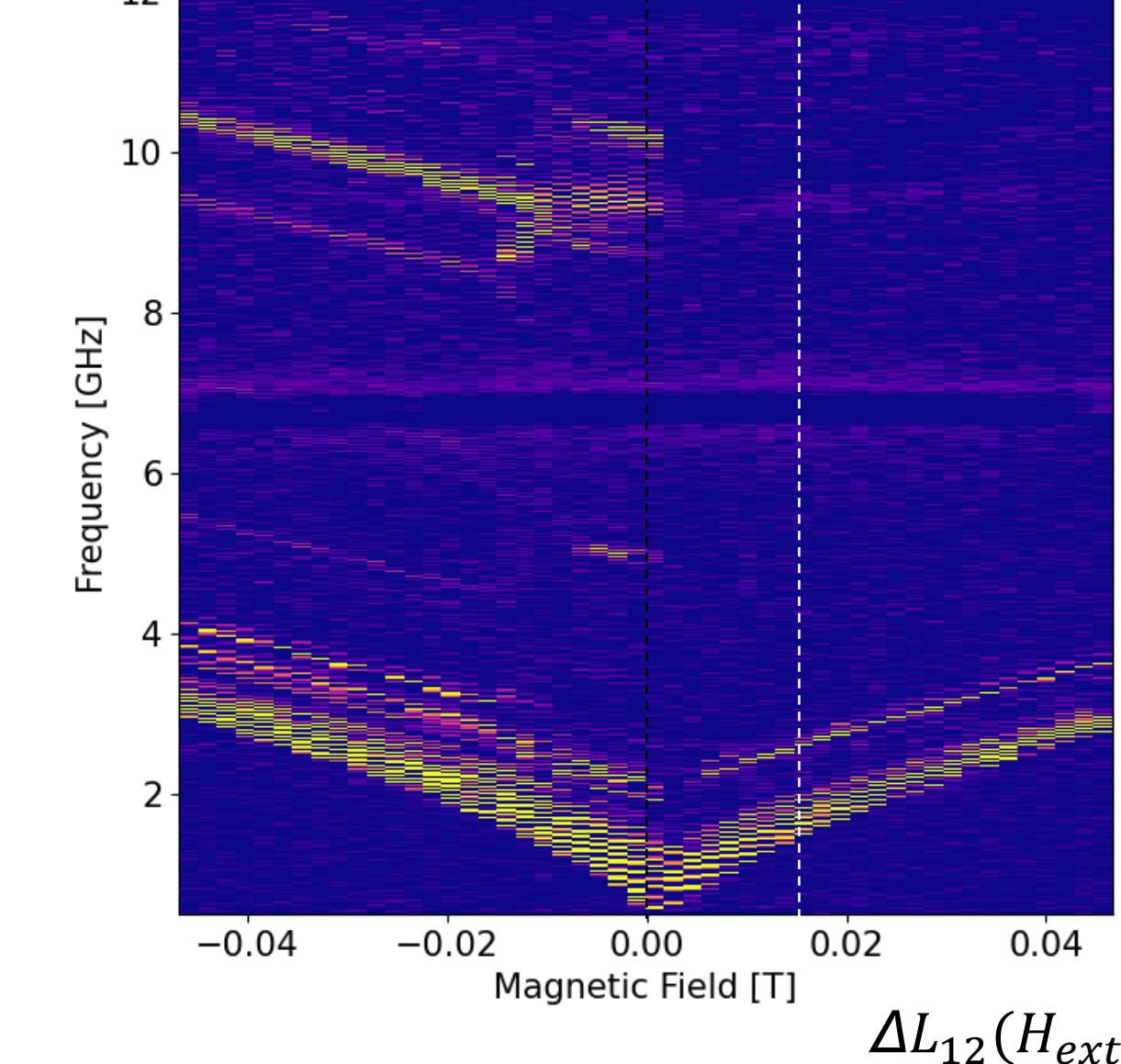
$$S_{ij} \rightarrow Z_{ij} \rightarrow \Delta L_{ij} : \quad \Delta L_{ij}(f, H) = \frac{1}{i2\pi f} (Z_{ij}(f, H) - Z_{ij}(H_{ref}))$$

ΔL_{21}



$$\Delta L_{21}(H_{ext} < 0) = 0$$

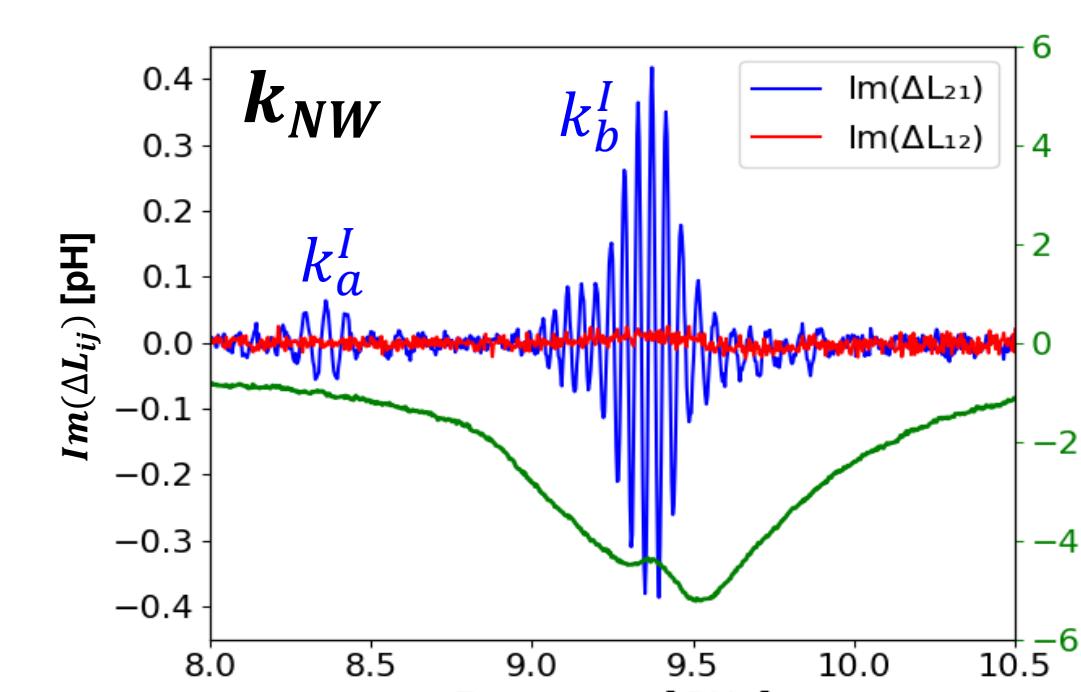
ΔL_{12}



$$\Delta L_{12}(H_{ext} > 0) = 0$$

Unidirectional transmission for k_{NW} reversed when field switches

► Dispersions f(k,H)



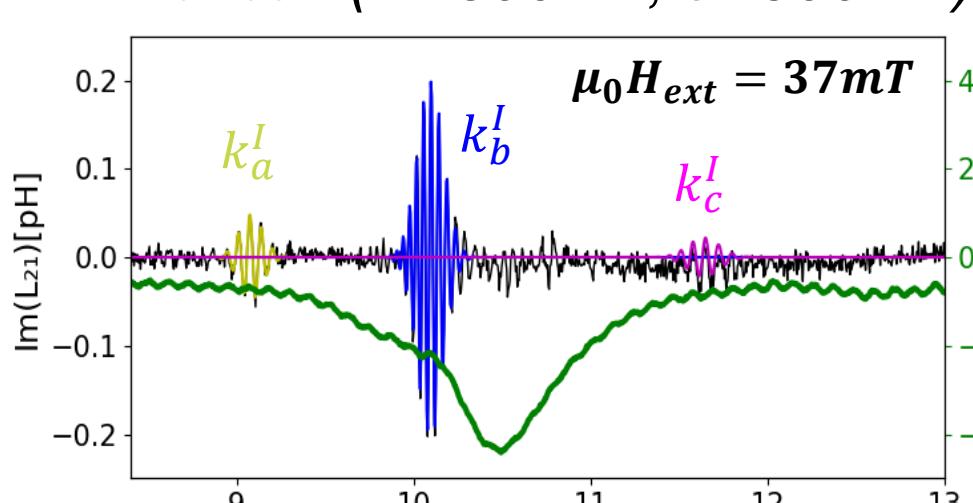
Separation between two adjacent modes k_a^I and $k_b^I < \frac{2\pi}{a}$
 $(\Delta k = k_b^I - k_a^I = 5.3 \text{ rad}/\mu\text{m} < \frac{2\pi}{a} = 12.5 \text{ rad}/\mu\text{m})$

High wave vector spin wave spectroscopy

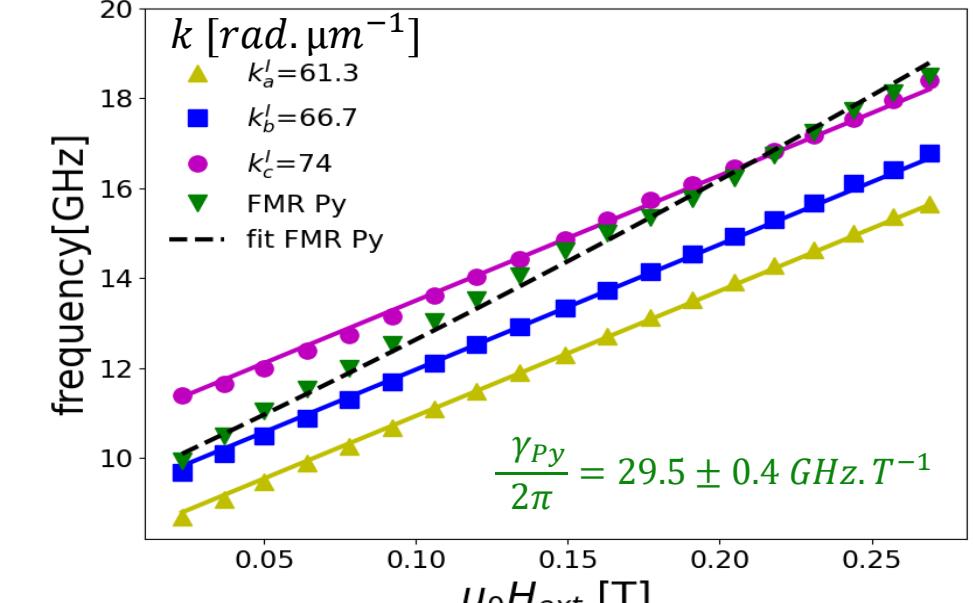
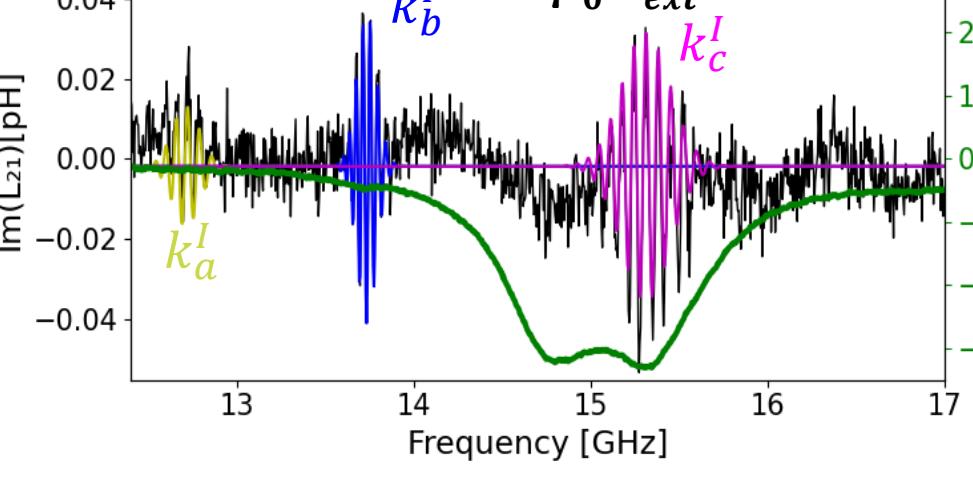
► Field dependence of modes features (A, f_{res}, f_{osc})

Fitting ΔL_{ij} with: $A \exp\left(\frac{(f-f_{res})^2}{\sigma^2}\right) \cos\left(\frac{2\pi}{f_{osc}}(f-f_{res}) + \varphi\right)$

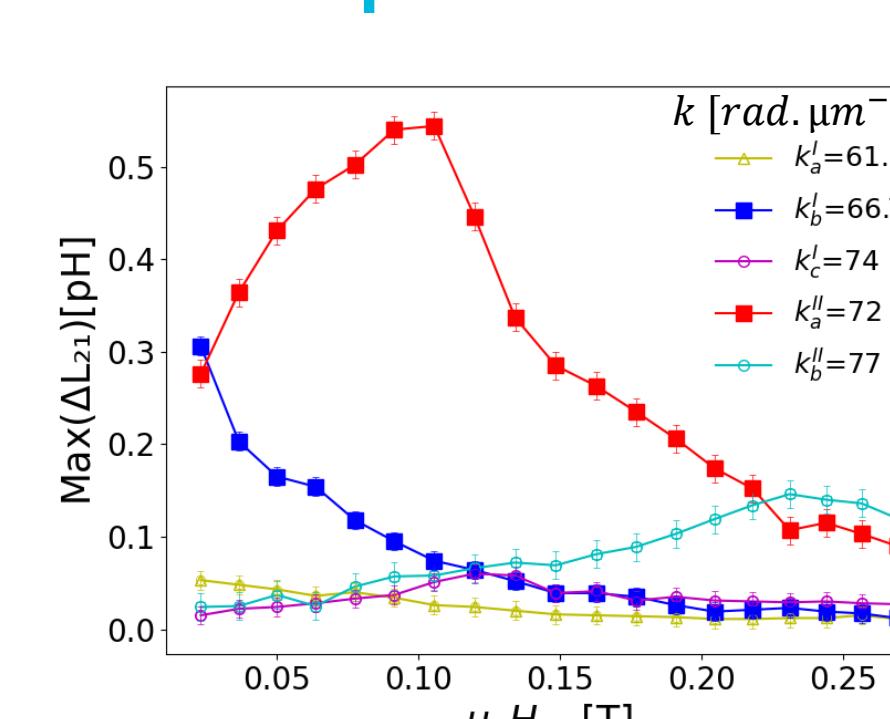
Device I (w=300nm, a=500nm)



Device II (w=200nm, a=400nm)



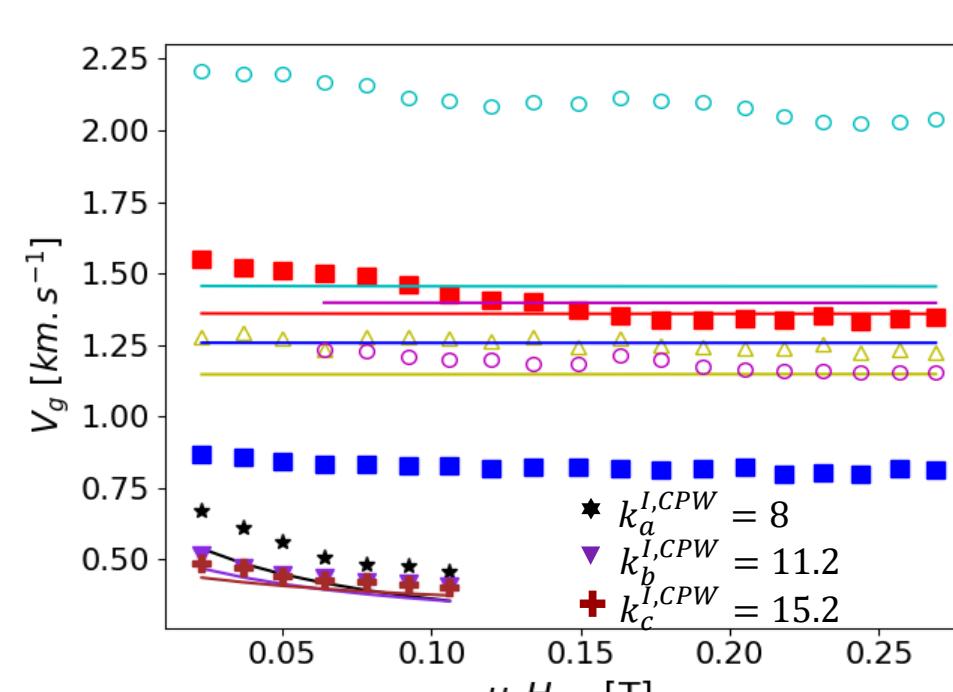
► Field dependence of the amplitude for k_{NW} -modes



- Non-monotonous coupling efficiency
→ no estimation of L_{att}
- $\gamma_{Py} > \gamma_{YIG} \rightarrow$ field dependence of the coupling efficiency all the stronger that $f(k_{NW}) \sim f(k_{Py})$

► Group velocity

Marker : from spectra $V_g = D * f_{osc}$; Solid line : from $V_g = d\omega/dk$



Agreement at lower wavevector, but discrepancies for $V_g(k_{NW})$ due to possible inhomogeneous static field

Conclusions

► Unidirectional transmission of 10μm wide spin wave beams up to $77 \text{ rad. } \mu\text{m}^{-1}$ in [9,20] GHz frequency range

► Miniaturization of NWA complicates the SW spectroscopy analysis : modes selection, non-monotonous coupling efficiency, inhomogeneous static field