Near-Field diffraction of spin waves

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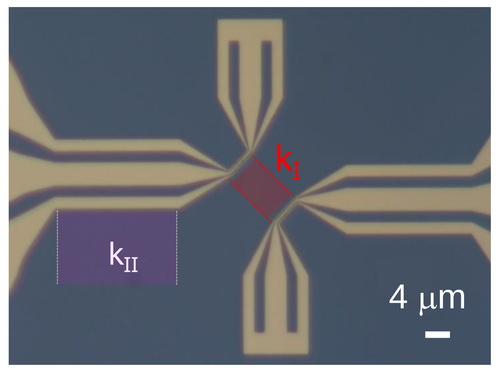
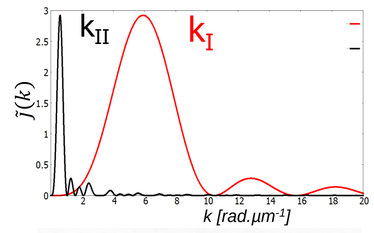
Motivations

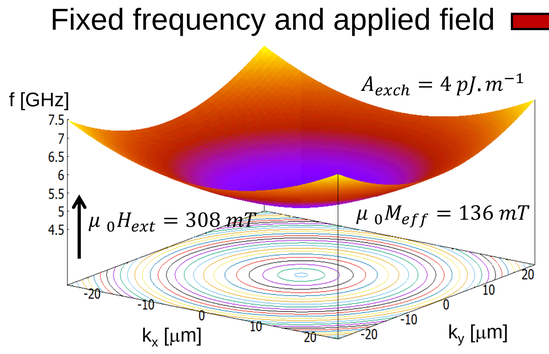
- **Shaping spin wave beams in continuous layers**
  From special design of constricted microwave antennae [1-3]
- **Diffraction model for all spin wave modes**
  Analytical understanding of the spin wave interference mechanisms from Fresnel's near-field diffraction [3]



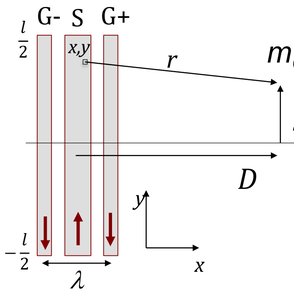


Isotropic out-of-plane modes (MSFVW) [3]

- **Diffraction of isotropic circular waves** (from 3 rectangular apertures)
  Fixed frequency and applied field ➡ **a single resonant k**

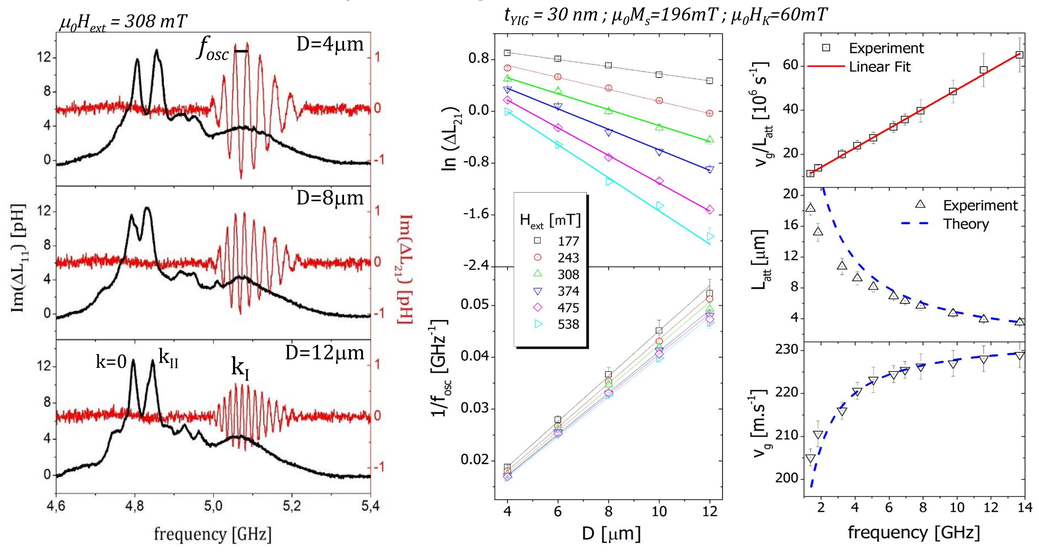


$$\omega(H,k) = \sqrt{(\omega_H + \eta k^2)(\omega_H + \eta k^2 + \omega_M P(k))}$$
$$P(k) = 1 - \frac{1 - e^{-kt}}{kt}$$

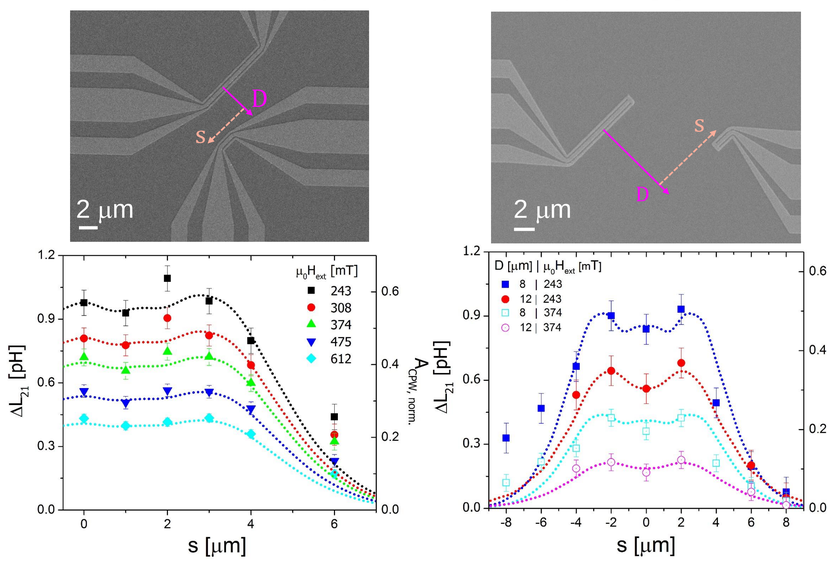


$$\tilde{m}_i(D,s) = \int_{-\frac{l}{2}}^{\frac{l}{2}} dy \int_{-\frac{w_i}{2}}^{\frac{w_i}{2}} dx \frac{1}{\sqrt{r_i}} e^{-\frac{r_i}{L_{att}}} e^{ik\,r_i}$$

- **Spin wave spectroscopy in continuous YIG films**
  No need to structure a spin wave guide



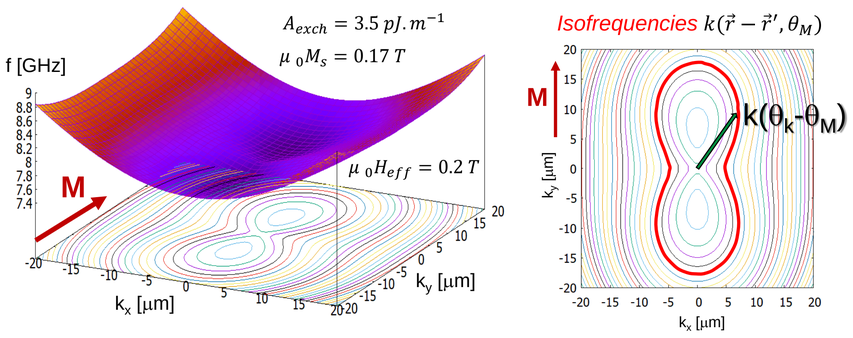
- **Discrete mapping of MSFVW modes**
  Via inductive technique with a smaller probe [3]



Near-field diffraction model for in-plane modes

- **Anisotropic dispersion**
  Each direction (θ_k) corresponds to a distinct ***k*** [4]

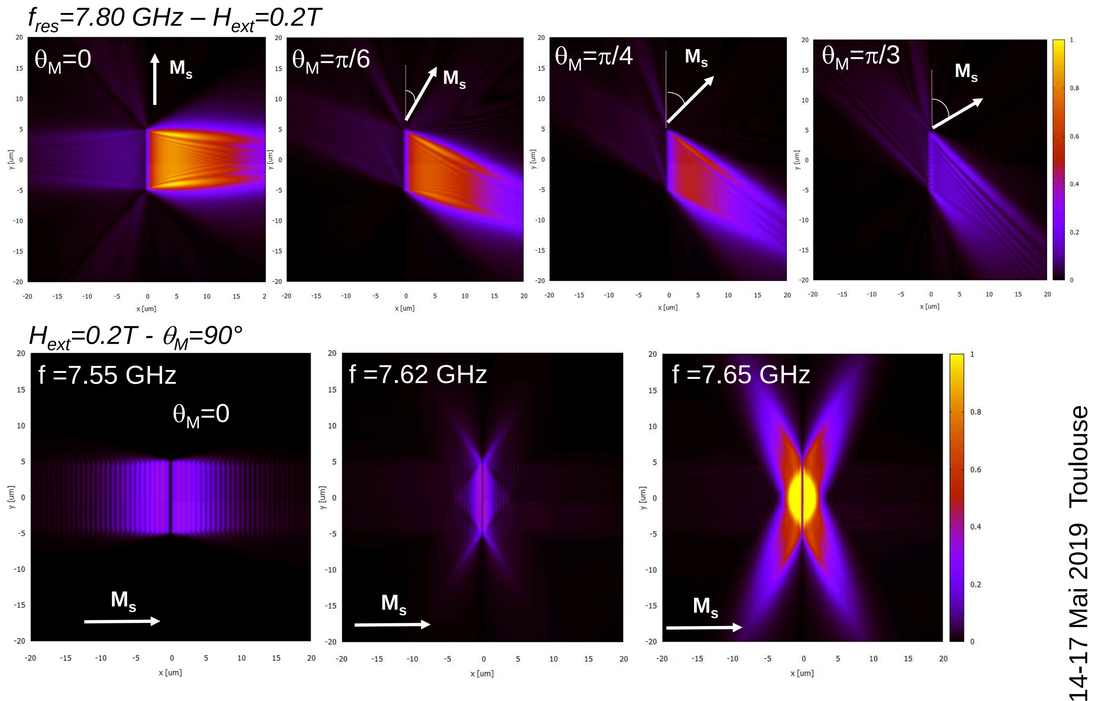
$$\omega(H,k,\theta_M,\theta_k) = \sqrt{(\omega_H + \eta k^2)(\omega_H + \eta k^2 + \omega_M F(k,\theta_k,\theta_M))}$$
$$F(H,k,\theta_k,\theta_M) = 1 - P\cos^2(\theta_k - \theta_M) + \frac{\omega_M P(1-P)}{\omega_H + \eta k^2}\sin^2(\theta_k - \theta_M)$$



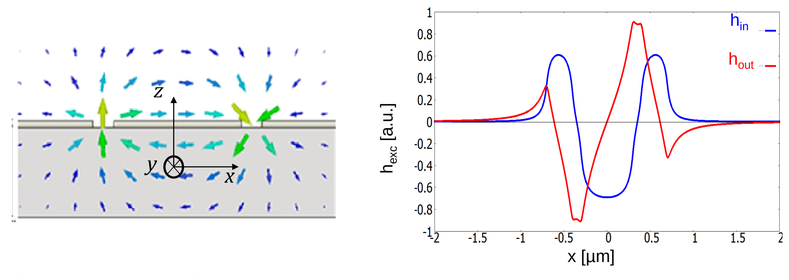
- **In-plane modes diffraction pattern adapted from Eq. 34 of [6]**

$$\tilde{m}(\vec{r},\theta_M) = \int_{-\infty}^{+\infty} dy' \int_{-\infty}^{+\infty} dx' \left\{ \begin{matrix} \aleph_{in}(\vec{r}-\vec{r}').h_{in}(\vec{r}').\cos\theta_M + \\ +\aleph_{out}(\vec{r}-\vec{r}').h_{out}(\vec{r}') \end{matrix} \right\} e^{-\frac{\|\vec{r}-\vec{r}'\|}{L_{att}}} e^{-ik\|\vec{r}-\vec{r}'\|}$$

$$\aleph_{out} = -\omega_M[\omega - (\omega_H + \eta k^2 + \omega_M P(k)\sin^2(\theta - \theta_M))]\ ;$$
$$\aleph_{in} = i\omega_M\left[\omega - \left(\omega_H + \eta k^2 + \omega_M(1 - P(k))\right)\right];$$
$$L_{att} = \frac{2}{\alpha(2\omega_H + \omega_M)}\frac{\partial\omega}{\partial k}(\vec{r}-\vec{r}',\theta_M)$$



- **Both h_{in} and h_{out} excites spin waves [5]**



Conclusions

- **Excellent agreement between a Fresnel approach and micromagnetic simulations for MSFVW**
- **Spin wave spectroscopy in continuous layers possible with sharply constricted antenna**
- **Near-field diffraction model for in-plane modes to be validated with micromagnetic simulations**

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