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Near-Field diffraction of spin waves

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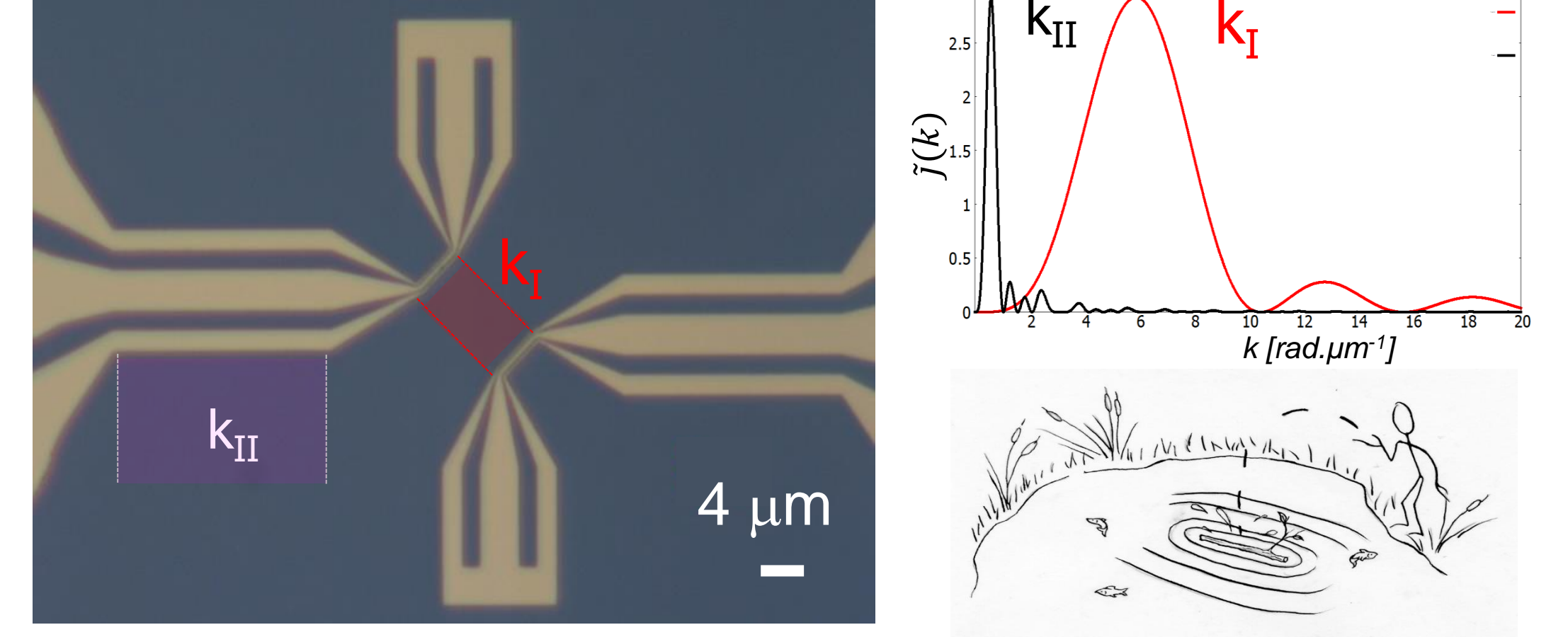


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Near-field diffraction of spin waves

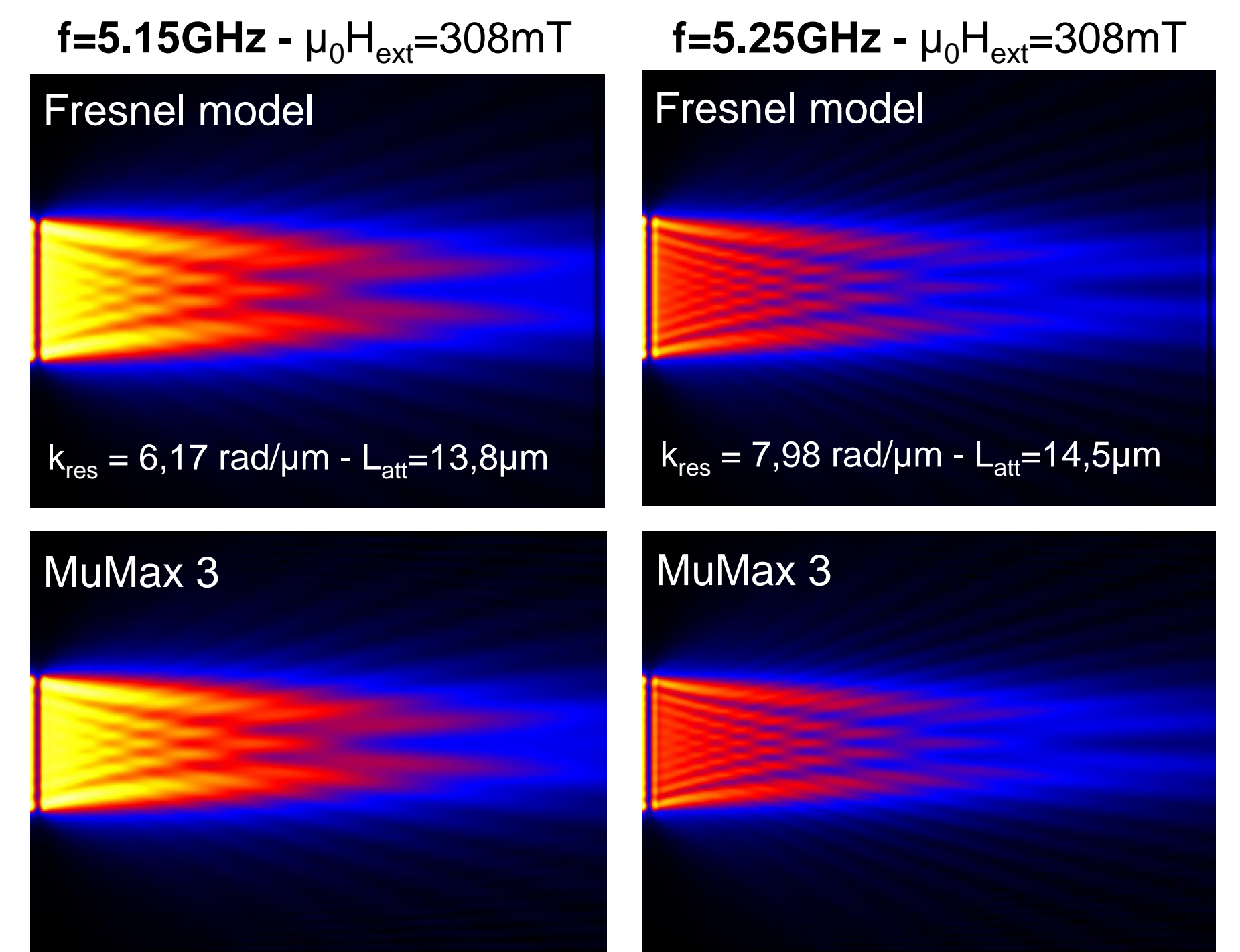
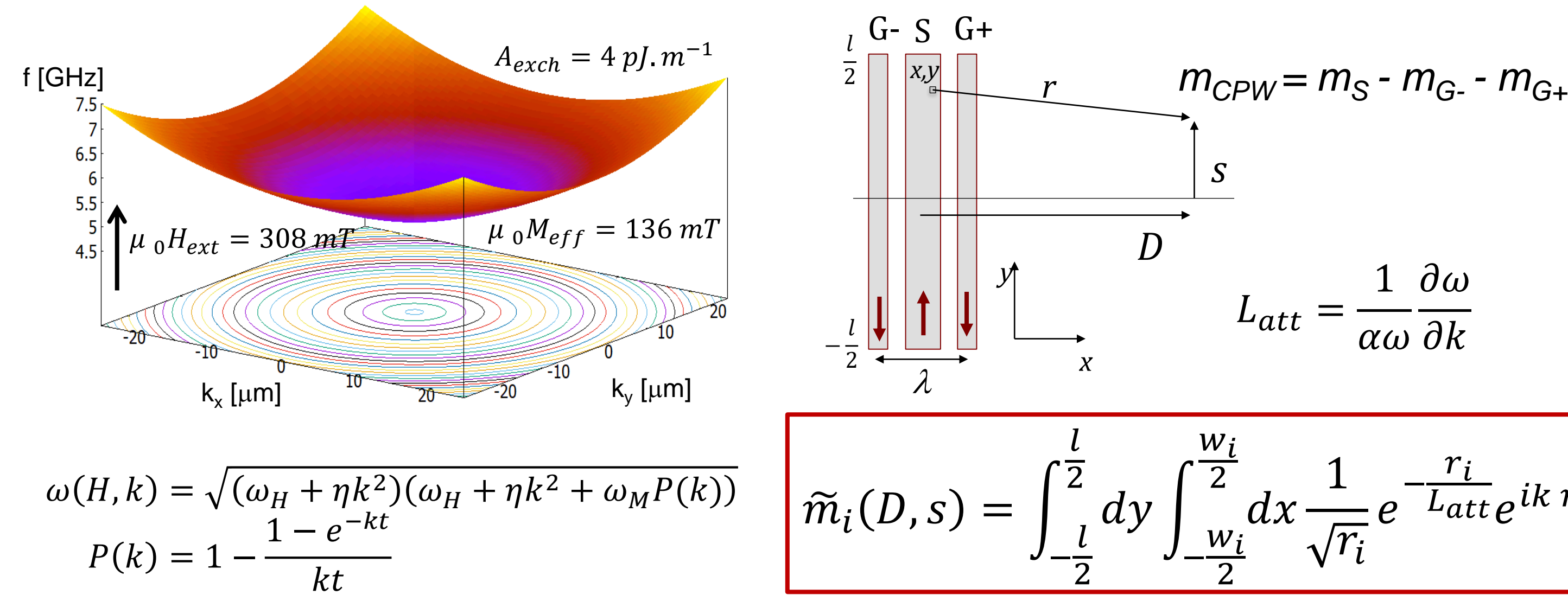
Motivations

- ▶ **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]



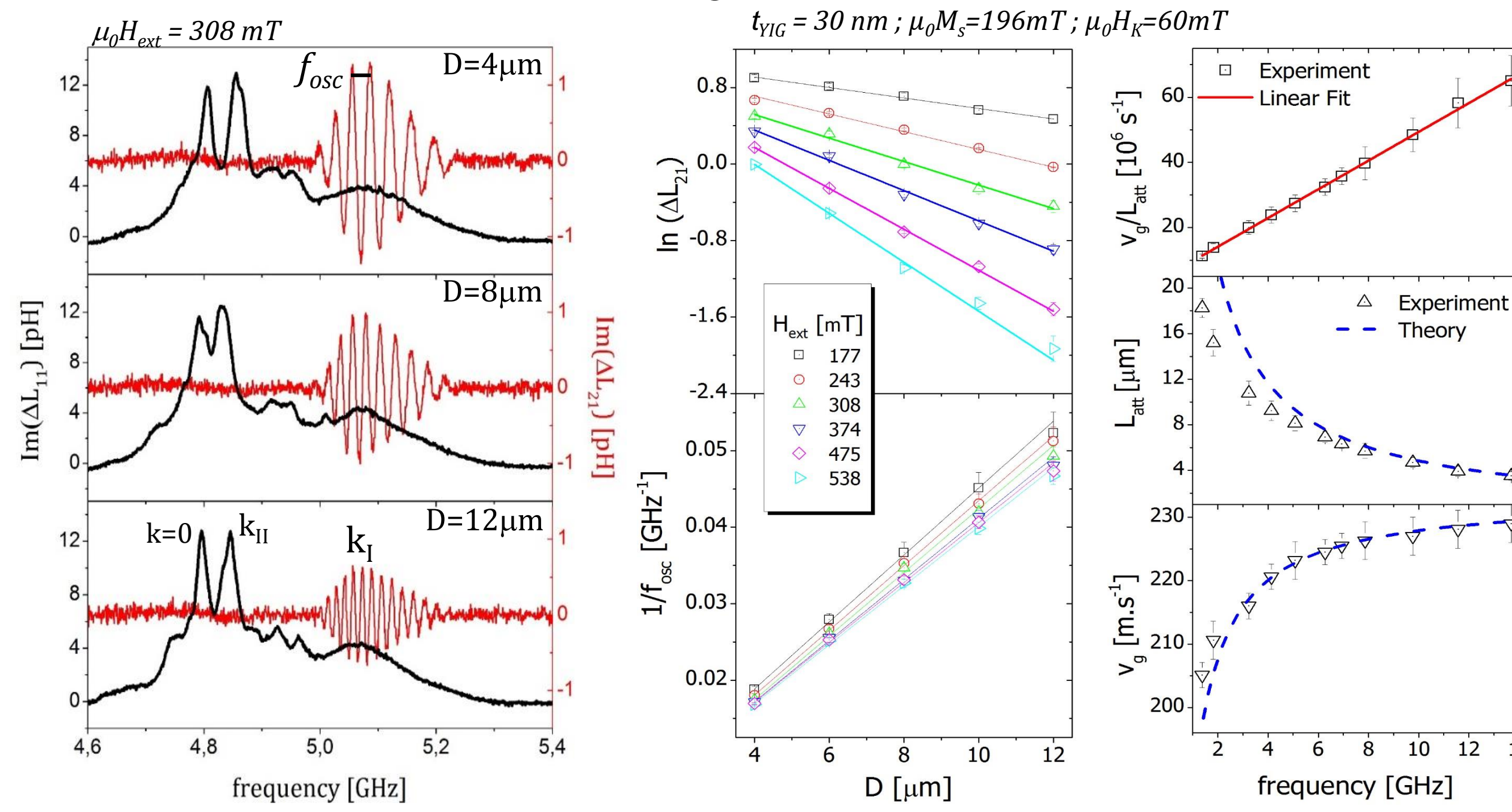
Isotropic out-of-plane modes (MSFVW) [3]

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



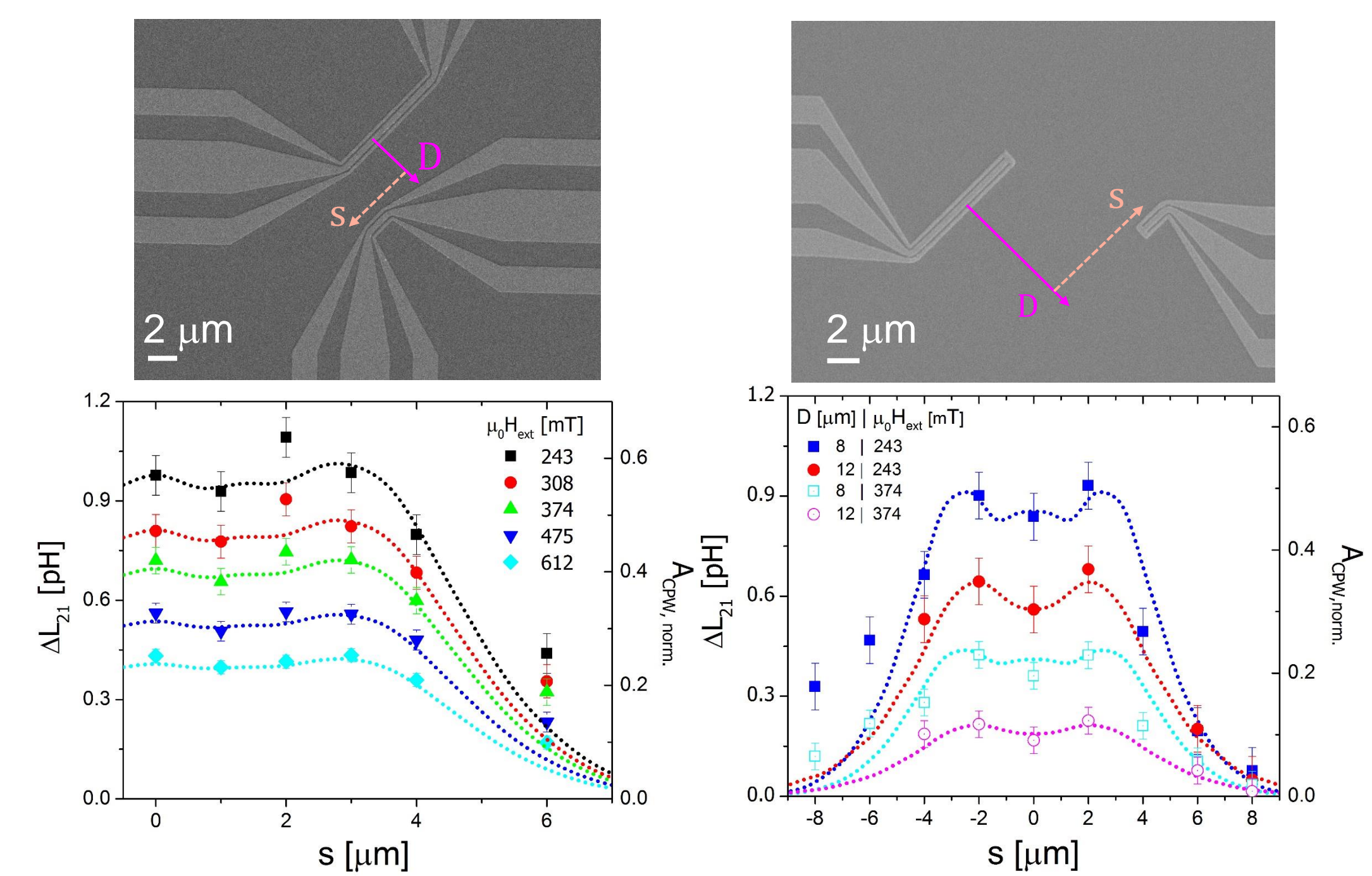
- ▶ **Spin wave spectroscopy in continuous YIG films**

No need to structure a spin wave guide



- ▶ **Discrete mapping of MSFVW modes**

Via inductive technique with a smaller probe [3]

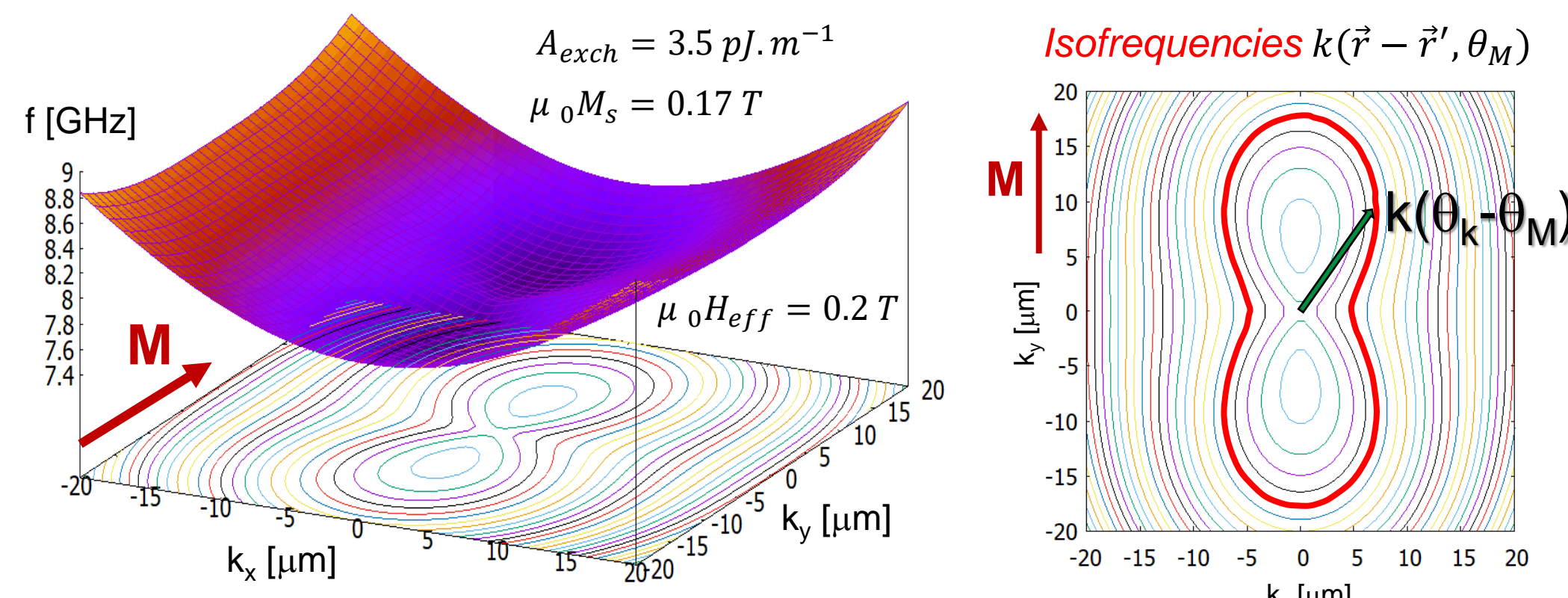


Near-field diffraction model for in-plane modes

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

$$\omega(H, k, \theta_M, \theta_k) = \sqrt{(\omega_H + \eta k^2)(\omega_H + \eta k^2 + \omega_M F(k, \theta_k, \theta_M))}$$

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

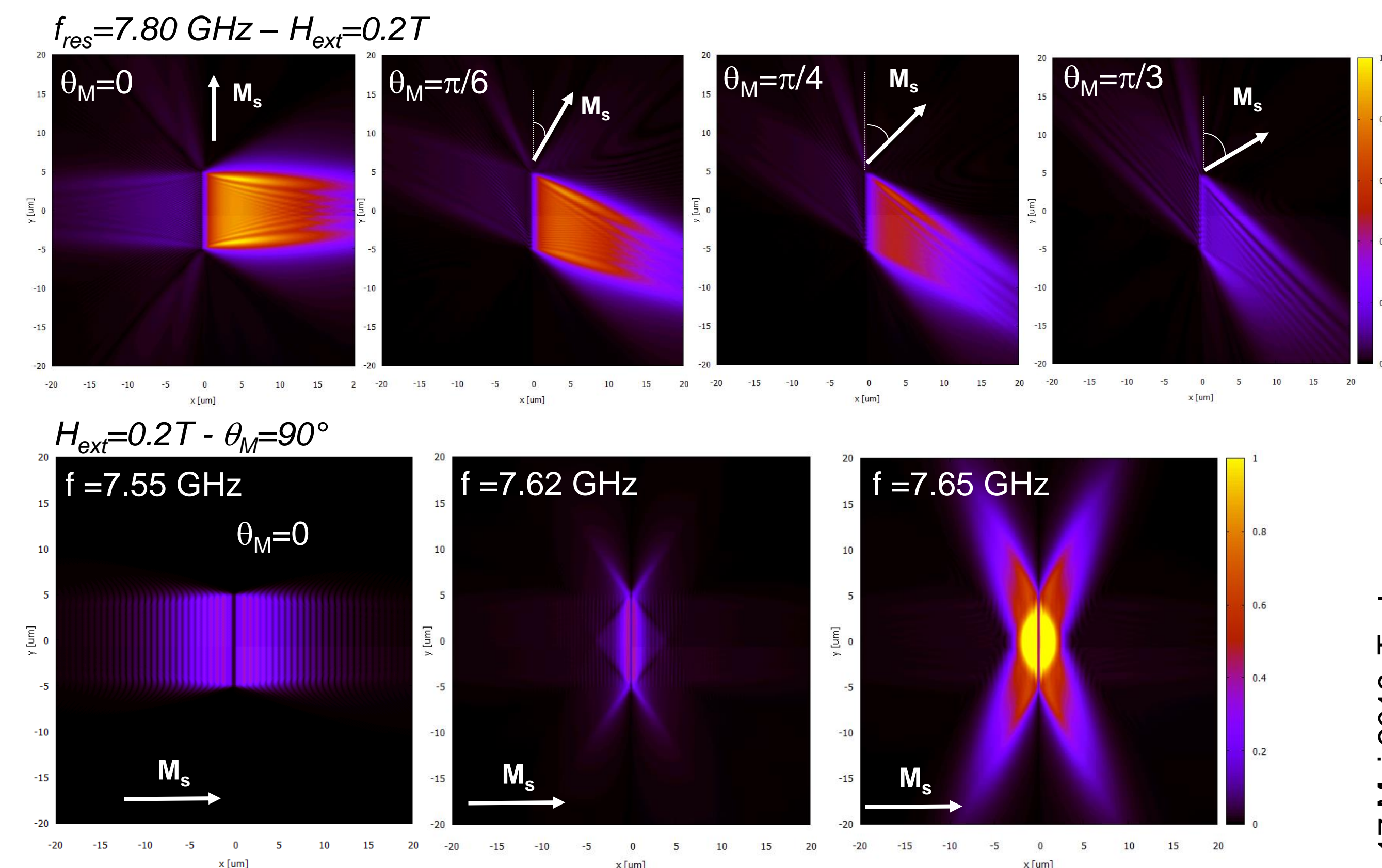


- ▶ **In-plane modes diffraction pattern adapted from Eq. 34 of [6]**

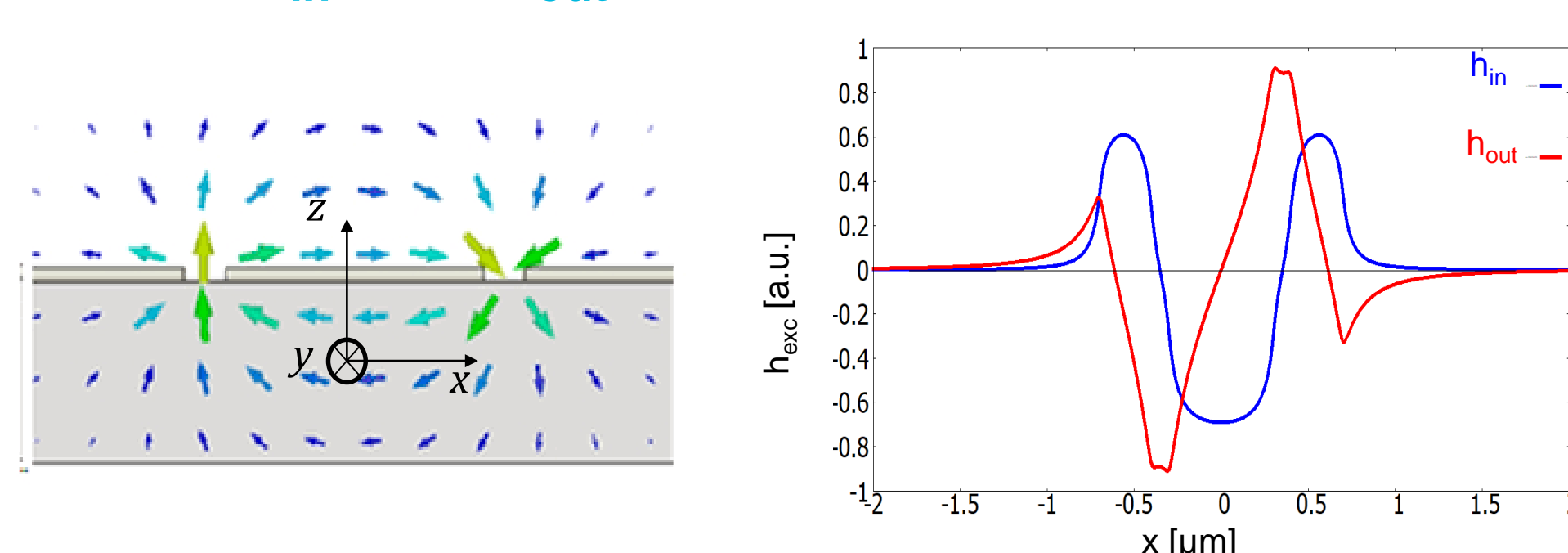
$$\tilde{m}(\vec{r}, \theta_M) = \int_{-\infty}^{+\infty} dy' \int_{-\infty}^{+\infty} dx' \left\{ \mathfrak{N}_{in}(\vec{r} - \vec{r}') \cdot h_{in}(\vec{r}') \cdot \cos \theta_M + \mathfrak{N}_{out}(\vec{r} - \vec{r}') \cdot h_{out}(\vec{r}') \right\} e^{-\frac{\|\vec{r} - \vec{r}'\|}{L_{att}}} e^{-ik \|\vec{r} - \vec{r}'\|}$$

$$\mathfrak{N}_{out} = -\omega_M [\omega - (\omega_H + \eta k^2 + \omega_M P(k) \sin^2(\theta - \theta_M))]; \quad L_{att} = \frac{2}{\alpha(2\omega_H + \omega_M)} \frac{\partial \omega}{\partial k}(\vec{r} - \vec{r}', \theta_M)$$

$$\mathfrak{N}_{in} = i\omega_M [\omega - (\omega_H + \eta k^2 + \omega_M(1-P(k)))];$$



- ▶ **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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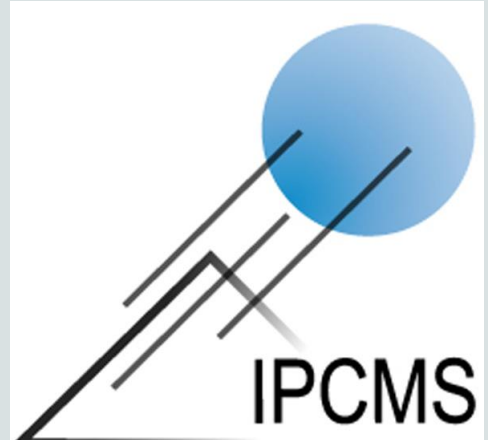
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