Spin wave excitation in magnetic insulators

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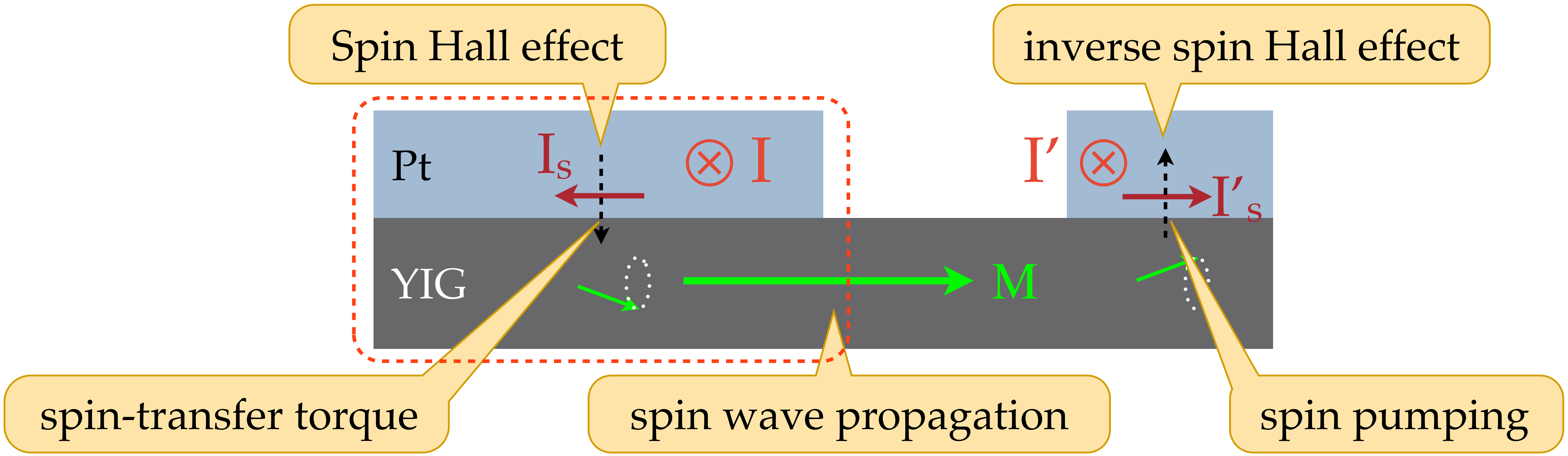
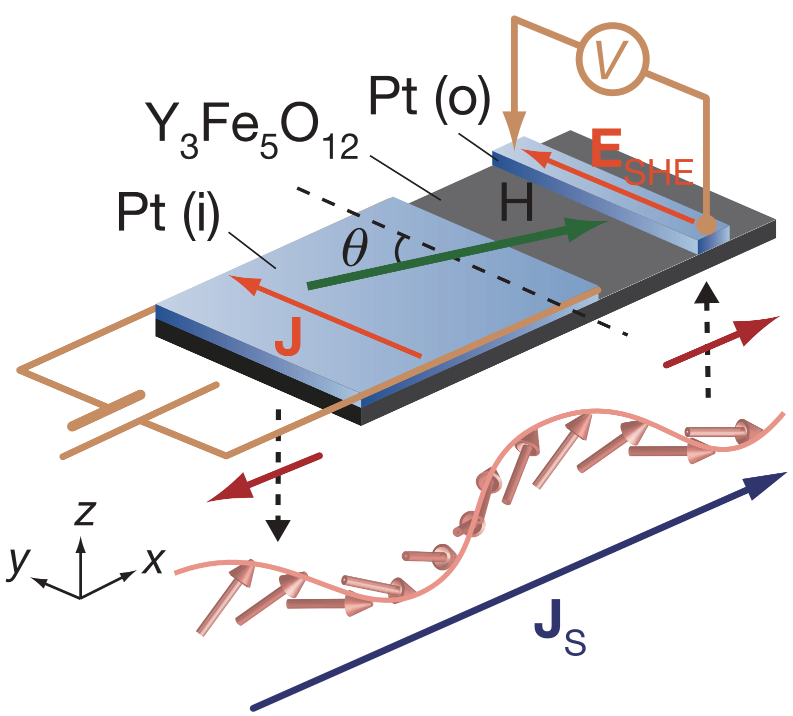
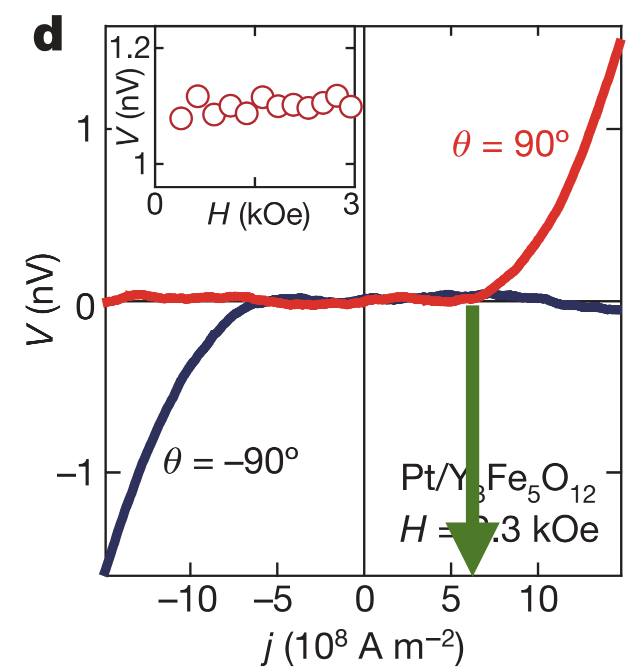
Jiang Xiao and Gerrit E. W. Bauer, *Physical Review Letters* **108**, 217204 (2012)
Yan Zhou, H. J. Jiao, Y. T. Chen, G. E. W. Bauer, and Jiang Xiao, arXiv:1307.7607

Convolution of all effects



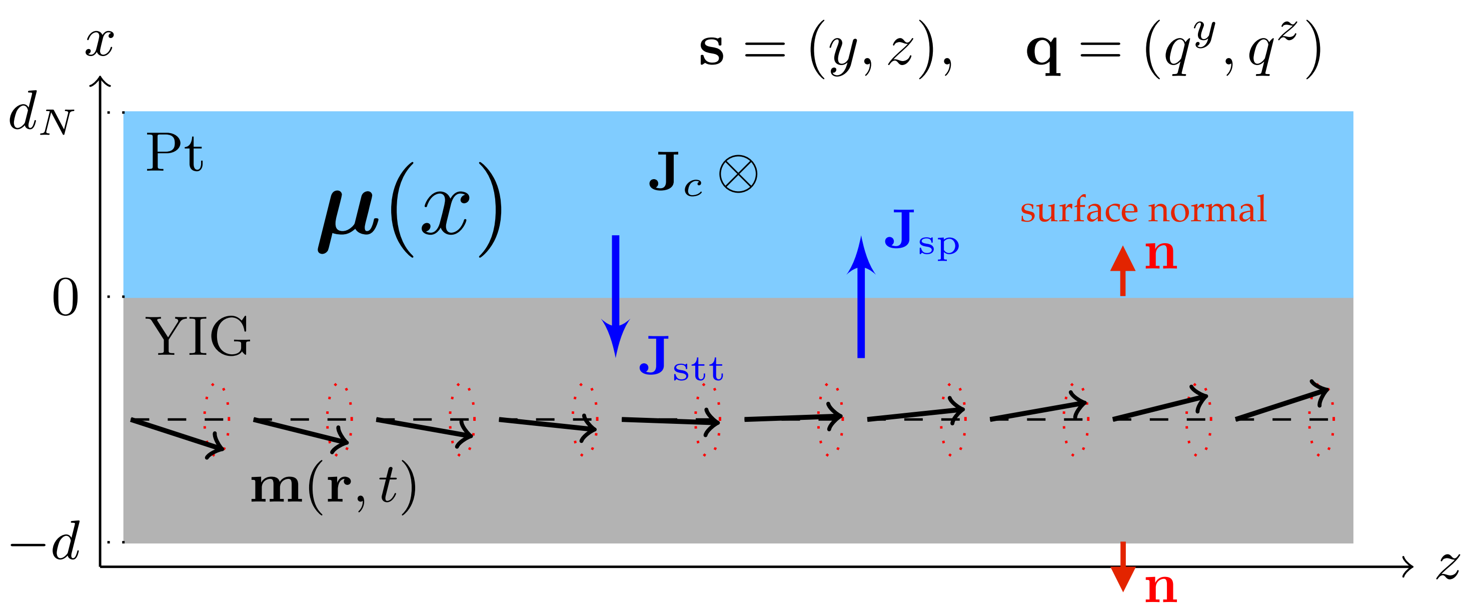




Kajiwara, Y. *et al*. Transmission of electrical signals by spin-wave interconversion in a magnetic insulator. *Nature* **464,** 262–266 (2010).

Model

In Pt, spin diffusion: $\nabla^2 \boldsymbol{\mu}(x) = \dfrac{\boldsymbol{\mu}(x)}{\lambda^2}$



In YIG, Landau-Lifshitz-Gilbert equation:

$$\dot{\mathbf{m}} = -\gamma\ \mathbf{m} \times \left[\mathbf{H}_0 + \frac{A_{\mathrm{ex}}}{\gamma} \nabla^2 \mathbf{m} + \mathbf{h} \right] + \alpha\ \mathbf{m} \times \dot{\mathbf{m}}$$

anisotropy and external field

exchange field

dipolar field: Maxwell eqs.

boundary conditions:

1) spin current vanishes at top surface of Pt at x = d_N

2) spin current is continuous at the Pt | YIG interface

3) spin current vanishes at the bottom YIG surface at x = -d

$$\mathbf{m}(\mathbf{r}, t) = \mathbf{m}_z + \mathbf{m}_\perp e^{i(\omega t - \mathbf{q}\cdot\mathbf{s})}$$

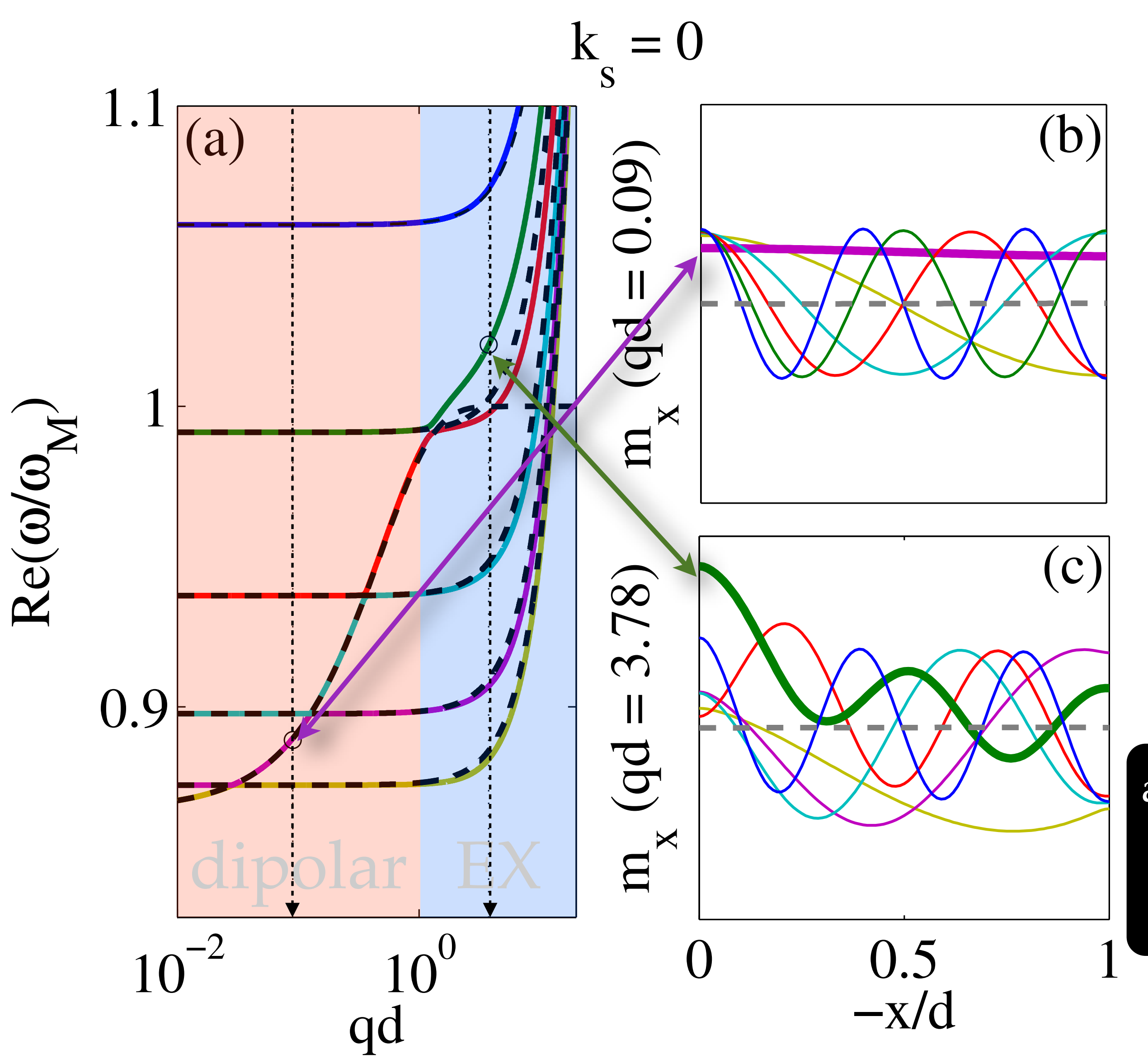
complex dispersion: $\omega(\mathbf{q}, k_j)$

criteria for excitation:

$$\mathrm{Im}\,(\omega(\mathbf{q}, k_j)) < 0$$

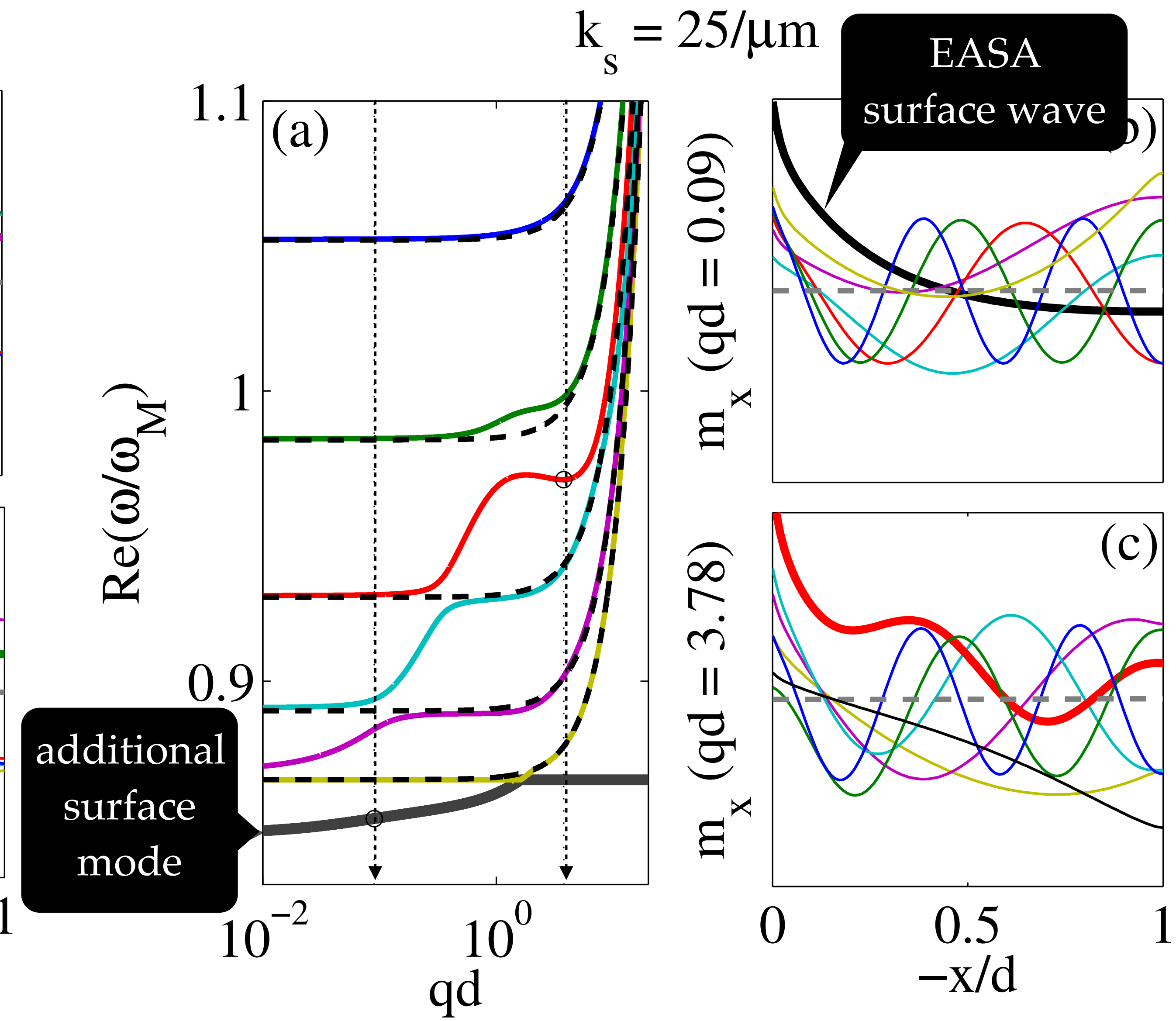
Spin wave dispersion Re(ω) & profile

No surface anisotropy



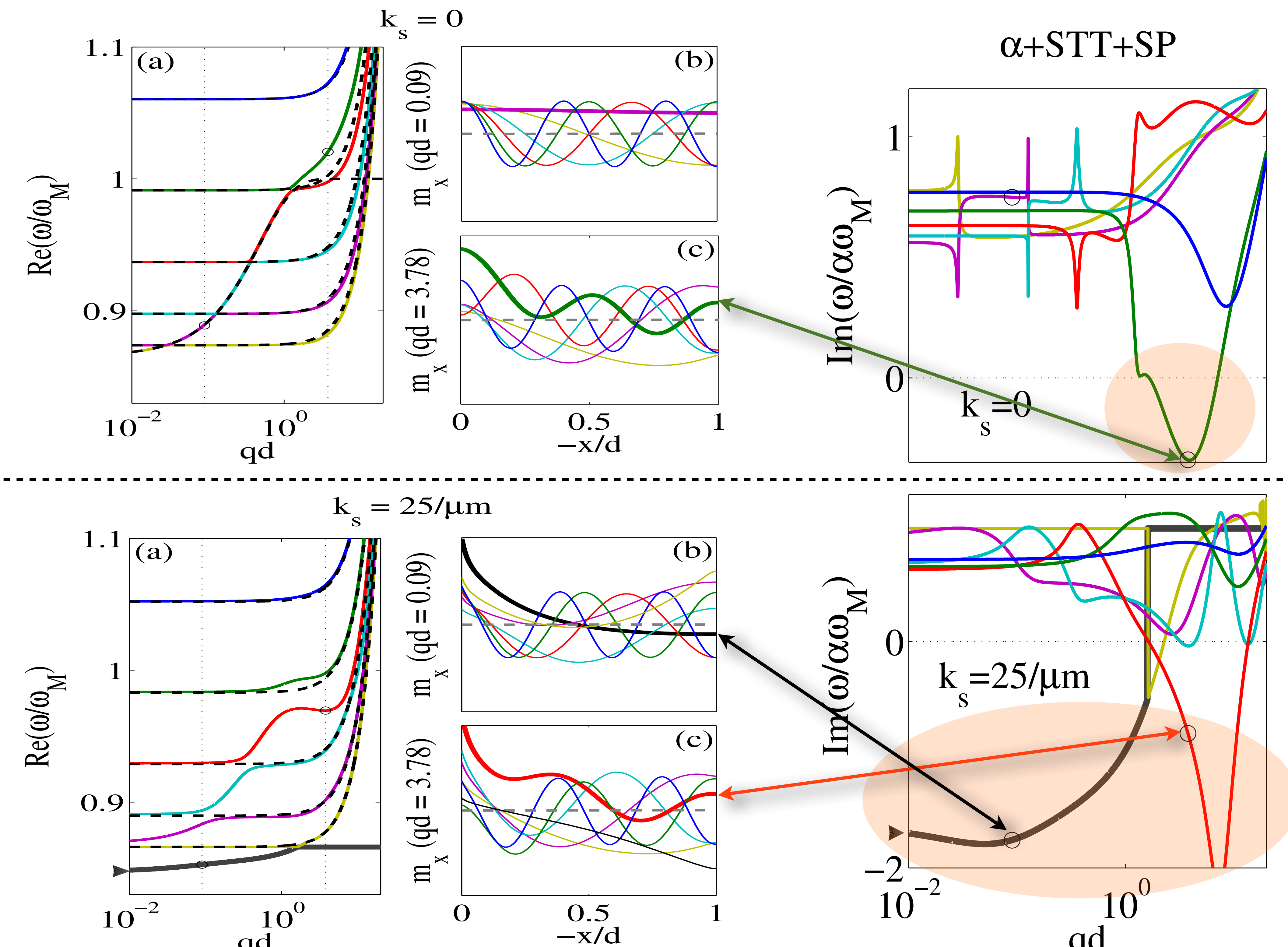
q ⊥ m

Easy axis surface anisotropy (EASA)



q ⊥ m

Spin wave dissipation: Im(ω)



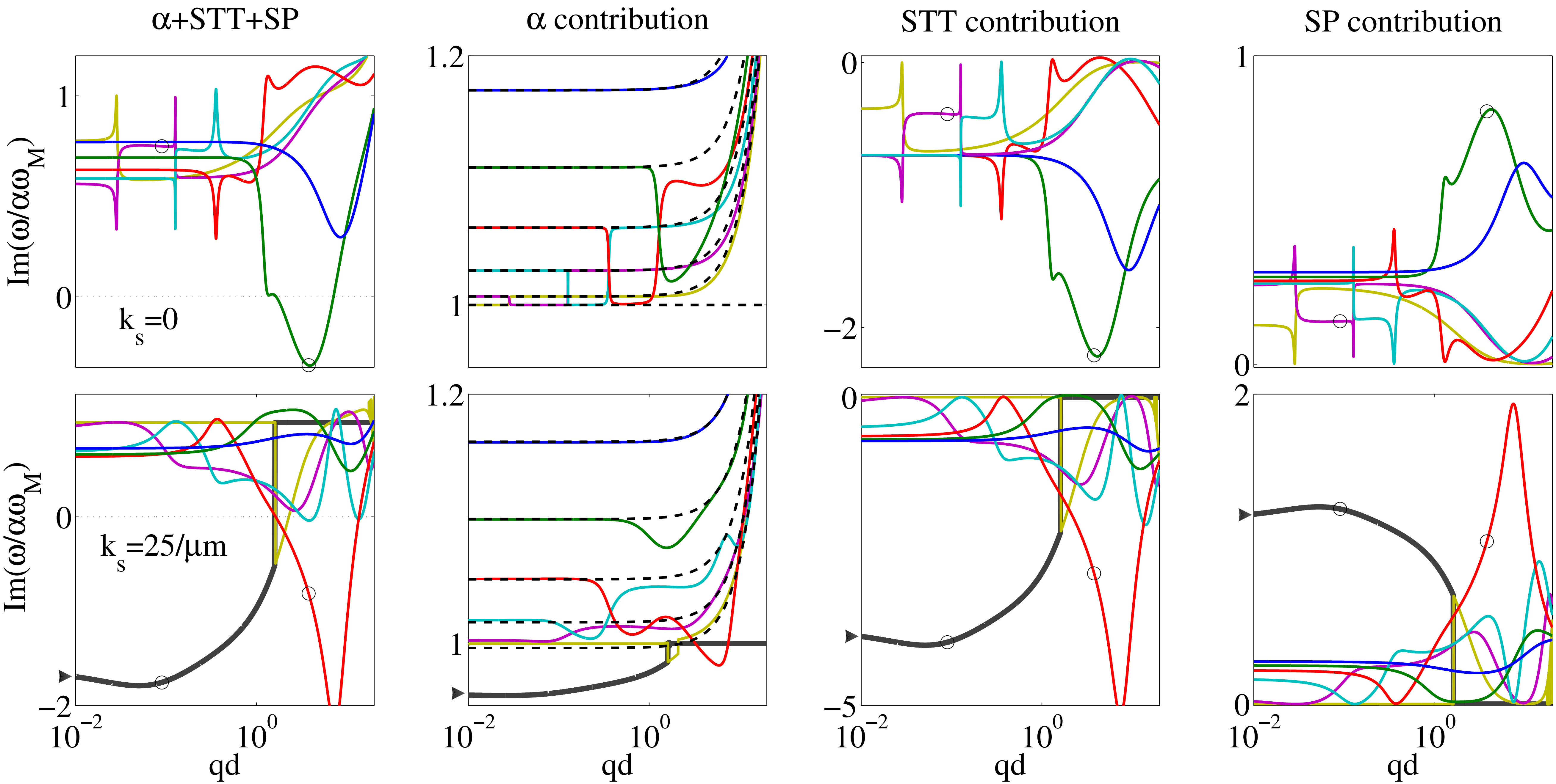
No surface anisotropy

$J_c = 2.3 \times 10^{11}\,\mathrm{A/m^2}$

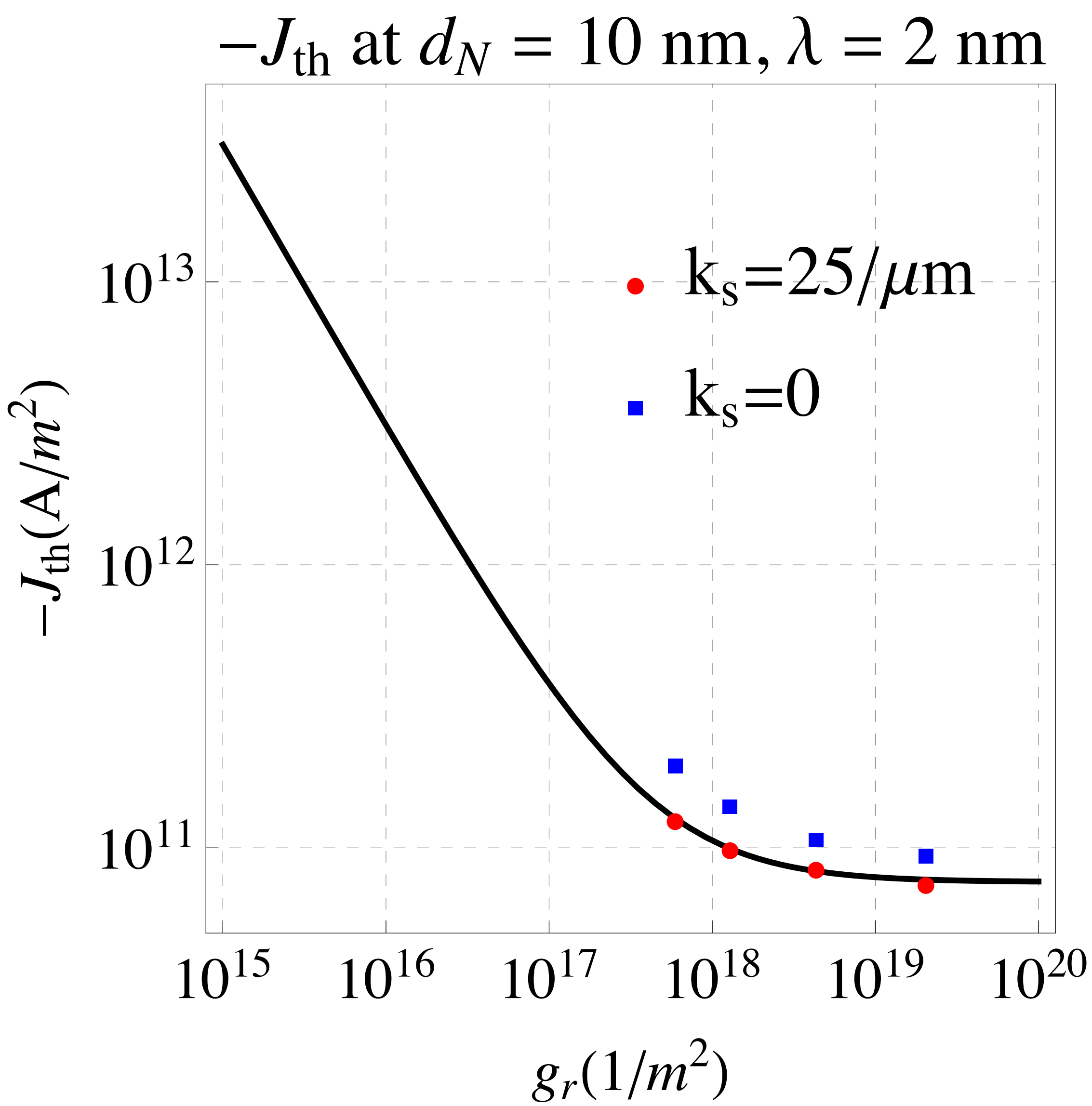
Easy axis surface anisotropy (EASA)

Different contribution to dissipation

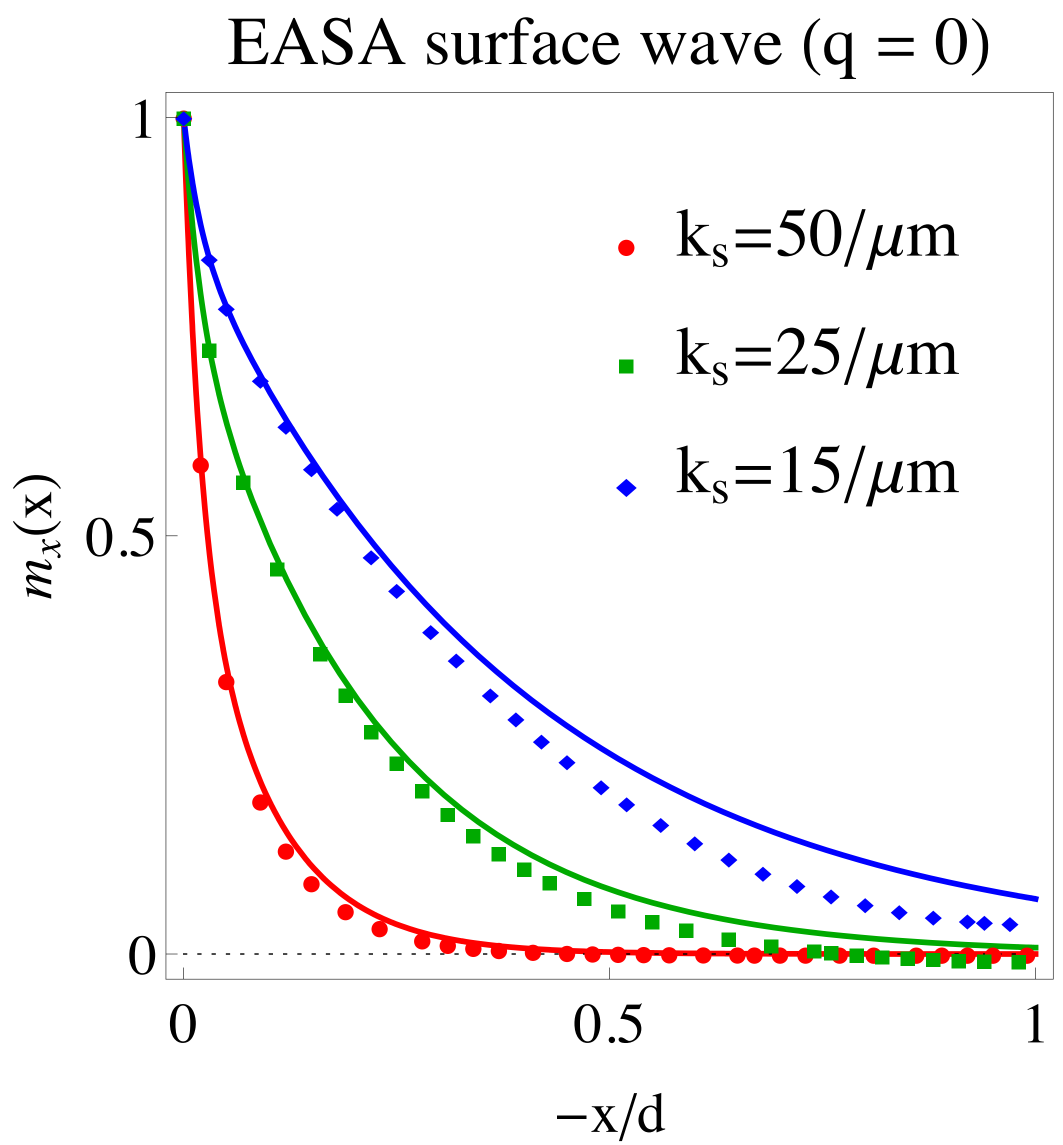
In linear response, different mechanisms (Gilbert damping, spin-transfer torque, spin pumping) for spin wave dissipation are additive.



EASA surface spin wave & threshold current



The threshold current for exciting EASA surface wave.



EASA surface wave profiles for different strength of k_s.

Excitation power