

# Multi-physical Simulation of Magnetoelastic coupling

Realize that the built-in solid module and the micromagnetic module which our research group developed couple with each other in time domain and frequency domain.

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## Introduction

Spin wave is the information carrier in spintronics, while elastic wave is also the information carrier in acoustics. Originating from spin-lattice interaction at the quantum scale, spin wave and elastic wave are coupled by magnetoelastic interactions at the classical scale. When the wavelength and

frequency of the two waves match at the strongly coupled region, elastic waves can significantly excite spin wave resonance (SWR). (Ref. 1)

## Methodology

The free energy density of magnetoelastic coupling for cubic lattice is

$$E_{me} = b_1 \sum_i m_i^2 S_{ii} + b_2 \sum_{i \neq j} m_i m_j S_{ij}, \quad S_{ij} = \frac{\partial u_i / \partial x_j + \partial u_j / \partial x_i}{2}$$

The magnetic moments of the nanowire is modeled using LLG equation:

$$\frac{d\mathbf{m}}{dt} = -\gamma \mathbf{m} \times \mathbf{H}_{eff} + \alpha \mathbf{m} \times \frac{d\mathbf{m}}{dt}$$

The deformation of the nanowire is modeled using elastic equation of motion

$$\rho \frac{d^2 \mathbf{u}}{dt^2} = (\lambda + \mu) \nabla (\nabla \cdot \mathbf{u}) + \mu \nabla^2 \mathbf{u} + \mathbf{F}_{eff}$$

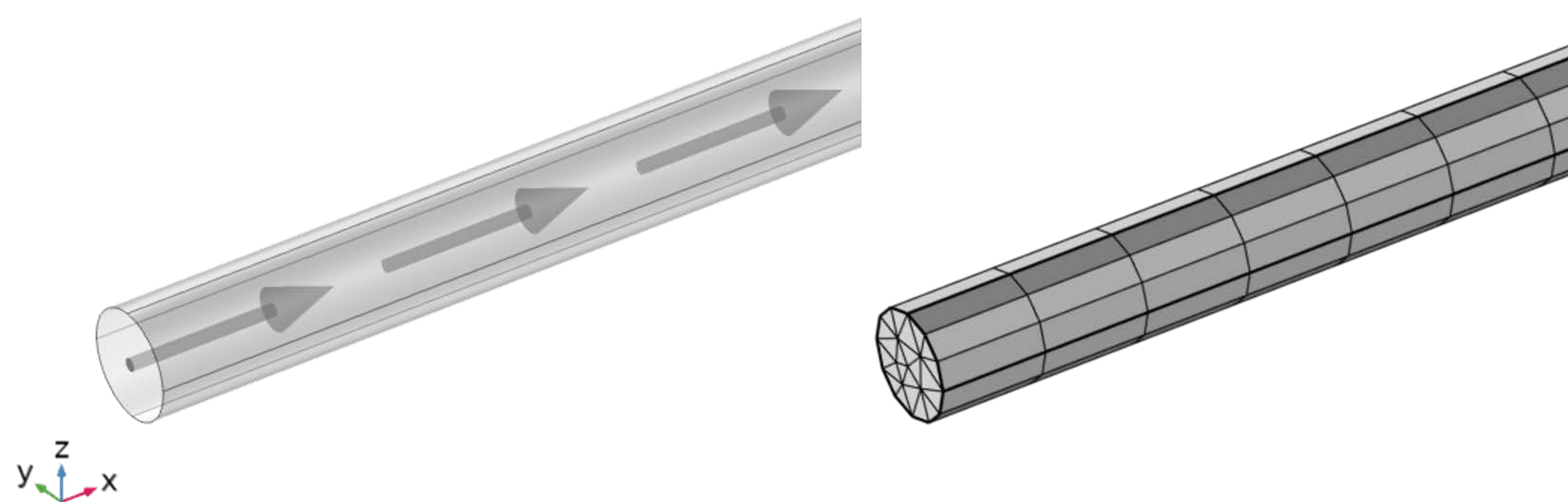
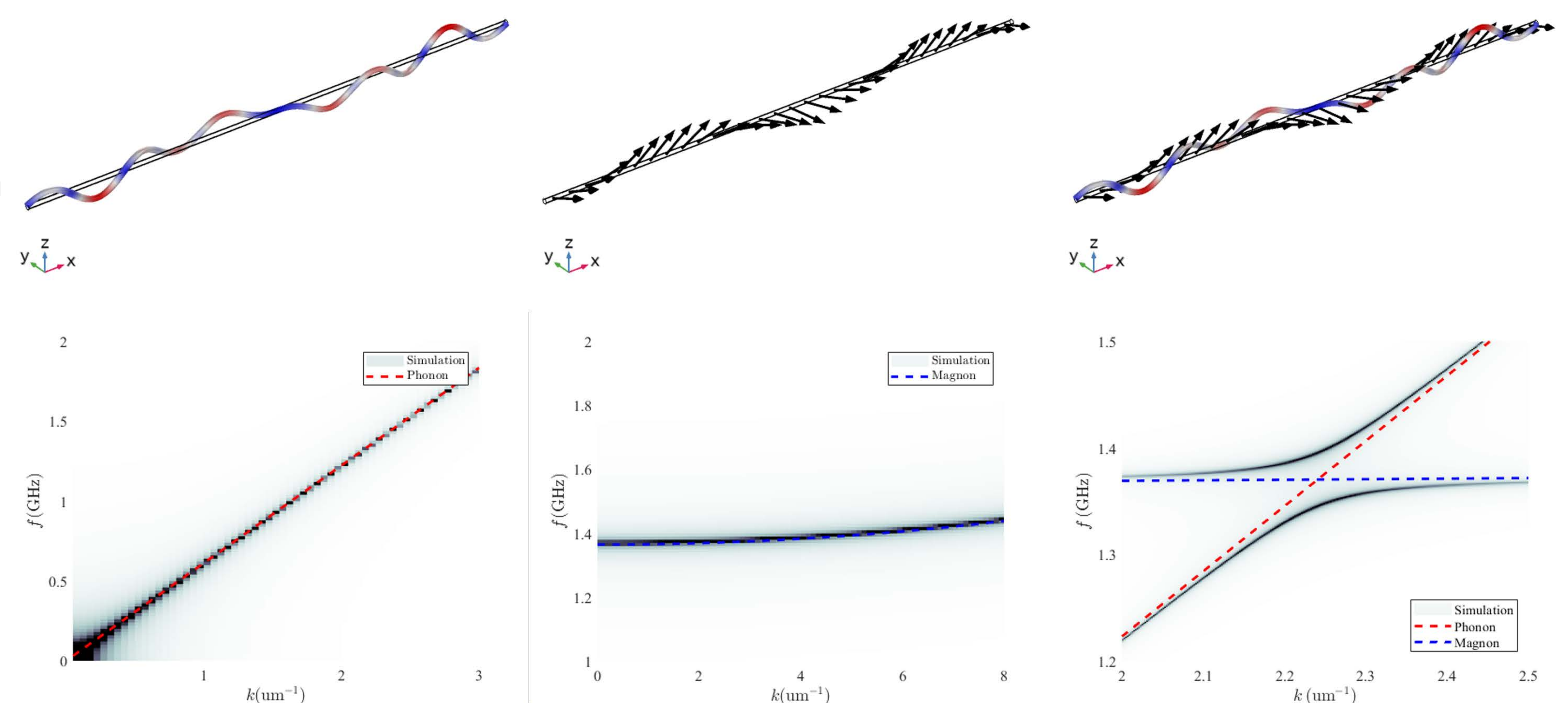


FIGURE 1. Left: Magnetic nanowire. (Black arrows represent magnetic moments) Right: Net of the bottom and side.

## Results

Magnetoelastic coupling leads to the hybridization between elastic wave and spin wave and forming magnon-phonon polaron. There is level repulsion between both dispersion relation at the strongly coupled region with magnetoelastic coupling.

FIGURE 2. Top: The deformation and magnetic moments after excitation at the middle of the nanowire without/with magnetoelastic coupling. Bottom: FFT of dynamic components  $u_y, m_y, m_x$ .



## REFERENCES

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