Magneto-elastic Boundary Conditions

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Ubiquitous excitation in solids, lattice deformation field (phonons), has “spin” when acoustic waves are circularly- or elliptically polarized. Recent experiments have demonstrated ferromagnetic pumping, transport and detection of circularly-polarized phonons by virtue of magneto-elastic coupling (MEC), shining a spotlight on “phonon spins” as a novel information carrier in solids [1, 2]. Yttrium iron garnet (YIG), for example, has an excellent acoustic quality and its characteristic phonon decay length reaches millimeter scales, exceeding by far that of magnon spin current [3].

Here, we derive the governing equations of lattice dynamics in the presence of MEC. The advantage is that the boundary conditions appropriately include magneto-elastic effects, which play an important role in ferromagnetic phonon pumping in submicron-scale devices. The boundary conditions successfully reproduce the strong coupling in the experiment [2] and predict nontrivial angular dependence of phonon pumping by a nanoscale magnetic disk (Fig) [4].

[1] J. Holanda *et al*., Nat. Phys. **14**, 500-506 (2018)

[2] K. An *et al*., Phys. Rev. B (R) **101**, 060407 (2020)

[3] A. Rückriegel *et al*., Phys. Rev. Lett. **124**, 117201 (2020)

[4] T. Sato, W. Yu, S. Streib, G. E. W. Bauer, in preparation.

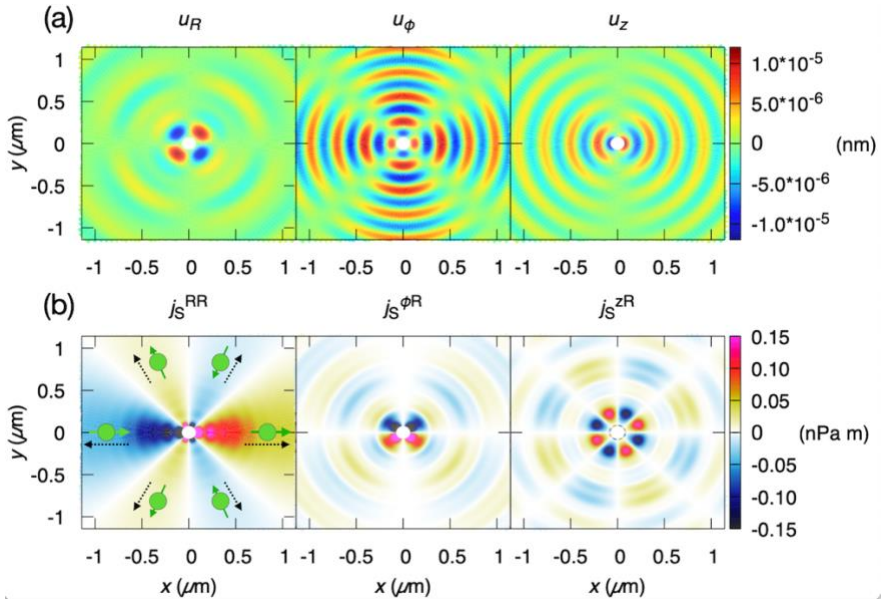

Fig. Spatial profile of the (a) displacement and (b) phonon spin angular momentum current emitted from a magnetic disk at the center (white region). Illustrations in (b, left) indicate spin orientation and propagation.