Micron-sized spherical optomagnonic resonators

E. Almpanis,[1,2] G. P. Zouros,[1,3] P. A. Pantazopoulos,[4] K. L. Tsakmakidis,[1] N. Papanikolaou,[2] and N. Stefanou[1]

[1] *Section of Condensed Matter Physics, National and Kapodistrian University of Athens, Panepistimioupolis, GR-15784 Athens, Greece*

[2] *Institute of Nanoscience and Nanotechnology, NCSR "Demokritos," P. Gregoriou and Neapoleos Str., Agia Paraskevi, GR-15310 Athens, Greece*

[3] *School of Electrical and Computer Engineering, National Technical university of Athens, Athens 15773, Greece*

[4] *Departamento de Física Teórica de la Materia Condensada and Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, E-28049 Madrid, Spain*

Controlling the interaction between visible/near-infrared light and spin waves could enable magnon-based microwave-to-optical transducers appropriate for quantum-computing applications [1], as well as fast and energy-efficient magnetic recording and signal processing technologies [2]. To this end, dual photonic-magnonic, so-called optomagnonic, cavities have recently been attracting increasing interest owing to their ability to simultaneously control photons and magnons and their mutual interaction. Here, on the basis of rigorous numerical calculations, we report on the coupling between spin waves and optical Mie resonances inside a dielectric magnetic spherical particle, which acts as an optomagnonic cavity [3-5]. Such dielectric magnetic particles with diameters of just a few microns support high-Q optical Mie resonances and localized spin waves, providing an ultra-small and compact platform for enhanced modulation of light by spin waves through multi-magnon absorption and emission mechanisms. We also report a thorough theoretical investigation of magnon-assisted photon transitions in such particles, where, matching the intra-band splitting of optical Mie modes (induced by particle magnetization) to the frequency of the Kittel magnon, gives rise to high-efficiency triply resonant optical transitions between these modes via emission or absorption of a magnon. Finally, we provide evidence for significantly increased optomagnonic interaction as compared to similar processes between whispering gallery modes of sub-millimeter spheres, enabled by the reduced magnon mode volume.

References:

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