Strong-coupling phenomena in spintronics

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Traditional spintronic devices control the magnetic order digitally. Magnetic and electric fields, charge, spin, and heat currents, sound, microwaves, light, etc. can write a bit by switching the magnetization of a memory element between the “up” to “down” states. However, new computational classical and quantum architectures require analogue control over the magnetic texture. Ideally, the dynamic magnetization is manipulated coherently to point into any direction on the Bloch sphere, which requires control parameters that strongly couple to the magnetic order, i.e. an interaction strength that exceeds the lifetime broadening. Since magnetic dipoles interact only weakly with the environment, the strong-coupling regime of spintronics can be reached with high-quality materials and devices only.

The material of choice to study the physics and applications of strong coupling is yttrium iron garnet (YIG), an electrically insulating ferrimagnet with a Curie transition far above room temperature. Its record magnetic, acoustic and optical quality led already to the discovery of entirely new phenomena, such as the spin Seebeck effect, which raise the hope for new applications in a sustainable future electronics. Due to a decade of a global research effort, we now quantitatively understand much of YIG’s basic physics, such as the temperature-dependent spin dynamics and the interaction of the magnetic order with photons and phonons.

I will present a selection of our recent progress in the physics of YIG and our search for evidence for strong coupling in YIG devices.