# Rare-earth iron garnets: A prototype material system for spintronics and magnonics

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Rare-earth iron garnets $RE_3Fe_5O_{12}$ constitute a fascinating class of materials, which are promising for technological applications in future spintronic devices utilizing pure spin currents. In these magnetically ordered insulators, pure spin currents can be transported by quantized excitations of the spin system without an accompanying charge current. A prominent example is the spin Seebeck effect (SSE), which describes the generation of electric signals by spin currents driven across a magnetically ordered insulator (MI)/heavy metal (HM) interface by a temperature gradient. It is widely accepted that the thermopower measured in such MI/HM bilayers in the longitudinal SSE geometry are indeed a consequence of magnonic spin currents generated by a temperature gradient. However, interface and bulk contributions to the SSE are still a matter of debate. To further clarify this point, we will discuss the SSE in ultra-thin $Y_3Fe_5O_{12}$ (YIG)/Pt bilayers with a YIG thickness varying between 1 and 5 unit cells. The measured SSE voltage as a function of the YIG thickness clearly shows that the SSE is mainly caused by bulk magnonic spin currents. This is further confirmed by the temperature dependence of the SSE signal in $RE_3Fe_5O_{12}$/Pt bilayers based on compensated rare-earth iron garnet $RE_3Fe_5O_{12}$ ($RE$=Gd, Tb, Dy, and Er) thin films and single crystals. In particular, in these $RE_3Fe_5O_{12}$/Pt bilayers a gradual sign change of the SSE signal is observed at low temperatures (see Fig. 1), which was attributed to competing magnon modes with different chirality [1]. However, using inelastic neutron scattering with polarization analysis we show that in $RE_3Fe_5O_{12}$ garnets with trivalent $RE$-ions with finite orbital momentum crystal field effects play an important role at low temperatures [2].

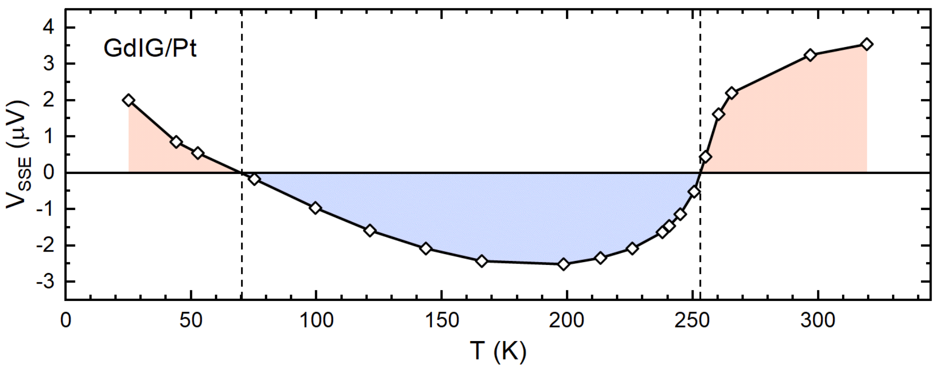


Fig.1: Temperature-dependent spin-Seebeck voltage in $Gd_3Fe_5O_{12}$(GdIG)/Pt bilayers. The two observed sign-changes are marked by vertical dashed lines.

[1] S. Geprägs *et al.*, Nature Communications **7**, 10452 (2016).

[2] B. Tomasello *et al.*, Annals of Physics **447**, 169117 (2022).