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In-situ Measurement of the spin Sebeeck Effect with Polarised Neutron Reflectivity

The spin Seebeck effect – generation of a spin polarised current in a magnetic material subjected to a temperature gradient – is a magnetothermal effect that could be used for generation of pure spin currents for spintronic applications. It is most often detected indirectly by placing a heavy metal such as Pt in contact with the magnet and measuring the voltage generated by the inverse spin Hall effect. This is, however, plagued by artefacts such as the anomalous Nernst effect (ANE), or proximity induced ANE and there are outstanding questions with regards to the influence of the interface on the detected voltage. In addition, recent work has shown an enhancement of the measured 'spin Seebeck voltage' for multilayer films that could be a result of enhanced magnon propagation[1], or a change in the ANE contribution to the measured voltage.

Polarised neutron reflectometry (PNR) can be used to directly probe the magnetism of thin films as a function of depth, which makes it a possible route to directly observe the spin Seebeck effect. The challenges with this technique, however, lie in the development of a sample environment that can maintain a suitable temperature gradient, whilst not distorting the sample, or introducing temperature dependent or time varying artefacts. We will show development of a thermal cell for PNR measurements of potential spin Seebeck multilayers, where we observe evidence of a change in magnetisation profile - as measured by the spin asymmetry - when a temperature gradient is applied (Figure 1).

[1] R. Ramos et al., Phys. Rev. B 92, 220407(R) (2015)

Figure 1 – PNR data obtained for a multilayer {Fe3O4:Au} film using the in-situ thermal cell. (a) Raw data for dT = 0K, and dT = 80K. (b) Corresponding spin asymmetry.

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