# Exploiting Polarised neutron and X-ray synergies to reveal magnetic structure and dynamics in spin caloritronics

Danny Mannix[1*], Paul Evans[2], Deepankar Sri Gyan[2], Ni Li[2], Jack Thomas-Hunt[3], Joerg Strempfer[4], Bruno Tomasello[5], Tim Ziman[6], Stephan Geprägs[7]

[1]ESS, Lund, Sweden
[2]University of Wisconsin, Madison, WI. USA.
[3]Aarhus University, Aarhus, Denmark .
[4]APS, Argonne, USA.
[5] University of Kent, Canterbury, UK.
[6]ILL, Grenoble, France.
[7]Walther Meissner Institute, Munich, Germany.
*Email: dan.mannix@ess.eu

Spin caloritronics are currently a science highlight due to their potential exploitation in the next generation of spintronics applications. This class of materials combine both spintronic and thermoelectric functionalities by interconversion of charge, spin, and heat currents. A prominent example is the spin Seebeck effect, where the generation of a net spin current is understood in terms of thermal excitation of chiral magnons and converted into a charge current by the inverse spin Hall effect [1]. We will present detailed insights into the physics of the spin caloritronic compounds, $Gd_3Fe_5O_{12}$ and $Tb_3Fe_5O_{12}$, by exploiting the synergies of the preeminent microscopic probes of polarised neutron and X-ray scattering. Polarised inelastic neutron scattering and RIXS experiments identify the chiral magnons involved in the SSE thermoelectric conversion. Polarised X-ray ptychography imaging brings to light subtle details a nanoscale spin texture, that can degrade the efficiency of SSE. Finally, ultrafast pump-probe experiments, combined with polarised resonant X-ray scattering, have been used to characterise timescales of heat currents involved in spin caloritronic heterostructures [2] and open up new possibilities to investigate acoustic wave induced magnetic excitations in thin films, with an energy resolution beyond the current limits of RIXS.

**References**

[1] S. Geprägs et al. Nature Com. 7, 10452 (2016).
[2] D. Sri Gyan, et al. Structural Dynamics No.9 045101 (2022)