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Thermo-Electro-Magnetic Coupling in Functional Composite Materials

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A large fraction of global primary energy is dissipated as waste heat, motivating the search for materials that can directly convert heat to electricity via the Seebeck effect. Tin selenide (SnSe) is a leading thermoelectric candidate due to its ultralow lattice thermal conductivity and favourable electronic structure. Beyond conventional optimisation strategies such as doping or alloying, the incorporation of magnetic nanoparticles offers an alternative pathway to tune transport properties through thermo-electro-magnetic coupling.

We investigate SnSe-Fe₃O₄ nanocomposites as a platform to probe the interplay between electrons, phonons, and magnons in a thermoelectric matrix. Structural and transport characterisation reveal that Fe₃O₄ inclusions can both enhance and suppress performance metrics depending on composition, temperature, and processing history. Time-of-flight inelastic neutron scattering demonstrates pronounced broadening of SnSe optical phonons in the composites, beyond that expected from a simple superposition of the constituent spectra, suggesting additional scattering channels, potentially from phonon-magnon coupling.

In this presentation we highlight the complexity and tunability of multi-quasiparticle interactions in magnetic thermoelectric composites and provide new insights into strategies for controlling coupled thermal, electrical, and magnetic transport.

Author: PORTWIN, Kyle (University of Wollongong)

Co-authors: Mr RAHMAN, Rezoan (University of Wollongong); Dr STAMPER, Caleb (University of Wollongong); Dr YU, Dehong (ANSTO); Dr GALAVIZ, Pablo (ANSTO); CORTIE, David; RULE, Kirrily (Australian Nuclear Science and Technology Organisation); Prof. CHENG, Zhenxiang (University of Wollongong)

Presenter: PORTWIN, Kyle (University of Wollongong)

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