中央大學物理學系

Department of Physics, National Central University

Colloquium

Turning Up the Heat in Spintronics

Prof. Danru Qu (曲丹茹)

Center for Condensed Matter Sciences,

National Taiwan University

Date: 2025/12/16 (Tue)

Venue: S4-625

Time: 14:00

Abstract :

The interplay among heat, spin and charge lies at the heart of spin-caloritronic research. Efficient conversion of heat flow into spin information opens alternative pathways for energy harvesting. In this talk, I will present two of our recent studies that utilize spin currents generated by thermal gradients. In the first work, we investigate intrinsic spin-to-charge conversion in epitaxial ruthenium dioxide (RuO_2) films via the spin current generation from a longitudinal spin Seebeck effect in the ferromagnetic insulator yttrium iron garnet (YIG) [1]. We observe an anisotropic spin-to-charge conversion in RuO_2 only when RuO_2 is epitaxially grown. By comparing three distinct crystal orientations of RuO_2, we attribute the anisotropic behavior to the anisotropic spin Hall effect inherent to the rutile structure, rather than the altermagnetic spin-splitting effect. Our results further demonstrate that the intrinsic spin-to-charge conversion in RuO2 becomes evident only when YIG is used as the spin source. In the second study, we explore transverse heat-to-spin conversion via the spin Nernst effect in NiCu alloys [2]. NiCu offers two key advantages for observing this effect: (1) a large Seebeck coefficient, enabling strong thermoelectric response, and (2) a Fermi level positioned at the steepest slope of the spin Hall conductivity vs. energy curve, ensuring a significant spin Nernst conductivity. We show the spin Nernst angle in NiCu can reach up to 70 %, nearly an order of magnitude higher than that of Pt. Interestingly, because the thermally induced spin current is detected via the inverse spin Hall effect, the geometry of signal detection is reversed from that of conventional thermoelectric effects: spin Seebeck signals are measured transversely to the heat current, while spin Nernst signals appear longitudinally. This contrast could open up new possibilities for designing next-generation energy-harvesting devices using spin-caloritronic phenomena.

[1] C.-T. Liao, Y.-C. Wang, Y.-C. Tien, S.-Y. Huang*, and **D. Qu***, Phys. Rev. Lett. 133, 056701 (2024)

[2] W.-Y. Li, C.-H. Lin, G.-Y. Guo, S.-Y. Huang, and **D. Qu***, Phys. Rev. B 111, 054421 (2025)