Seminar of Farkhad Aliev

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Magnetic control over the superconducting thermoelectric effect

Thermoelectric technologies, directly converting heat flow into electricity or vice versa, are not only of great significance for solving the global energy crisis, but also to be important for optimization of solid-state cooling in the wide temperature range. Controlling thermopower both by the design (composition) but also by variation of external parameters such as magnetic field is critical for the development of versatile thermoelectric platforms. This talk will first briefly summarise how the thermoelectric effects in the bulk materials and spintronic devices are being controlled by the external magnetic field or magnetic state of the magnetic tunnel junctions. Secondly, I shall discuss recently predicted and confirmed experimentally effective magnetic state control of the giant thermopower in superconductor-ferromagnet (spin valve) hybrids.

The thermopower in superconductors coupled to strongly spin-polarized ferromagnets may be orders of magnitude higher than metallic thermoelectric devices at comparable temperatures. We have recently demonstrated a new key advantage of superconductor-ferromagnet hybrids as a platform for novel thermoelectric devices. We experimentally showed that the thermopower in V/MgO/Fe/MgO/Fe/Co superconductor-spin valve hybrids (which recently revealed equal spin superconducting triplet generation due to spin-orbit coupling and symmetry filtering [1]) could be controlled via the relative magnetic alignment of the ferromagnetic electrodes [2]. Importantly, we confirmed the theoretical prediction that by rotating one magnetic layer we can not only substantially change the thermoelectric effect, but can even reverse its sign [2,3] with an optimum antiparallel alignment of the ferromagnetic electrodes. Additionally, we demonstrated the in-situ control of thermoelectric effects in Fe/MgO/V/MgO/Fe/Co junctions by the relative alignment of the two ferromagnetic electrodes, in this case one at each side of the superconductor [4]. Our results could lead to the development of a novel kind of superconducting thermoelectric generators and sensors.

[1]. P. Tuero et al, J. Phys.D: Appl. Phys. 59, 133003 (2026). Topical review: https://doi.org/10.1088/1361-6463/ae4e3a
[2]. C. González-Ruano et al., Phys. Rev. Lett., 130, 237 (2023).
[3]. J. A. Ouassou et al., Phys. Rev. B 106, 094514 (2022).
[4]. P. Tuero et al., Phys. Rev. X (Energy) 4, 033003 (2025).

Farkhad Aliev graduated with top honors from the Faculty of Physics at Lomonosov Moscow State University, where he also completed and defended his doctoral thesis. He has served as an invited professor and visiting scientist at both the Universidad Autónoma de Madrid and Katholieke University Leuven. He is currently a full professor at the Universidad Autónoma de Madrid. His research focuses on strongly correlated systems, thermoelectric effects, magnetization dynamics, electron transport and noise in magnetic and superconducting nanostructures. Since 2026, he has been actively collaborating with the University of Lorraine / CNRS, resulting in nearly 20 joint publications. His talk will present an overview of the latest developments from this collaboration, highlighting work published over the past five years.

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