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Thursday 24th June, 2025 – 10:30 AM

IJL- Room 4.014

Giant Shot Noise in Superconductor/Ferromagnet Junctions with Orbital-Symmetry-Controlled Spin-Orbit Coupling

A common goal in science and technology is to suppress noise and increase the signal-to-noise ratio[1]. However, noise also enables elucidating subtle phenomena, hidden from other experimental probes[2]. A striking example is shot noise, which can be used to characterize strongly-correlated systems, strange metals, quantum entanglement, or fractionally charged quasiparticles[3]. Since shot noise stems from charge quantization, the fractional quantum Hall effect will be characterized by the reduced shot noise, while in superconductors, where the charge is added in Cooper pairs, even doubling of the normal-state shot noise is possible. By measuring the shot noise, in a superconductor/insulator/ferromagnet (V/MgO/Fe) junctions[4], grown in the group of Dr. Lu, we discover a giant increase, orders of magnitude larger than expected[5]. The origin of this giant noise is a peculiar realization of a superconducting proximity effect[6], where a simple superconductor influences its neighbors. Our measurements reveal largely unexplored implications of orbital-symmetry-controlled proximity effects. The importance of orbital symmetries and the accompanying spin-orbit coupling is manifested by an unexpected emergence of another superconducting region strikingly different from the parent superconductor. Unlike vanadium's common spin-singlet superconductivity, the broken inversion symmetry in V/MgO/Fe junctions and the resulting interfacial spin-orbit coupling leads to the formation of spin-triplet superconductivity across the ferromagnetic iron[5,6]. In contrast to the reports of an enhanced shot noise in Josephson junctions with *two superconductors*, we measure such a phenomenon with a *single superconductor* and attribute it to transport being determined by the spin-orbit coupling, which provides a large effective scattering. Our findings motivate further studies for superconducting spintronics and for emulating properties of widely used Josephson junctions but with only a single superconductor.

References:

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Igor Žutić is a Professor of Physics at the University at Buffalo, the State University of New York. He received PhD in theoretical physics at the University of Minnesota in 1998. His work spans topics from spin transport, superconductors, and Majorana fermions, to magnetic semiconductors, proximity effects, and two-dimensional materials. His predictions for spin devices not limited to magnetoresistance, such as spin-photodiodes, transistors, and lasers, have been experimentally realized. Igor Žutić is a fellow of the American Physical Society, a recipient of 2006 National Science Foundation CAREER Award, and 2019 State University of New York Chancellor's Award for Excellence

Séminaire organisé dans le cadre du programme interdisciplinaire MAT-PULSE