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Anisotropic vortex squeezing and supercurrent diode effect in non-centrosymmetric Rashba superconductors

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Abstract

Most of 2D superconductors are of type II, i.e., they are penetrated by quantized vortices when exposed to out-of-plane magnetic fields. In a presence of a supercurrent, a Lorentz-like force acts on the vortices, leading to drift and dissipation. The current-induced vortex motion is impeded by pinning at defects. Usually, the pinning strength decreases upon any type of pair-breaking interaction perturbs a system.

In the talk I will discuss surprising experimental evidences showing an unexpected enhancement of pinning in synthetic Rashba 2D superconductors when applying an in-plane magnetic field. When rotating the in-plane component of the field with respect to the driving current, the vortex inductance turns out to be highly anisotropic. We explain this phenomenon as a direct manifestation of Lifshitz invariant that is allowed in the Ginzburg-Landau free energy when space-inversion and time-reversal symmetries are broken. As demonstrated in our experiment [1], elliptic squeezing of vortices—an inherent property of the non-centrosymmetric superconducting condensate—provides an access to fundamentally new property of Rashba superconductors, and offers an entirely novel approach to vortex manipulation.

Another interesting feature of the non-centrosymmetric superconductors in the applied magnetic field is the supercurrent diode effect—the critical current in one direction exceeds its counterpart in the opposite one—what stems from the Cooper pairs with finite centre of mass momentum. In the pioneering experiment [2] we demonstrated the emergence of the supercurrent diode effect in the Josephson junctions based on synthetic Rashba superconductors made of Al-InAs quantum wells. In the talk, I will discuss novel experimental method—measurements of the Josephson inductance—and the semiquantitative microscopic model capturing all the essential features as observed in experiment.

References
[1] L. Fuchs, D. Kochan, C. Baumgartner, S. Reinhardt, S. Gronin, G. Gardner, T. Lindemann, M. Manfra, C. Strunk, N. Paradiso; arXiv:2201.02512

[2] C. Baumgartner, L. Fuchs, A. Costa, S. Reinhardt, S. Gronin, G. Gardner, T. Lindemann, M. Manfra, P. Faria Junior, D. Kochan, J. Fabian, N. Paradiso, C. Strunk; Nature Nanotechnology 17 (1), 39 (2022)

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