Hybrid Josephson junctions based on InSb nanoflags

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High-quality III-V narrow bandgap semiconductor materials with strong spin-orbit coupling and large Lande g-factor provide a promising platform for next-generation applications in the field of high-speed electronics, spintronics, and quantum computing. InSb stands out due to its narrow bandgap, high carrier mobility, and small effective mass, making it very appealing in this context. In fact, this material has attracted tremendous attention in recent years for the implementation of topological superconducting states.

In this context, the simultaneous breaking of time-reversal and inversion symmetry can lead to peculiar effects in Josephson junctions, such as the anomalous Josephson effect or supercurrent rectification, which is a dissipationless analog of the diode effect. Due to their potential impact in new quantum technologies, it is important to find robust platforms and external means to manipulate the above effects in a controlled way. Here, we demonstrate that hybrid Josephson junctions made of high-quality InSb nanoflags constitute a promising platform for supercurrent rectification due to its strong spin orbit coupling. The high quality of the devices enabled the observation of the diode effect in these Josephson junctions [1,2]. When subjected to an in-plane magnetic field, these devices enter a non-reciprocal transport regime, manifesting an asymmetry between positive and negative critical currents.

Furthermore, under microwave irradiation, we have observed half-integer Shapiro steps that are robust to temperature, suggesting their possible nonequilibrium origin [3]. Our results demonstrate the potential of ballistic InSb nanoflag Josephson junctions as a valuable platform for understanding the physics of hybrid devices and investigating their nonequilibrium dynamics.

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