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Orbital Interference Effects in Nanowire Josephson Junctions for Exploring Majorana Physics

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The Josephson effect in a nanowire-based superconductor-normal-superconductor (SNS) junction is studied theoretically and experimentally, focusing on the effects of nanoscale confinement on the current-phase relationship of the junction. We identify a new type of Josephson interference based on the coupling of an applied axial magnetic flux to N-section Andreev quasiparticles (bound and continuum states) occupying electronic subtends of non-zero orbital angular momentum. The Bogoliubov-de Gennes equations are solved while considering the transverse subbands in the N-section, yielding energy-versus-phase curves that are shifted in phase in the presence of the flux. A similar phase shift is observed in the continuum current of the junction. Experimental observations of similar oscillations of critical current in a Nb-InAs nanowire-Nb junction are described, and analyzed in the context of our theoretical model. Since this type of semiconductor-superconductor junction can, in theory, support Majorana fermions, this orbital interference effect must be taken into account when looking for topological signatures in the critical current versus field and temperature.

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