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SNS junctions in nanowires with spin-orbit coupling: role of confinement and helicity on the sub-gap spectrum JORGE CAYAO, Consejo Superior de Investigaciones Científicas (CSIC) - Spain, ELSA PRADA, Universidad Autónoma de Madrid (UAM) - Spain, PABLO SAN-JOSE, RAMÓN AGUADO, Consejo Superior de Investigaciones Científicas (CSIC) - Spain — We study normal transport and the sub-gap spectrum of superconductor-normal-superconductor (SNS) junctions made of semiconducting nanowires with strong Rashba spin-orbit coupling. We focus, in particular, on the role of confinement effects in long ballistic junctions. In the normal regime, scattering at the two contacts gives rise to two distinct features in conductance, Fabry-Perot resonances and Fano dips. The latter arise in the presence of a strong Zeeman field B that removes a spin sector in the leads (*helical* leads), but not in the central region. Conversely, a helical central region between non-helical leads exhibits helical gaps of half-quantum conductance, with superimposed helical Fabry-Perot oscillations. These normal features translate into distinct subgap states when the leads become superconducting. In particular, Fabry-Perot resonances within the helical gap become parity-protected zero-energy states (parity crossings, related to Yu-Shiba-Rusinov bound states), well below the critical field B_c at which the superconducting leads become topological. As a function of Zeeman field or Fermi energy, these zero-modes oscillate around zero energy, forming characteristic loops, which evolve continuously into Majorana bound states as B exceeds B_c.

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