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Unconventional superconductivity induced in the surface states of 3D Topological insulators

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Josephson junctions involving a conventional superconductor and an exotic conductor, represented by the surface of a 3D topological insulator (TI), a Dirac semimetal or the edge states of two-dimensional quantum wells, are ideal systems to emulate topological superconductivity characterized by unconventional order parameter (OP), with an orbital component assuming the form of a chiral px + ipy wave. Topological superconductivity is instrumental for the nucleation of Majorana fermion at the basis for topological quantum computation Here I will report our results on phase-sensitive measurements, based on the quantum interference in a Josephson junction, realized using Al- Bi2Te3-Al devices. The experiment allows to establish that the proximity with a conventional superconductor induces an order parameter in the surface states of the topological insulator Bi2Te3, which is consistent with a chiral px + ipy (p-wave) order parameter (OP). This is achieved by measuring the magnetic field pattern of the junctions which shows a dip at zero external magnetic field, a signature of the simultaneous existence of "0" and "π" coupling within the junction, inherent to an OP with a non trivial phase1. The peculiar nano-textured nature of the morphology of the Bi2Te3 flakes, and the dramatic role played by thermal strain are the surprising key factors for the display of an effective induced chiral px + ipy OP. To reduce the number of modes and to reveal the 4π-periodic current-phase relation inherent to Majorana bound states in superconducting hybrids we have also realized Josephson junctions using 3DTI nanowires 2. In such devices we observe a contribution of 4π-periodic Majorana bound states to the supercurrent in Al-Bi2Se3-Al devices revealed by studying the junction under GHz microwave irradiation and the Josephson current as a function of the temperature.

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