Let's Twist (Again); Developments Related to Topology in Superconducting Electronics

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Abstract - One of the aspects that makes superconductivity such a special phenomenon is the fact that the superconducting state is phase-coherent. In an analogy, one could compare the superconducting state with a rope: it is possible to bend it and apply torsion to it, but there always remains a certain form of connectivity from one end to the other. Likewise, as the ends of a rope can be glued together, potentially with knots and twists incorporated (think about the Möbius strip), also in closed connections of superconductors such topological properties play role.

This aspect of topology forms a basis for applications, with the SQUID sensors as the foremost example. More unconventional topological aspects came in view with the advent of the high-Tc superconductors and their *d*-wave symmetry. For example, superconducting rings could be produced that spontaneously generated half-integer magnetic flux quanta. Currently, such 'pi-phase shift devices', albeit now based on superconductor-ferromagnet-superconductor Josephson junctions, are showing increased popularity as new elements in the toolbox of superconducting electronics.

Exciting recent developments in the area of topological insulators have once again placed topology in the spotlights. Connections between superconductors and topological insulators can serve as a basis for the creation of Majorana particles, which have special properties that make them very useful for quantum information processing.

In this talk I will attempt to introduce these developments in generally understandable terms.

Keywords - topology, topological insulator, SQUID, *d*-wave symmetry, half-integer flux quantum, π-phase shift, Josephson junction, S-ferromagnet-S junction, Majorana particle

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