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Non-centrosymmetric Superconductors

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The unusual physics of non-centrosymmetric superconductors is introduced. Non-centrosymmetric systems are those where spatial inversion symmetry is absent. Usually, superconductors are describable by the Bardeen, Cooper, Schrieffer theory. They consist of Cooper pairs with their spin part being singlet and the orbital part being s-wave. On the other hand, in non-centrosymmetric superconductors, the Cooper pairs are neither spin singlets nor triplets, and the orbital parts are neither s- nor p-wave. Contrary to what one might believe, non-centrosymmetric superconductors are actually very common and examples would be given.

We explain how the unusual properties of these superconductors can arise provided the relevant materials have strong spin-orbit coupling. Strong spin-orbit coupling gives rise to spin-splitting of the Fermi surface, and the gap magnitudes on these Fermi surfaces are also in general unequal. Either one would be sufficient to generate the following exotic properties. Magneto-electric couplings, e.g., the coupling between magnetic field and electric current, occur naturally due to the lack of inversion symmetry. For example, in a two-dimensional system, an in-plane Zeeman field can induce and therefore control a supercurrent in the perpendicular direction. In general, dissipationless spin-supercurrents can also arise, in particular near sample boundaries. These spin-currents may have applications to the field of spintronics. We explain how these boundary spin-currents are related to what have been recent discussed in topological insulators, a type of materials also currently being hotly pursued in spintronics. Non-centrosymmetric superconductors can also fall into distinct topological classes, as for topological insulators versus trivial band insulators, but spin supercurrents can exist in either class of non-centrosymmetric superconductors.

We provide examples of bulk materials where the above exotic properties can be realized. We discuss other candidates such as superconducting films deposited on materials with strong spin-orbit couplings, superconducting artificial superlattices, and superconductivity at interfaces.

Keywords: non-centrosymmetric superconductors, spin-currents

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