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Superconductivity: past, present and future

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Superconductivity, the ability to carry electrical current without any resistance whatsoever, is perhaps the longest known example of a quantal order—defined by an order parameter, the phase of the electronic wave function, that does not have a classical analogue. While the problem of classifying superconducting states is largely solved, the question of mechanism remains in many respects open. We believe we understand the origin of superconductivity in "conventional"materials such as mercury, the compound where the phenomenon was first observed, but recent decades have seen a remarkable series of discoveries of new families of compounds, in which superconductivity coexists with, and may well be derived from, a wide range of novel physics including Kondo-renormalized heavy fermion materials, Mott insulators, quantum magnets, and fractional Chern and other topological states. In this talk I will present via a few examples recent progress and open questions related to understanding the evident diversity of mechanisms, and raise questions related to using this understanding to design new materials with even higher transition temperatures.

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