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Approaches to New Superconducting Materials[1]

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Over the last twenty years a large set of new superconductors with extraordinary properties have been discovered and studied. They are all by any measure complex materials, involving several elements arranged in complex crystal structures. Even the normal states of these materials exhibit highly correlated behavior, and the superconducting states are equally unusual, with complex order parameter symmetries, exotic vortex behavior and strong dependence on carrier doping. In the future, new complex materials that are chemically stable compounds will certainly continue to be found, at least some of which may result from rational searches. There is also an opportunity to create new materials in which the molecular, electronic, spin and phonon structure that sets the stage for the emergence of a superconducting state is defined artificially. Such "meta-materials" allow for the factors that are important for an emergent state to be included in new ways, and they also provide a test bed for predictive theory. Oxides are particularly well suited for this kind of work, since heterojunctions between different phases can be formed in many cases with little disorder. In other correlated systems, some new and useful properties not found in naturally occurring compounds have been engineered this way by researchers in several labs. Many heterojunction issues governing the resulting electronic and magnetic structure remain to be systematically studied, including state line-up, charge transfer, interface composition and bond energies to name a few.

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