Boson-fermion approach to superconductivity: an overwiev

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It is widely accepted that superconductivity of the cuprate oxides is associated with the tightly bound electron/hole pairs residing on neighboring lattice sites. A low density of the local pairs and quasi-two-dimensional nature of these materials imply, however, that formation of such bosonic entities alone is insufficient to guarantee a true phase transition to superconductivity. This transition can occur at an onset of the long-range phase coherence of the preexisting pairs. Such scenario is naturally captured within the boson–fermion model, which was introduced more than 40 years ago, before the discovery of high-T_c superconductors. Remarkably, this approach predicted the pseudogap phase above the superconducting transition temperature, that has been indeed observed experimentally from the underdoped to the optimally doped regime of cuprates.

I shall discuss the underlying concepts of the boson–fermion model, describing the local electron or hole pairs coupled to itinerant charge carriers through an Andreev-type hybridization. This picture can be effectively derived from the microscopic models of correlated fermions via the Hubbard–Stratonovich transformation. Moreover, the same framework is relevant to the superfluidity of ultracold fermionic atoms, where pairing is due to a Feshbach resonance, and similar methodology can be extended to various unconventional superconducting and/or superfluid states of matter.