Quantum critical Eliashberg theory, the Sachdev-Ye-Kitaev superconductor and their holographic duals

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Superconductivity is abundant near quantum-critical points, where fluctuations suppress the formation of Fermi liquid quasiparticles and the Bardeen-Cooper-Schrieffer theory no longer applies. To address this issue we introduce and solve a models of interacting electrons and phonons thatare natural generalizations of the Sachdev-Ye-Kitaev model and that become superconducting at low temperatures. In the normal state, non-Fermi-liquid behavior characterised by universal exponents emerges. The superconducting ground state is characterized by coherent quasiparticle excitations and higher-order bound states thereof, revealing that it is no longer an ideal gas of Cooper pairs, but a strongly coupled pair fluid. The normal-state incoherency primarily acts to suppress the weight of the superconducting coherence peak and reduce the condensation energy. We also discuss the crossover from Non-Fermi liquid to Fermi liquid.