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Solvable models of quantum matter without quasiparticles

I will describe mathematical aspects of the Sachdev-Ye-Kitaev (SYK) class of models of interacting fermions. The fermions can occupy any of N quantum states ($N \to \infty$), and have random all-to-all q-fermion interaction terms in the Hamiltonian ($q \geq 4$ and even). The low energy excitations of these models cannot be expressed in a quasiparticle basis, but remarkably many aspects are exactly solvable. I will describe the computation of the low temperature free energy, and the many-body density of states at low energy. There is a non-vanishing entropy in the zero temperature limit. The density of states is determined by a path integral of a quantum gravity theory in two-dimensional anti-de Sitter space. Applications to 'strange metal' states of correlated electron materials will be briefly mentioned.