Department of Theoretical Physics

THE QUANTUM SPACETIME SEMINAR SERIES

Quasiparticle lifetime in a finite conductor and the problem of many-body localization .

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A quasiparticle in a Landau Fermi liquid has a lifetime that varies inversely as the square of its energy. This understanding is ultimately based on a Fermi Golden Rule argument: the decay rate is proportional to the square of the matrix element for Coulomb interaction of the fermions as well as the phase space available to the final products of the decay process. In a finite conductor, the single-particle energy levels are discrete and the Fermi Golden Rule based understanding of the quasiparticle lifetime is no longer valid when their energies are comparable to the mean level spacing, delta. Indeed, in this regime, the interparticle interactions merely shift these energy levels and the excitation lifetime is infinite. A careful analysis shows that the quasiparticle lifetime diverges below an energy scale that is parametrically larger than delta. It is instructive to look at this problem from a different perspective. In principle, one could diagonalize the interacting many-particle system and the system, prepared in any of the eignestates, would persist forever in that state. A quasiparticle can always be expressed as a linear superposition of the exact many-body eignestates. If this superposition involves many-body eigenstates whose energy spread exceeds the quasiparticle energy, then the excitation "decays" on a time scale that is inversely proportional to the energy spread. If the superposition involves a small number of many-body eigenstates, then the excitation does not decay. I will show that this transition is in fact a many-body localization transition, i.e., an Anderson localization transition in the Fock space of many-body states. I will place this analysis in the context of the problem of quasiparticle lifetime in the Kitaev model subjected to integrability-breaking perturbations.