Many body density of states of a system of spinless fermions

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Densities of states are crucial quantities for studying physical systems in particular many body quantum systems in condensed matter, where they control material properties. By enumerating accessible states around a given conserved quantity (e.g. energy), they allow to quantify equilibrium as well as transport properties.

Regarding fermionic systems, the success of Landau's theory of Fermi liquids and the associated concept of quasi-particle has promoted the use of Single Body Densities of States and focused attention on the low lying energy states around the Fermi surface. It is only recently that the engineering of nearly isolated quantum simulators, undergoing strongly out of equilibrium dynamics, has revived the necessity to consider Many Body Densities of States, quantities originally investigated in the context of nuclear physics [1]. Indeed, understanding phenomena like for instance Many Body Localization [2,3] requires to take into account potential contributions of strongly correlated many body states over the full spectrum of the system.

In this talk, we will focus on the problem of calculating the Many Body Density of States of a system of identical spinless and non interacting fermions. Surprisingly, even without interactions, this enumeration problem proves to be difficult because of the Pauli exclusion principle [1]. We propose a solution involving the spectral decomposition of matrices of filling factors [4]. The many body spectrum can be decomposed as a weighted sum of weakly correlated components, where remarkably the single body energies are only involved in the weighting coefficients. We consider applications of our results to several condensed matter models.

[1] Ericson, Advances in Physics 9, 36, pp 425-511 (1960)

[2] Schreiber et al, 349, 6250, pp. 842-845, Science, (2015)

[3] Gross et al, 357 6355, pp. 995-1001, Science (2017)

[4] R. Lefevre et al, in preparation