Contribution ID: **44** Type: **Poster**

A New Look on an Old Problem: Mass Enhancement in Fermi Liquids

Tuesday 6 January 2026 09:45 (30 minutes)

Understanding how quasiparticle renormalization influences thermodynamic properties is a central question of Fermi-liquid theory. In this work, we analyze the mass enhancement arising from the reduction of quasiparticle weight and its impact on the electronic specific heat. A straightforward microscopic evaluation of the Migdal–Galitskii expression, using a T-independent spectral function, seems at first to disagree with Landau' s phenomenological prediction for the Sommerfeld coefficient. We demonstrate that this apparent discrepancy is not a failure of Landau theory, but rather a consequence of missing contributions in the microscopic treatment.

By carefully incorporating the temperature dependence of the single-particle spectral function $A(k, \omega, T)$, we derive an additional sum rule that restores full consistency with Landau's result. This sum rule links the quasiparticle renormalizations m^* (includes both energy and momentum contributions), and identifies a previously overlooked contribution coming from
$dfrac\partial^2 A\partial T^2$ at the Fermi level.

Our analytical insights are benchmarked using Dynamical Mean-Field Theory (DMFT) applied to the Hubbard model on the Bethe lattice. The numerical results confirm the validity of the new sum rule and highlight the key role played by the temperature dependence of the self-energy in determining the specific heat.

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Session Classification: Tuesday Coffee Break and Poster

Track Classification: Categories: Theory