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Exact Spectral Properties of Fermi Polarons in One-Dimensional Lattices: Anomalous Fermi Singularities and Polaron Quasiparticles

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We calculate the exact spectral function of a single impurity repulsively interacting with a bath of fermions in one-dimensional lattices, by deriving the explicit expression of the form factor for both regular Bethe states and the irregular spin-flip state and η -pairing state, based on the exactly solvable one dimensional Hubbard model. While at low impurity momentum $Q \sim 0$ the spectral function is dominated by two power-law Fermi singularities, at large momentum we observe that the two singularities develop into two-sided distributions and eventually become anomalous Fermi singularities at the boundary of the Brillouin zone, with the power-law tails extending toward low energy. Near the quarter filling of the Fermi bath, we also find two broad polaron peaks at large impurity momentum, collectively contributed by many excited many-body states with non-negligible form factors. Our exact results of those distinct features in one-dimensional Fermi polarons, which have no correspondences in two and three dimensions, could be readily probed in cold-atom laboratories by trapping highly imbalanced twocomponent fermionic atoms into one-dimensional optical lattices.

References:

- [1] H.Hu, J. Wang, and X.-J. Liu, Phys. Rev. Lett. 134, 153403 (2025);
- [2] X.-J. Liu and H. Hu, AAPPs Bulletin (2025) 35:9.

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