Transient localization from the interaction with quantum Fluctuations

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Understanding anomalous charge transport in quantum materials remains a major challenge, particularly in systems where conventional Fermi liquid theory fails. In this work, we investigate the transient localization (TL) arising from interactions between charge carriers and bosonic modes[1] or two-level systems (TLS)[2]. Using the finite-temperature Lanczos method (FTLM), we show that these interactions create self-generated disorder, leading to a displaced Drude peak (DDP) in the optical conductivity and suppressed charge mobility. Unlike conventional disorder-driven Anderson localization, TL emerges dynamically and influences transport at intermediate timescales. We further examine the interplay between static and dynamic disorder, revealing that TLS fluctuations can modify localization effects and restore finite mobility at long times.

References

[1] Hadi Rammal, Arnaud Ralko, Sergio Ciuchi, and Simone Fratini. Transient localization from the interaction with quantum bosons. Phys. Rev. Lett., 132:266502, Jun 2024.

[2] Hadi Rammal, Sergio Ciuchi, and Simone Fratini. Transient localization from the interaction with two level systems. in preparation, 2025.

Figures

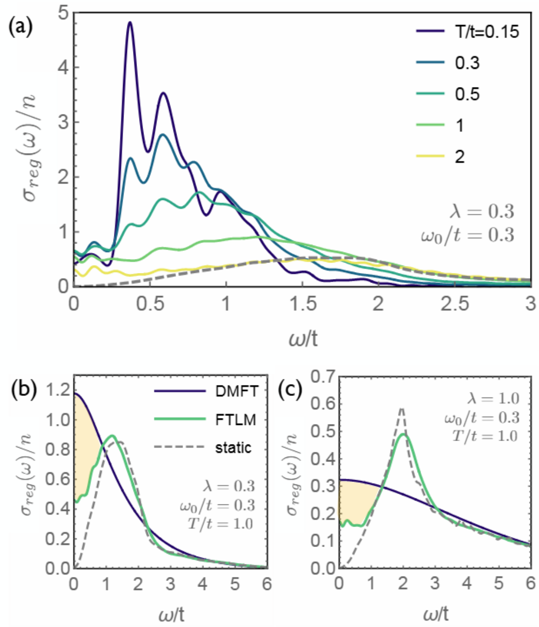

Figure 1:
Regular part of the optical conductivity per particle for λ = 0.3, ω_0/t = 0.3 calculated at different temperatures, expressed in units of $a^2e^2/\hbar$.
The dashed line is the result from the static boson approximation at T /t = 2 .
(b) Zoom of the FTLM data at T /t = 1.0 compared with the DMFT result and the static boson approximation.
(c) Similar to (b), at λ = 1.0.