Effective Cluster Typical Medium Theory for Diagonal Anderson Disorder Model in one and Two-Dimensions

C.E. Ekuma, H. Terletska, Z.Y. Meng, J. Moreno (LSU); M. Jarrell (LSU); S. Mahmoudian, V. Dobrosavljevic (NHMFL ,FSU, Physics).

Introduction

According to the one-parameter scaling theory [1], there is no delocalized phase in one and two dimensions, whereas, a metal-insulator-transition occurs at finite disorder strength in three-dimensions (3D). Effective medium theories like the coherent potential approximation (CPA) and its cluster extensions cannot capture the localized state in one and two dimensions, and even the transition in 3D. Here, we develop an extension of the Typical Medium Theory (TMT) [2], which is able to capture the localized state. Within this theoretical framework, where the arithmetically averaged local density of states is replaced with the geometrically averaged local density of states, the typical density of states vanishes continuously as the disorder strength increases towards the critical point. However, this simplest single-site self-consistent theory fails to capture the effect of spatial correlations. Here, we extend the local typical medium theory to a cluster version (CTMT) utilizing the ideas from the dynamical cluster approximation (DCA). Therefore, quantum coherence, which is important for Anderson localization, is captured within this approximation.

Results and Discussion

We develop a cluster typical medium theory to study localization in disordered electronic systems. Our formalism (CTMT) utilizes the momentum resolved typical density of states and hybridization function to characterize the localization transition. We apply the formalism to the Anderson model of localization in one and two-dimensions. In one dimension, we found that the critical disorder strength scales inversely with the linear cluster size with a power-law; whereas in two dimensions, the critical disorder strength decreases logarithmically with the linear cluster size. Our results are consistent with the one-parameter scaling theory.

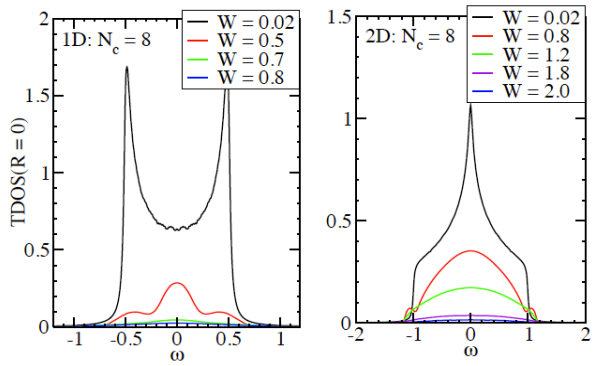

Figure 1.The local typical density of states, as a function of frequency for various disorder strengths, W, for clusters of size Nc=8 for one- (left panel) and two-(right panel) dimensional systems.

Conclusions

We develop a cluster extension to the local typical medium theory via the dynamical cluster approximation for studying localization in low dimensional disordered electronic systems. The developed CTMT systematically incorporates nonlocal corrections to capture quantum coherence. The formalism recovers the local TMT when the cluster size is $N_c = 1$, and becomes exact as $N_c \rightarrow \infty$. Such an approach opens a new avenue to study localization effects in lower dimensional model systems.

Acknowledgements

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References

[1] Abrahams, E., *et al.*, Phys. Rev. Lett. **42**, 673 (1979).
[2] Dobrosavljević, Int. J. Mod. Phys. B 24, 1680 (2010)..