SCALING BEHAVIOR OF AN ANDERSON IMPURITY CLOSE TO THE MOTT-ANDERSON TRANSITION

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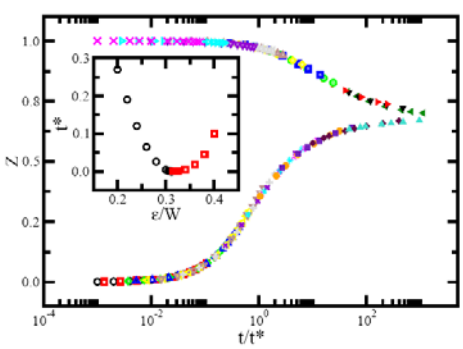
Introduction

The Mott and the Anderson routes to localization are two of the processes that can drive the metal-insulator transition. Theories separately describing each of these mechanisms were discussed long ago, [1, 2] but an approach including both of them has remained elusive. The basic effect of disorder on the Mott transition was outlined by Mott, [1] who pointed out the differences seen in the strongly localized (atomic) limit. In the absence of disorder, if the system is half-filled, each site is singly occupied. In the disordered case, for disorder strength compared to the Coulomb repulsion, a fraction of the sites becomes either doubly occupied or empty and we have a two-fluid picture. In the metallic side of the transition, the problem can be solved using the Typical Medium Theory (TMT), [3] which is able to describe both the Mott and Anderson routes to localization. Instead of addressing the structure of the self-consistent solution of the TMT, we examined the two-fluid picture through a simpler problem. [4] We looked at the behavior of a collection of Anderson impurity models (SIAM), defined by the on-site energies ε_i, as the spectral weight of the bath function "seen" by them is reduced. The latter is a measure of the distance t to the transition and we thus mimic the approach to it.

Results and Discussion



We found that when t decreases, depending on the value of ε_i, the quasiparticle weight Z_i goes either to 0 or 1, which corresponds to a two-fluid picture, as in the limit analyzed by Mott. [1] Our results indicate that as a function of t the "charge" Z(t) "flows" away from the unstable "fixed point" Z^* (which corresponds to ε^*), and towards either stable "fixed points" Z = 0 or Z = 1. The structure of these flows shows power-law scaling as the scale $t \to 0$, which implies that the entire family of curves $Z(t,\delta\varepsilon)$, where $\delta\varepsilon = (\varepsilon-\varepsilon^*)/\varepsilon^*$, can be collapsed onto a single universal scaling function $Z(t,\delta\varepsilon) = f[t/t^*(\delta\varepsilon)]$, as seen in Fig. 1, where $t^*(\delta\varepsilon) = C^{\pm}|\delta\varepsilon|^{\phi}$ with $\phi = 2$ around the unstable fixed point.

Fig. 1. Scaling of Z as a function of $t/t^*(\delta\varepsilon)$. The inset shows the scaling parameter t^* for the upper (squares) and bottom (circles) branches.

Conclusions

We focused on understanding the behavior of SIAM in a model bath chosen to mimic the approach to the Mott-Anderson transition. We presented numerical and analytical results that portray a simple scaling behavior in the critical regime where the bath spectral weight becomes vanishingly small. Our scaling analysis clarifies the emergence of the two-fluid behavior at the critical point, which is as a first step towards constructing a full self-consistent description of the transition.

Acknowledgements

This work was supported by NSF grants DMR-9974311 and DMR-0234215 (VD) and DMR-0096462 (GK). MCOA was supported in part by NSF grant DMR-0312495.

References

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