Strong-disorder Renormalization Group Study of the Anderson Localization Transition

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Introduction

The Anderson transition is a nontrivial consequence of destructive interference effects in disordered materials. Its simplest realization is provided by the tight-binding model which describes electronic states in a "dirty" conductor by mimicking the effect of impurities through a random on-site potential. One main challenge in investigating the localization transition is the limited range of applicability of well known analytical approaches. For example, as in ordinary critical phenomena, the epsilon-expansion around d = 2 seems to have extremely bad convergence properties when extrapolated to d = 3, making it virtually useless if one is interested in quantitative estimates of the critical exponents [1]. In contrast, the progress in numerical calculations during the last 20 years has increased dramatically our knowledge of the metal-insulator transition, especially in dimensions such as d = 3 and 4 for which a rigorous analytical treatment is not available. Avoiding finite-size effects by having access to very large system sizes and flexibility to work in any dimensions or topology in reasonable time and computer memory resources have been always a long lived goal for computational physicists. In this project, we achieve this goal by designing an efficient numerical approach able to study the localization transition in the tight-binding model by computing the conductance in all dimensions without much effort. Our implementation of the method only keeps track of the main couplings in the system which allowed us to greatly speed up the computer time.

Results and Discussion

We implement an efficient SDRG procedure[3] to study disordered tight-binding models in any dimension and on the Erdős–Rényi random graphs, which represent an appropriate infinite dimensional limit. Our SDRG algorithm is based on a judicious elimination of most (irrelevant) new bonds generated under RG. The reconnection of the lattice during SDR process requires an increasing amount of memory and the procedure becomes unpractical. In order to avoid this problem, many schemes were proposed which are model dependent. The modification of the SDRG scheme we adopt in this work is setting a maximum coordination number k_max per site, i.e., we follow the exact SDRG procedure but only keep track of the strongest k max couplings in each site. It yields excellent agreement with exact numerical results for universal properties at the critical point without significant increase of computer time.

Conclusions

We showed our modified SDRG method is suitable to study the localization properties of large system in any dimension. This significant progress eliminates previous obstacles such as computational time or computer memory size and paves the avenue for future study of the Anderson transition.

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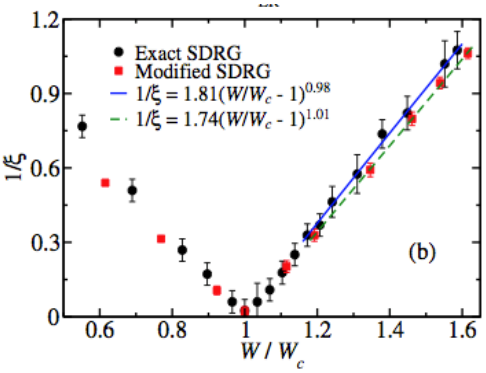

Fig.1 The localization length near the localization transition using two methods exact and modified SDRG approaches. Our result is very close to the exact value for the critical exponent [3].

References

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