Anderson Localization in Discrete Systems: Beyond the Random Phase Approach

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To date, the theory of Anderson localization in one-dimensional disordered systems is developed in detail. In particular, various analytical methods applied to the continuous models allow deriving all transport characteristics in dependence on the disorder strength and sample size. On the other hand, for the discrete models, the rigorous analysis is a difficult task due to the presence of resonances of the Fabry-Perot type that results in a nonuniform distribution of the phase of the wave function. One of the open problems, in connection with these resonances, is how to relate global transport characteristics to the localization length, which near the resonances should be obtained with one of specific methods beyond the conventional random phase approach.

As a typical example of a discrete system, we consider an array of barriers and/or wells of fixed thickness and random heights. Its inherent peculiarity is the presence of the resonances emerging due to the coherent interaction of the waves reflected from the interfaces and resulting in the enhancement of the Anderson localization. Our theoretical approach allows deriving the localization length in infinite samples both out of the resonances and close to them. We examine how the transport properties of finite samples can be described in terms of this length. It is shown that the analytical expressions obtained by standard methods for continuous random potentials can be applied to our discrete model, in spite of the presence of resonances that cannot be described by conventional theories. All our results are illustrated with numerical data manifesting an excellent agreement with the theory.