The Abdus Salam
International Centre
for Theoretical Physics
50th Anniversary 1964-2014

Workshop on Coherent Phenomena in Disordered Optical Systems
26 - 30 May 2014, Trieste, Italy

Measurement of the Mobility Edge for 3D Anderson Localization

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Abstract:

The localization of single-particle quantum states in disorder, the so-called Anderson localization, lays at the heart of the behavior of many real materials. In three spatial dimensions, a transition to localization occurs when the particle energy goes below a critical threshold, the mobility edge, whose value depends on the disorder properties. After more than 50 years of intense research, the experimental observation of the Anderson transition and the measurement of the mobility edge trajectory in the disorder-energy plane, have proved to be challenging tasks. Recently, experiments on ultrasounds and light as well as on ultracold atomic systems have provided the experimental evidence of the transition. The determination of the disorder-dependent mobility edge is however still missing, due to the difficulty in reaching the desired control over both energy and disorder. We now employ an ultracold bosonic gas with tunable interactions to measure the mobility edge associated to a controlled optical speckle disorder. We find that initially the mobility edge increases following the mean disorder energy, while the increase slows down when the mobility edge becomes comparable to the disorder correlation energy. These results offer the opportunity of an unprecedented quantitative comparison with existing theories of Anderson localization. The control over interactions allowed by our system is enabling us to explore also the fate of 3D Anderson localization in presence of nonlinearities, an open problem also from the theoretical point of view.