SYAL 1: Anderson Localization in Nonlinear and Many-Body Systems

Time: Monday 14:00–17:00 Location: BAR SCHÖ

Invited Talk SYAL 1.1 Mon 14:00 BAR SCHÖ
Delocalization by nonlinearity and interactions in systems with disorder — •Dima Shepelyansky — Laboratoire de Physique Theorique, CNRS, Univ. P.Sabatier

Analytical and numerical studies are presented showing that in disordered systems with Anderson localization nonlinearity, or interactions between quantum particles, lead to delocalization of probability in space. Relation of this phenomenon to various experimental situations is briefly discussed.

Invited Talk SYAL 1.2 Mon 14:30 BAR SCHÖ
Absence of Diffusion in a Fröhlich-Spencer-Wayne model for nonlinear random systems — •Serge Aubry — Laboratoire Leon Brillouin, CEA Saclay, 91191 Gif-sur-Yvette, France

In linear random models with Anderson localization, there is absence of diffusion for any initially localized wavepacket. When nonlinearity is present, the localized Anderson eigenmodes interact by higher order nonlinear terms and then, it is often believed, on the basis of certain numerical observations, that wavepackets exhibit a (slowly) diffuse behavior (subdiffusion). However, there is a great debate to determine whether this behavior is only transient or lasts forever. We shall describe new numerical results on a variation of the standard nonlinear Anderson model, called Fröhlich-Spencer-Wayne (FSW) model, which consists of a random DNLS model with purely nonlinear nearest neighbor interactions (and norm conservation). For that kind of models, a theorem predicts the existence of many non-diffusive quasiperiodic (KAM) solutions at small enough nonlinearity. In agreement with this prediction, we numerically observe that at small nonlinearity, an initial single-site wavepacket does evolve quasiperiodically over very long time and does not spread at all. At larger nonlinearity, the single site initial wavepacket begins to spread chaotically, possibly over a large number of sites, but later the spreading always slows down and seems to stop. Moreover, in that model, for even larger nonlinearity, norm conservation forbids the complete spreading of any wavepacket. Our results support (at least in that family of models) the absence of diffusion for any initially localized wavepacket.

Invited Talk SYAL 1.3 Mon 15:00 BAR SCHÖ
Anderson localization and nonlinearity in disordered photonic lattices — •Yaron Silberberg — Weizmann Institute of Science, Rehovot, Israel

Arrays of optical waveguides are excellent systems to study wave phenomena in periodic and disordered media. We experimentally investigate the evolution of linear and nonlinear waves in a realization of the Anderson model using disordered one-dimensional waveguide lattices. Two types of localized eigenmodes, flat-phased and staggered, are directly measured. Nonlinear perturbations enhance localization in one type and induce delocalization in the other. We studied the evolution of wave packets in the presence of disorder, and observed the transition from ballistic wave packet expansion to exponential (Anderson) localization and how nonlinearity affects it. We also realized the quasi-periodic structure known as the Aubry-Andre model, observed the unique localization phase transition in this system and studied the effect of nonlinearity on it.

Invited Talk SYAL 1.4 Mon 15:30 BAR SCHÖ
Many Body Localization — •Boris Altshuler — Columbia University; NEC Laboratories America, 538 West 120th Street, Pupin Hall, 10027 New York, NY, USA

Usually the term Anderson localization is applied to the wave functions of single quantum particles in a random potential. However the concept of localization turns out to be much broader and manifests itself in various forms. For example, it provides an adequate framework for discussing the transition between integrable and chaotic behavior in quantum systems: it is tempting to view such a transition as a delocalization of the system in the space of quantum numbers of the original integrable model due to its perturbation, which violates the integrability. Recently it became clear that the ideas developed for understanding quantum mechanics of a single particle can be extended to solve many-body problems in the presence of disorder, e.g., to describe Metal to Insulator Transitions in conductors, where the interaction between the charge carriers can not be neglected.

Invited Talk SYAL 1.5 Mon 16:00 BAR SCHÖ
Localized states and interaction induced delocalization in Bose gases with quenched disorder — •Thomas Nattermann — Institute for Theoretical Physics, Universität zu Köln,Zulpicher Str. 77, 50937 Köln, Germany

Zero temperature properties of a dilute weakly interacting d-dimensional Bose gas in a random potential are studied. We calculate geometrical and energetic characteristics of the localized state of a gas confined in a large box or in a harmonic trap. Different regimes of the localized state are found depending on the ratio of two characteristic length scales of the disorder, the Larkin length and the disorder correlation length. Repulsing bosons confined in a large box with average density n well below a critical value n_c are trapped in deep potential wells of extension much smaller than distance between them. Tunneling between these wells is exponentially small. The ground state of such a gas is a random singlet with no long-range phase correlation For $n > n_c$ repulsion between particles overcomes the disorder and the gas transits from the localized to a coherent superfluid state. The critical density n_c is calculated in terms of the disorder parameters and the interaction strength. For atoms in traps four different regimes are found, only one of it is superfluid. The theory is extended to lower (1 and 2) dimensions. Its quantitative predictions can be checked in experiments with ultracold atomic gases and other Bose-systems.

Invited Talk SYAL 1.6 Mon 16:30 BAR SCHÖ
Single-particle and many-body Anderson localizations with Bose-Einstein condensates — •Laurent Sanchez-Palencia — Laboratoire Charles Fabry de l'Institut d'Optique, 2, avenue Augustin Fresnel, Palaiseau, F-91128, France

We present our recent theoretical and experimental works on the expansion of a Bose-Einstein condensate in a disordered potential. We show that a such a system can exhibit single-particle Anderson localization under conditions that we will discuss. We determine analytically the localization and find that experimental data are in very good agreement. In addition, we show that the one-dimensional speckle potentials used in the experiments are very peculiar as they exhibit an effective mobility edge.

We also investigate the effects of disorder in a Bose-Einstein condensate at equilibrium in a regime where the interaction energy dominates over the kinetic energy. While the ground state is extended owing to the strong interactions, we show that the elementary excitations of the condensate (Bogolyubov quasi-particles) are localized. This constitutes an exemple of many-body Anderson localization in a system with strong meanfield interactions. We present a general formalism to determine analytically the localization lengths and compare them to numerical calculations in 1D.