Localization landscape for interacting Bose gases in one-dimensional speckle potentials

Filippo Stellin*[1], Marcel Filoche[2,3], and Frederic Dias[4,5]

[1]Centre Borelli – Université Paris-Saclay, Ecole Normale Supérieure Paris-Saclay, CNRS : UMR9010 – France

[2]Laboratoire de Physique de la Matière Condensée – Ecole polytechnique, IPParis, CNRS : UMR7643 – France

[3]Institut Langevin – Université Paris sciences et lettres, ESPCI Paris, PSL Research University, CNRS : UMR7587 – France

[4]School of Mathematics and Statistics, University College Dublin – Ireland

[5]Centre Borelli – Université Paris-Saclay, Ecole Normale Supérieure Paris-Saclay, CNRS : UMR9010 – France

Abstract

While the properties and the shape of the ground state (GS) of a gas of ultracold bosons are well understood in harmonic potentials, they remain for a large part unknown in the case of random potentials. Here, we use the localization-landscape (LL) theory to study the properties of the solutions of the Gross-Pitaevskii equation (GPE) in one-dimensional (1D) speckle

potentials. In the cases of intermediate and strongly attractive interactions, we find an approximate relation which allows to evaluate the disorder-averaged localization length from the nonlinear coefficient of the GPE. For weakly repulsive interactions, we illustrate that the GS of the quasi-1D GPE can be understood as a superposition of a finite number of single-particle

states. For intermediate repulsive interactions, we show numerically that, in the smoothing regime, the GS can be predicted using a Thomas-Fermi-like approach involving the effective potential, which is given by the reciprocal of the LL. Moreover, we point out that, in the Lifshitz glass phase, the particle density and the chemical potential can be well estimated by means

of the LL. Our approach can be applied for any positive-valued random potential endowed with finite-range correlations and can be generalized to higher-dimensional systems.

*Speaker