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DISORDER & INTERACTIONS: INPUT FROM NUMERICAL SIMULATIONS

Nicolas LAFLORENCIE
with F. Alet, J.P. Alvarez Zuniga, G. Lemarie, D.J. Luitz
Laboratoire de Physique Théorique, IRSAMC
Université de Toulouse, CNRS,France

Abstract:
We discuss two recent examples of disordered interacting quantum systems where stateof-the-art numerical simulations have been pushed towards their limit in order to address (at least) two questions.
(i) We first explore the nature of the $T = 0$ Superfluid to Bose-Glass transition (relevant to the superconductor-insulator transition for instance) for two-dimensional bosons in a random potential using ultra-low temperature quantum Monte Carlo simulations [1]. Very large sampling allows us to carefully measure the critical exponents and to identify an absence of self-averaging at the onset of the localized Bose-Glass regime, supporting an analogy with the glassy phase of directed polymers.
(ii) Reducing the dimensionality, many-body localization physics is studied for the Heisenberg chain in a random external field [2] using Exact Diagonalization at high energy up to $L = 22$ sites. Our results allow for an energy-resolved interpretation of the manybody localization transition including the existence of an extensive many-body mobility edge. The ergodic phase is well characterized by Gaussian orthogonal ensemble statistics, volume-law entanglement, and a full delocalization in the Hilbert space. Conversely, the localized regime displays Poisson statistics, area-law entanglement, and nonergodicity in the Hilbert space where a true localization never occurs. Very recent results [3] for nonequilibrium dynamics will be also presented for the ergodic regime, where a sub-ballistic growth of the entanglement entropy is observed with a disorder-dependent dynamical exponent.
This supports the idea of a sub-diffusive regime, whose extension in function of disorder strength will be discussed.

[1] J. P. Álvarez Zúñiga, D. J. Luitz, G. Lemarié, N. Laflorencie, Critical Properties of the Superfluid - Bose-Glass Transition in Two Dimensions, PRL 114, 155301 (2015).
[2] D. J. Luitz, N. Laflorencie, F. Alet, Many-body localization edge in the random-field Heisenberg chain, PRB 91, 081103(R) (2015).
[3] D. J. Luitz, N. Laflorencie, F. Alet, unpublished (2015).