The Abdus Salam International Centre for Theoretical Physics

Conference on Long-Range Interacting Many-Body Systems: from Atomic to Astrophysical Scales (25 - 29 July 2016)

Venue: ICTP Leonardo da Vinci Building - Budinich Lecture Hall
(tel: +39 040 2240346, fax: +39 040 224163, e-mail: smr2830@ictp.it)

Title:
Dynamics of correlations in long-range quantum systems

Speaker:
Lorenzo CEVOLANI

Affiliation:
Institut d'Optique Graduate School
Essonne, France

Abstract:

We study the out-of-equilibrium dynamics of quantum systems with long range interactions[1]. We study how (and how fast) correlations can spread in a quantum system abruptly driven out of equilibrium by a quantum quench. This protocol can be experimentally realized with ultra-cold atoms, which allow to address fundamental questions concerning the quasi-locality principle in isolated quantum systems with both short- [2,3] and long-range interactions [4]. We focus on two different models describing, respectively, lattice bosons, and spins. Our study is based on a combined approach, based on one hand on accurate many body numerical calculations [5,6], and on the other hand on a quasi-particle microscopic theory [7]. We find that, for sufficiently fast decaying interaction potential, the long-range version of the Lieb-Robinson theorem [8], is never attained and the propagation is ballistic, as predicted from the standard short-range quasi-particle point of view [9]. When the interactions are really long range the scenario is completely different in the two cases. In the bosonic system the locality is preserved and a ballistic propagation is still present while in the spin system an instantaneous propagation of correlations completely destroys locality [10]. Using the microscopic point of view we can provide a justification of all the different regimes studied in the two model and we can understand how locality is protected in the bosonic model.

[1] L. Cevolani, G. Carleo, and L. Sanchez-Palencia, Phys.Rev. A 92 041603 (R) (2016).
[2] M. Cheneau et al., Nature 481, 484 (2012).
[3] T. Langen et al., Nat. Phys. 9, 640 (2013).
[4] P. Richerme et al., Nature 511, 198 (2014).
[5] G. Carleo, F. Becca, M. Schiro, and M. Fabrizio, (Nature) Sci. Rep. 2, 243 (2012).
[6] G. Carleo, F. Becca, L. Sanchez-Palencia, S. Sorella, and M. Fabrizio, Phys. Rev. A 89, 031602(R).
[7] Stefan S. Natu and Erich J. Mueller Phys. Rev. A 87, 053607 (2013).
[8] M. B. Hastings and T. Koma, Commun. Math. Phys. 265 , 781 (2006).
[9] Pasquale Calabrese and John Cardy Phys. Rev. Lett. 96, 136801 (2006).
[10] P. Hauke and L. Tagliacozzo Phys. Rev. Lett. 111, 207202 (2013).