CRC 1227
Designed Quantum States of Matter

GUEST LECTURE

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(Guest of Prof. Dr. Klemens Hammerer)

Leibniz Universität Hannover
Welfengarten 1, 30167 Hannover
(building 1101)
Seminar room D326
at the Institute of Quantum Optics
24 January, 2019, 3:30 pm

"Dynamical Phase Transition Crossing and Relaxation of Trapped Quantum Gases"

The formation of an equilibrium state from an uncorrelated thermal one through the dynamical crossing of a phase transition is a widely-debated topic [1] at the heart of quantum many-body physics. This crossing is facilitated by a spontaneous breaking of a symmetry of the system Hamiltonian, associated with the spontaneous emergence of defects in its density. This topic was first raised by Tom Kibble in the cosmological context, and subsequently successfully applied to the condensed-matter realm by Wojciech Zurek. Such predictions, and their implications are currently being critically re-assessed in the context of quantum gases.

Using stochastic numerical simulations for experimentally-relevant conditions, I will demonstrate a clear visualization of the entire dynamical process in elongated ultracold atoms, revealing a clear demonstration of spontaneous emergence of symmetry-breaking in the critical region for Bose-Einstein condensation, and excellent agreement with experimental observations. Specifically, I will discuss decoupling of the relevant timescales for number and coherence growth, arising from the interplay of the spontaneously-generated defects and their subsequent dynamics [2]. Such findings are also of potential relevance to rapid desired initial state preparation for quantum-technological devices.

Related questions can also be addressed in the two-dimensional context, where the system can instead exhibit the Berezinskii-Kosterlitz-Thouless transition. Building on earlier work on phase-ordering kinetics in driven-dissipative (exciton-polariton) systems [3], I will discuss relaxation dynamics following an instantaneous quench across the phase transition in a two-dimensional atomic box trap.

[1] M.J. Davis, T.M. Wright, T. Gasenzer, S.A. Gardiner & N.P. Proukakis, Formation of Bose-Einstein Condensates in "Universal Themes of Bose-Einstein Condensation", N.P. Proukakis, D.W. Snoke & P.B. Littlewood (Eds) (Cambridge University Press, 2017).

[2] I.-K. Liu, S. Donadello, G. Lamporesi, G. Ferrari, S.-C. Gou, F. Dalfovo and N.P. Proukakis, Dynamical Equilibration Across a Quenched Phase Transition in a Trapped Quantum Gas, Communications Physics (Nature) 1, 24 (2018).

[3] P. Comaron, G. Dagvadorj, A. Zamora, I. Carusotto, N. P. Proukakis and M. H. Szymanska, Dynamical Critical Exponents in Driven-Dissipative Quantum Systems, Phys. Rev. Lett. 121, 095302 (2018).

All DQ-mat members and all interested are cordially invited to attend.