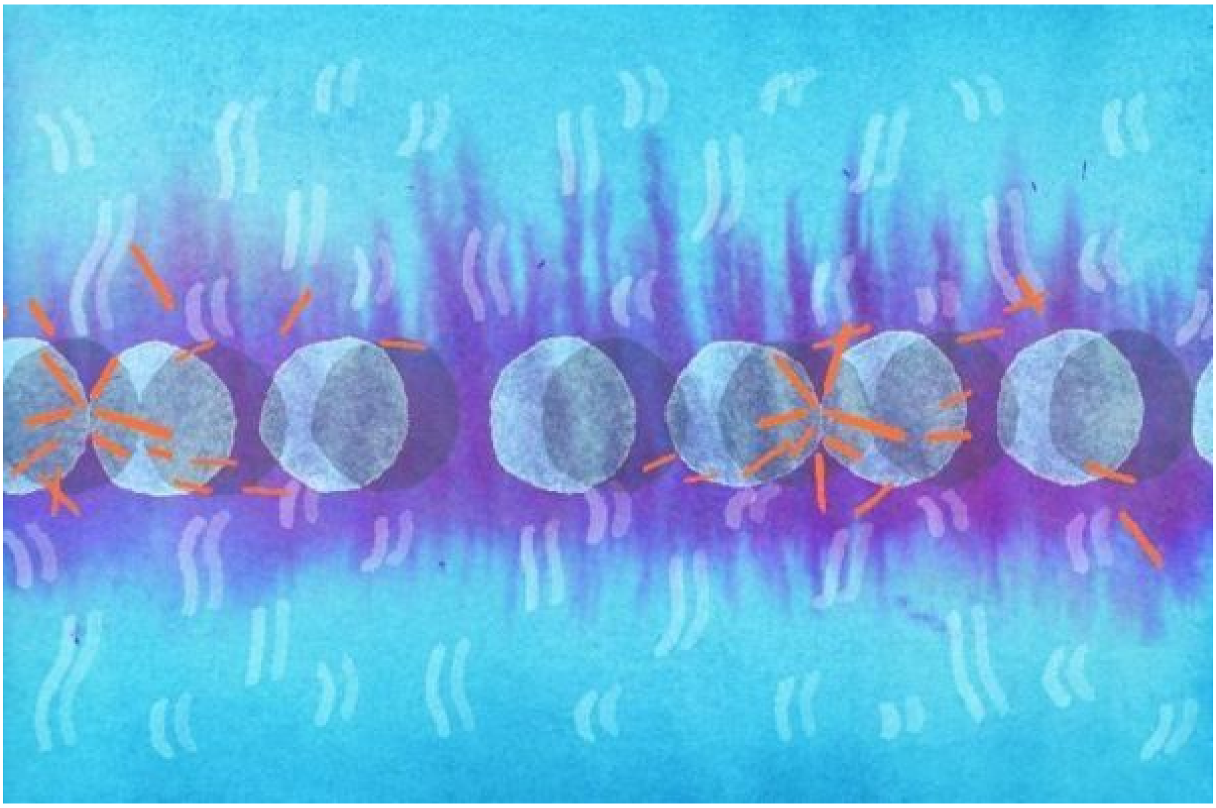

Unveiling the finite-temperature thermodynamics of a Bose gas

A team of researchers from ICFO and UPC in Barcelona developed a new theory to explain the finite temperature properties of bosons in one dimension.

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A system of particles moving along one dimension looks deceivingly simple, but it is actually an extremely sophisticated system due to the intricate interplay of thermal motion, collisions and quantum statistics. Understanding the properties of ensembles of bosons with pairwise contact repulsive interactions is crucial for both fundamental research and for the development of future quantum technologies, high-critical-temperature superconductors and quantum computers. Similar systems have been experimentally realized since 2004 with ultracold atomic gases.

At very low temperatures, the Luttinger Liquid theory provides a unified description of one-dimensional bosonic ensembles in terms of phononic excitations with a linear dispersion. As temperature increases, however, such unified picture breaks down. Higher momenta get explored and the deviation of the spectrum from the simple linear behavior becomes important. A problem which remained open until now was the understanding of the microscopic mechanisms ruling the different thermodynamic behaviors for weak and strong interactions.

In a study published this week in Physical Review Research, result of a tight collaboration between ICFO and the Universitat Politecnica de Catalunya (UPC), ICFO researchers Giulia De Rosi and ICREA Prof. at ICFO Maciej Lewenstein, together with Pietro Massignan and Grigori Astrakharchik at UPC, demonstrated that for weak interactions the finite temperature contributions to the thermodynamic variables can be accurately accounted for by Bogoliubov excitations. In the strongly-interacting regime their thermal properties instead naturally emerge from hard-sphere effects.

This study will stimulate further investigations aiming at characterizing the microscopic nature of one-dimensional Bose gases. These predictions apply to different quantum systems, such as helium liquids, quantum mixtures and impurities immersed in a bath.