Contribution ID : **105** Type : **presentation (QT PhD program student)**

Self-induced Josephson junction in a supersolid dipolar quantum gas

martedì 30 agosto 2022 18:50 (15)

Supersolid is a state of matter in which coexist both a periodic modulation, characteristic of the solid state, and the ability of the superfluid to flow without any friction. Its theoretical prediction dates back to 1960s, but it was experimentally observed for the first time few years ago, in a dipolar quantum gas. This work is based on the idea of searching for coherent tunneling phenomena, such as Josephson oscillations, in this dipolar supersolid, to demonstrate the superfluidity of the system. This phenomenon usually requires an external potential barrier through which the tunneling arises, but the intrinsic modulation of the supersolid creates minima in the potential, which act as a self-induced barrier. This gives rise to a junction that can support Josephson oscillations and the Macroscopic Quantum Self-Trapping regime. We have observed both phenomena using a 3D numerical simulation of an extended Gross-Pitaevskii equation (i.e. with the addition of first-order quantum fluctuations) and predicted the location of this transtition through a theoretical model.

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Session Classification : Students Talks 2