Protected cat states in a driven superfluid boson gas

Fernando Sols, Gregor Pieplow, and Charles E Creffield

Universidad Complutense de Madrid, Dpto. Física Materiales, Plaza de las Ciencias 1, E-28040 Madrid, Spain

We investigate the behavior of a one-dimensional Bose-Hubbard gas whose kinetic energy is made to oscillate with zero time average. The effective dynamics is governed by an atypical many-body Hamiltonian where only even-order hopping processes are allowed. At a critical value of the driving, the system passes from a Mott insulator to a superfluid formed by two quasi-condensates with opposite nonzero momenta. In some parameter range the system has similarities to the Richardson model, which permits a detailed understanding of its key features. The ground state is a cat-like superposition of two macroscopically occupied one-atom states of opposite momentum. Interactions give rise to a reduction (or modified depletion) cloud that is common to both macroscopic branches. Symmetry arguments permit a precise identification of the two orthonormal, macroscopically distinguishable many-body states yielding the cat state, each involving a large number of momentum configurations. In the ring, the system is sensitive to variations of the effective flux but in such a way that the macroscopic superposition is preserved. We discuss other physical aspects that contribute to protect the cat-like nature of the ground state.

[1] G Pieplow, F Sols, C E Creffield, New J. Phys. 20 (2018) 073045.

[2] G Pieplow, C E Creffield, F Sols, arXiv:1905.13596 (2019).