Supertakumas ir sukinio supertakumas spinorinėse Bozė dujose

Superfluidity and spin superfluidity in spinor Bose gases

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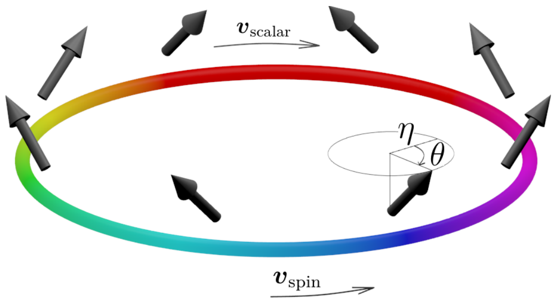

Fig. 1. By counterflowing, a supercurrent and a spin supercurrent create a stationary state with no mass flow in a spinor Bose gas on a ring. In a uniform-density system, the supercurrent $\boldsymbol{v}_{\rm scalar}$ is due to the global phase texture of the atomic condensate (indicated by color online), whereas the spin supercurrent $\boldsymbol{v}_{\rm spin}$ is due to the in-plane magnetization texture (indicated by arrows which can be recast in terms of a phase θ) of the magnon condensate with a measure of the condensate fraction η. The two textures can be independently engineered in a ferromagnetic spinor Bose gas.

We show that spinor Bose gases subject to a quadratic Zeeman effect exhibit coexisting superfluidity and spin superfluidity, and study the interplay between these two distinct types of superfluidity. To illustrate that the basic principles governing these two types of superfluidity are the same, we describe the magnetization and particle-density dynamics in a single hydrodynamic framework. In this description spin and mass supercurrents are driven by their respective chemical potential gradients. As an application, we propose an experimentally accessible stationary state, where the two types of supercurrents counterflow and cancel each other, thus resulting in no mass transport. Furthermore, we propose a straightforward setup to probe spin superfluidity by measuring the in-plane magnetization angle of the whole cloud of atoms. We verify the robustness of these findings by evaluating the four-magnon collision time, and find that the time scale for coherent (superfluid) dynamics is separated from that of the slower incoherent dynamics by one order of magnitude. Comparing the atom and magnon kinetics reveals that while the former can be hydrodynamic, the latter is typically collisionless under most experimental conditions. This implies that, while our zero-temperature hydrodynamic equations are a valid description of spin transport in Bose gases, a hydrodynamic description that treats both mass and spin transport at finite temperatures may not be readily feasible.

Reikšminiai žodžiai: superfluid, spin superfluid, ultracold atomic gas

Literatūra

[1] J. Armaitis and R. A. Duine, Phys. Rev. A **95**, 053607 (2017).