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Excitation of Bose-Einstein condensates with temporal resolution in separate zones

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One manifestation of superfluidity in a Bose-Einstein condensate (BEC) is the emergence of the so-called collective modes. Due to the breaking of gauge symmetry U, the system acquires a macroscopic wavefunction with a global phase that can be described by the Gross-Pitaevskii equation (GPE) under a mean-field treatment, where, by an hydrodynamic description, the eigenfrequencies of those modes can be obtained. (1) We start by considering a BEC made of 87Rb atoms with repulsive interaction in an anisotropic harmonic magnetic trap under action of an oscillating magnetic field being applied at the BEC elongated direction, which firstly causes an abrupt change in the potential and excites the cloud's center of mass motion around the minimum of the potential. (2) This mode is known as the dipolar mode. Besides the dipolar mode, collective modes inherent to the shape of the BEC might be exciting. In that case, the so-called quadrupole mode and the breathing mode may arise, characterized by out-of-phase and in-phase oscillations of the BEC widths, respectively. The oscillation frequency of these modes is strongly dependent on the non-linear contribution of the GPE related to the system's interaction and the configuration of the trap anisotropy. The emergence of these highly coherent modes when externally excited offers an interesting analogy with an atom being irradiated by a resonant laser beam. Despite the fundamental differences between the two systems, they share a fundamental common property - coherence. This analogy raises the idea of achieving precise control over these coherent modes in a BEC, inspired by the Rabi and Ramsey experiments. In order to do that, the external oscillation will be modulated by a signal which can be either Rabi-like or Ramsey-like. The difference between them is the splitting of a square pulse into two separate zones, which enables interference phenomena in the resonance curve such as the Ramsey fringes. (3) Moreover, with this method, for strongly excited samples using the Ramsey-like procedure, we expect to be able to analyze the persistence of coherence of these samples as a consequence of interference from a fragmented BEC. Thus, the main proposal of this work is the development of theoretical models and the elaboration of computer simulations that will reproduce the experiments that are currently being carried out in order to get more knowledge about how an external signal can modulate and also select a specific path in the route of turbulence.

Palavras-chave: Coherence. Ramsey fringes. Quantum turbulence.

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