Excitation of Bose-Einstein Condensates Through the Separate Fields Technique

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We propose a new approach to excite a Bose-Einstein condensate by introducing perturbations to the trapping potential through the separate fields technique, originally introduced by Norman F Ramsey. We employed the variational method based on the Thomas-Fermi wave function Ansatz to obtain dynamical equations governing the radii of a Bose-Einstein condensate when under external perturbations. The obtained dynamical equations allow us to construct the resonance curves for the collective modes of Bose-Einstein condensates, specifically focusing on the dipole, quadrupole and breathing modes. We observed that depending on whether the external signal is modulated by the Rabi or Ramsey procedure, the system behaves differently due to its inherent coherence, that reflects on the resonance curve of the collective modes, giving rise to the Ramsey fringes in a clear interference pattern, enabling a more precise frequency measurement. With the insights offered by the variational method, we introduced an alternative model to describe the dynamics of collective modes based on a three-level system, which proved to be consistent with the variational model. Moreover, the three-level model provided a framework for fostering the idea of coherent control by manipulating the population associated with collective modes through the application of perturbation pulses, such as a π-pulse and a $\pi/2$-pulse. As a complementary study, we numerically solved the three-dimensional Gross-Pitaeviskii equation to analyze the presence of collective modes in the regime far from equilibrium. Lastly, we present some prospects using the Ramsey protocol for the understanding of quantum interference phenomena in BECs and the generation of quantum turbulence.