Critical Effects in the Dynamical Behavior of a Bose-Condensed Gas

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The macroscopic population of the quantum-mechanical ground state of a confining potential is the Condensation recently achieved [1]. A natural question that can be raised is. Is it possible to realize the macroscopic population of some other quantum-mechanical state? The answerto this question is yes. The details concerning the possibility of creating non-ground state BEC is been recently presented by us [2]. Such a non-equilibrium state can be obtained through a population transfer from the ground state to a non-ground state using an external pumping field.

Subject to the action of the external oscillatory field the population dynamics shows interesting new effects [3]. Unusual critical effects are found exhibiting sharp qualitative changes. Considering the normalized pumping amplityde (b) and the normalized detening (δ) as controlable parameters a critical line appears for $b + \delta \cong 0.5$. Crossing this line, the occurrence of bifurcation in this dynamical system is some what analogous to phase transition and critical phenomena in equilibrium statistical systems. To elucidate this analogy, we consider the time-overaged behavior of the populations through the definition of an effective Hamiltonian that generate the evolution equationspreviously determined. An order parameter can be defined for the average system, as well as a heat capacity and susceptibility. Aroung the critical point all those quantities present sharp variations or divergency characterizing the phase transition. This is the first prediction of a critical effect whitin a BEC and may revel interesting and importanty macorscopic effects.

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