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Mean-field transition and fluctuation phenomena in a modulated cold atom system

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Periodic modulation of a magneto-optical trap can lead to parametric resonance with excitation of atomic vibrations at half the modulation frequency. For a small number of trapped atoms such resonance was seen earlier as the onset of counterphase vibrations of two atomic clouds, which were equally populated [1]. Later it was observed that, as the number of trapped atoms increases, the populations of the clouds become different [2]. This indicates spontaneous breaking of the symmetry with respect to time translation by the modulation period: it takes two periods for the system to go back to its state. We show that the effect is an ideal mean-field transition [3], with the order parameter proportional to the population difference. We describe the observations of the dependence of the order parameter on the control parameters, including nonanalytic field dependence at the critical point. We also describe anomalous behavior of the population variance. A microscopic theory of the symmetry breaking transition is developed. The transition is explained as resulting from the interplay of the long-range interatomic interaction and nonequilibrium fluctuations in the strongly modulated system. The mechanism is the modulation by the interaction, and ultimately by the cloud populations, of the effective barrier [4] that atoms have to overcome in order to switch between the clouds. The theory fully describes the observations.

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