자기 광학적 포획에서 맺음변수 구동으로 형성된 두 끌개 사이의 대칭성 깨짐 현상

Symmetry Breaking between two Dynamic Attractors in the Parametrically-driven Magneto-optical Trap

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After Maxwell's Demon thought experiment[1], when there occur a symmetry breaking (SB) of temperature or population between two separated compartments filled with gas, it has been natural to search out underlying mechanism not explicitly revealed in the system. It is widespread in nature with examples from cosmology to biology and numerous studies about the symmetry breaking have been studied[2]. Through the thought experiment, the second law of thermodynamics were developed and clearly understood with the concept of entropy. Recently in a vibro-fluidized granular gas, spontaneous SB of temperature and population between two boxes connected by a hole of certain height, were reported and understood by density dependent inelastic collision rate[3] and employed to rachet[4].

Nowadays there have been lots of studies about fluctuation-induced transitions in equilibrium[5] and far from equilibrium states[6][7]. The double well structure of those systems are very similar to that of the box separated into two compartments of the same section. When there are diffusions which comes from thermal noise or spontaneous emissions the populations of both states are nearly same except some fluctuations. Surprisingly, in our parametrically driven magneto-optical trap (MOT) we have observed at certain experimental conditions the number of atoms in one state was much different from that of the other. Because in our system the atoms in each state are nearly non-interacting ideal gas, which is much different from the granular particles, those number symmetry breaking between two states in our system are very strange and need to understand the underlying mechanism.

In this abstract we report the experimental investigations of the SB, theoretical model that explains the phenomena very well, and quantitative simulation results compared to the experiments. We have found the most important factor to cause SB was the total number of atoms in both states. The critical numbers have been measured by slowly increasing and decreasing total number of atoms. We have also studied the critical populations at various modulation frequencies and modulation amplitudes and compared them to the developed theoretical and simulation results. To explain SB collective effects of laser-atom interactions, shadow effect[8] and radiation trapping effec t[9], were considered. According to our calculations shadow effect caused by absorptions of atoms in

the cloud produce an asymmetry in dynamic double potentials in phase space, which result in SB of populations between double states.

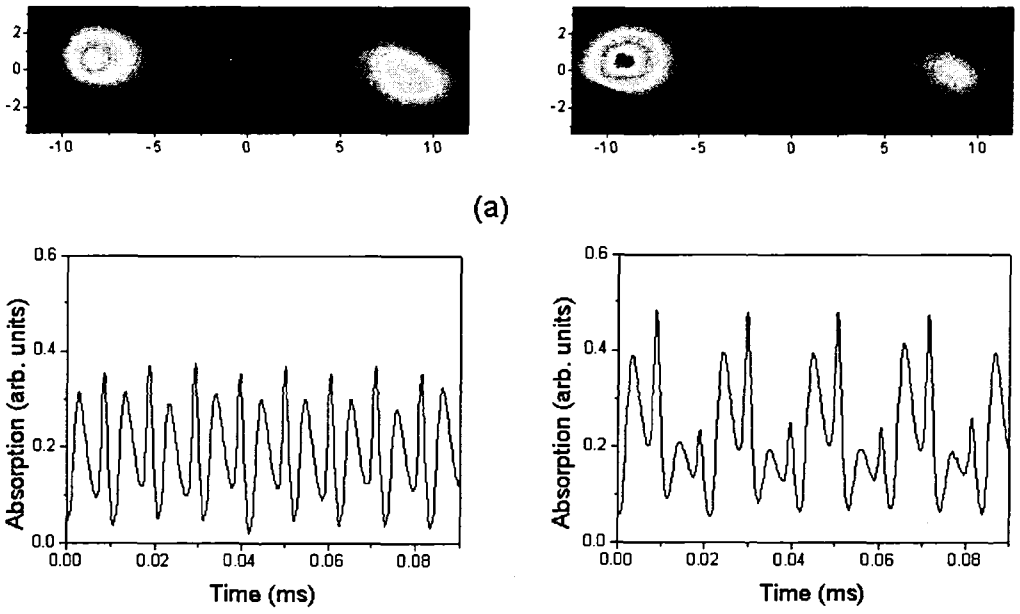

Figure 1 (a) The CCD image of symmetry state (Left) and asymmetry state (Right). These were taken at 270° phase relative to the modulation. (b) The absorption of probe laser at the same conditions to (a). These were from 11th channel of the photodiode array. These were done at f = 96 Hz (2.19 f_0), h = 0.9.

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