

자기 광학적 포획에서 맷음변수 구동으로 형성된 두 끌개 사이의
자발적 대칭성 깨짐

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

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Nonlinear system driven by a sufficient strong periodic field often display period doubling. In the presence of noise, there occur fluctuational transitions between the period-two attractors, which correspond to phase flip of the system by π . Most of the cases the transition rate is symmetric. But if there is an asymmetry in the potential, even a small asymmetry lead to a parametrically large difference in the activation energies of interwell transitions in opposite directions, giving rise to a current in a double-well potential.⁽¹⁾

We have experimentally observed an asymmetry between the numbers of atoms in period-two attractors in a parametrically driven magneto-optical trap. The asymmetry is mainly dependent on the total number of atoms in the attractors, that is, the symmetry breaking between the two states happens above some critical number.

By Monte-Carlo simulation, we concluded that the origin of the asymmetry is the shadow effect of atom clouds, which cause the imbalance of laser intensities.

We calculated the noise induced transition rate between two attractors⁽²⁾ and showed that the shadow effect cause the difference of transition rate between two attractors.

For large number of atoms in the parametrically driven magneto-optical trap, nonequilibrium phase transition take place with a spontaneous symmetry breaking entailing the appearance of a current in the absence of an external force.⁽³⁾

These phenomena have an Ising model like nature such as phase transition and fluctuation divergence, where the critical parameter is total number instead of temperature.

With this model, the solutions of transition rate equation are in well agreement with the experiment results.

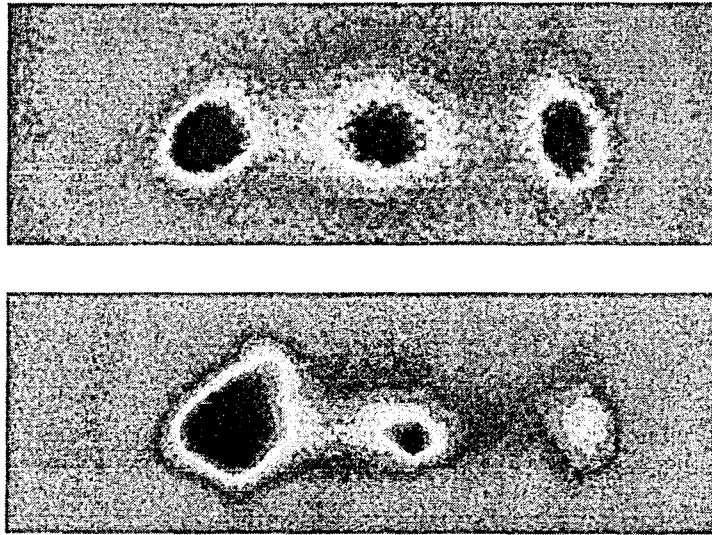


Fig1. Symmetric attractors in the parametrically driven MOT system(Upper).
Asymmetry suddenly occur when the total number of atoms increase(Lower).

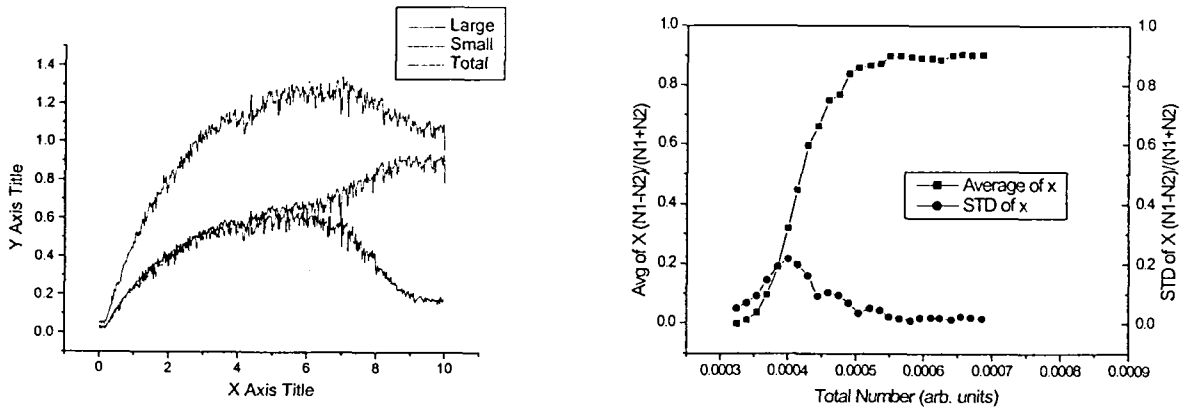


Fig2. Aspects of symmetry breaking. Symmetry breaking take place above some critical number(Left). The number difference of two attractors and the STD of number difference, which is like Ising model(Right).

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