Collision Dynamics of ^{87}Rb Spin-2 Bose-Einstein Condensates

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We have experimentally studied elastic and inelastic collision dynamics of $F = 2$ ^{87}Rb Bose-Einstein condensates (BEC) in an optical trap. The $F = 2$ BEC is thought to have a new magnetic response in comparison with $F = 1$ BEC, and to have many interesting spinor dynamics owing to its rich variety of internal degrees of freedom. In condition of $m_{\rm F} = 0$ state populated initially, we observed other magnetic states, which is spin relaxations to $m_{\rm F} = \pm 1$ and $m_{\rm F} = \pm 2$, and the population oscillation between these states at certain magnetic field strength because of spin-mixing [1].

Starting with $m_{\rm F} = \pm 2$ states with almost same population at weak magnetic field strength, we found no spin relaxations of the two components in the trap as shown in Fig. 1. These results are clear evidence for polar behavior and strongly suggest that the ground state of $F = 2$ ^{87}Rb BEC is antiferromagnetic [2]. When the condensated atoms were initially prepared in imbalanced population between $m_{\rm F} = \pm 2$, decay of the number of atoms depended on the population ratio of $m_{\rm F} = +2$ (see Fig. 2). We calculated number of atoms with imbalanced population by population-dependent rate equation for two-body loss that described spin-selective inelastic collision. The results were in good agreement with the experimental ones. The property of two-body inelastic collision between different spin states plays an important role in investigation of spinor-BEC dynamics including the ground state property.

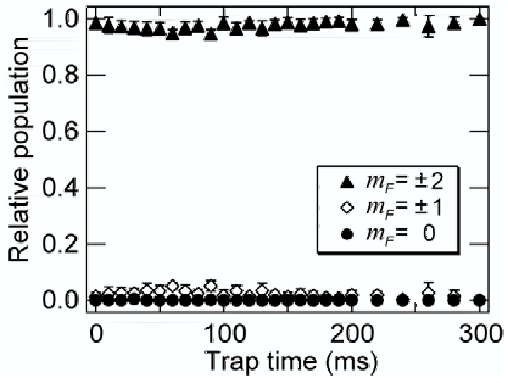

Fig. 1: Trap-time dependence of relative population in the magnetic sublevels of $F = 2$ with initially populated to $m_{\rm F} = \pm 2$.

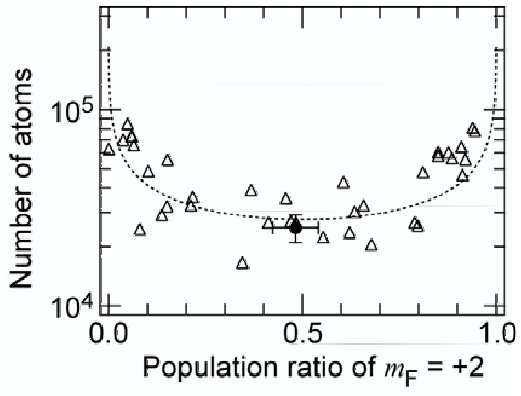

Fig. 2: Number of atoms in various relative populations of $m_{\rm F} = +2$ and $m_{\rm F} = -2$ states at a trap time of .280 ms (open triangles). Closed circle shows averaged data in the range from 0.45 to 0.55 of the relative population. Dotted curve is calculation result.

[1] T. Kawamoto et al., Phys. Rev. **A** 69, 063604 (2004).
[2] H. Saito and M. Ueda, Phys. Rev. **A** 72, 053628 (2005).