

(MOT) laser for 150ms and play the holograms movie to make the trap shape transformation and to allow atom transfer between traps, (2) switch on the MOT light to induce collisions and detect the atoms in the single MFORT for 60ms. The time bin of the single photon counting module (SPCM, EGG AQRH-14-FC) is 20ms. We get the final results for 200 shots as shown in Fig. 3(c). From the signal we can learn that two atoms could not stay in the same MFORT under the MOT light. This is just the direct confirmation of the "collision blockade" that would occur between trapped atoms in the ultra small trapping volume [2]. The one body loss rate is about 15.5% derived from Fig. 3(c).

But we cannot distinguish a two-atom loss and one-atom loss from two uncorrelated two-atom losses and one-atom loss during the transformation of the computer generated holograms, we quantify the latter by carrying out the entire experimental sequence with only one atom in double well. Figure 3(d) is the accumulated signal after 200 shots. It indicates that single atom would be transferred from lattice to single trap with high success rate. The probability is 96.5%. From this, we can omit the uncorrelated two-atom losses rate with 0.1% in our experiment. The uncorrelated one-atom loss probability from the double well is about 7.0%. So the success rate of inserting two atoms into a single microscopic dipole trap is larger than 90%.

The one-atom loss during switching of computer generated holograms is due to reduced first-order diffracting efficiency and shallower trap potential. The energy distribution of the single atom in the dipole trap is thermal and has the Boltzmann distribution. Adiabatic lowering of the trap depth would lead to atoms with a higher energy escaping. And the survival probability of the atom remaining in the dipole trap after the truncation of the Boltzmann distribution is given by [23]:

$$P_{surv}(\rho) = 1 - (1 + \rho + 0.5\rho^2)e^{-\rho}, \quad (5)$$

where $\rho = E/k_B T$, E is trap potential, and $k_B T$ is the mean energy of trapped atoms. For our experimental parameters, the mean energy of trapped atoms loading from the MOT is about $70\mu K$ and the intermediate lowest trap potential is about $0.5mK$. So survival probability of single atoms is about 0.97 calculated from Eq. (5).

Collision leading to atom loss in the presence of near-resonant laser light is governed by the long-range resonant dipole-dipole interaction including radiative escape (RE), fine-structure-changing collisions (FCCs), which can be described by a simple semiclassical model called Gallagher-Pritchard model [24,25]. Asymptotically, the potential is of the form $V_{S+P} = -C_3/R^3$ for one atom in the ground and the partner atom in the excited state. For RE progress, spontaneous emission of a photon red-shifted from the atomic resonance can take place. The resulting kinetic energy gained by collisional atoms has a continuous distribution. If spontaneous emission does not occur, the atoms oscillate on the quasimolecular potential curve until they undergo a change of fine structure, and because of the large fine structure splitting (300K) in Rb, this process always causes an escape of both atoms from the shallow dipole trap. So we can learn that RE collision progress would response to the correlated one-atom loss event, in our experiment the probability is about 8%.

4. Conclusion

In conclusion, we have presented a simple implementation method of inserting two ^{87}Rb atoms into a single MFORT with high efficiency larger than 90%, and observed the strong interaction between these atoms leading to light-induced collisions. With this method, we could also trap two single ^{85}Rb atoms and bring them together to show the isotopic difference in trap loss collisions of laser cooled rubidium atoms [26] or we could combine one ^{87}Rb and one ^{85}Rb atom trapped in both sites of the double well to study the heteronuclear excited state-ground state collisions [27]. Determinate two atoms trapped in an MFORT can show how van der Waals

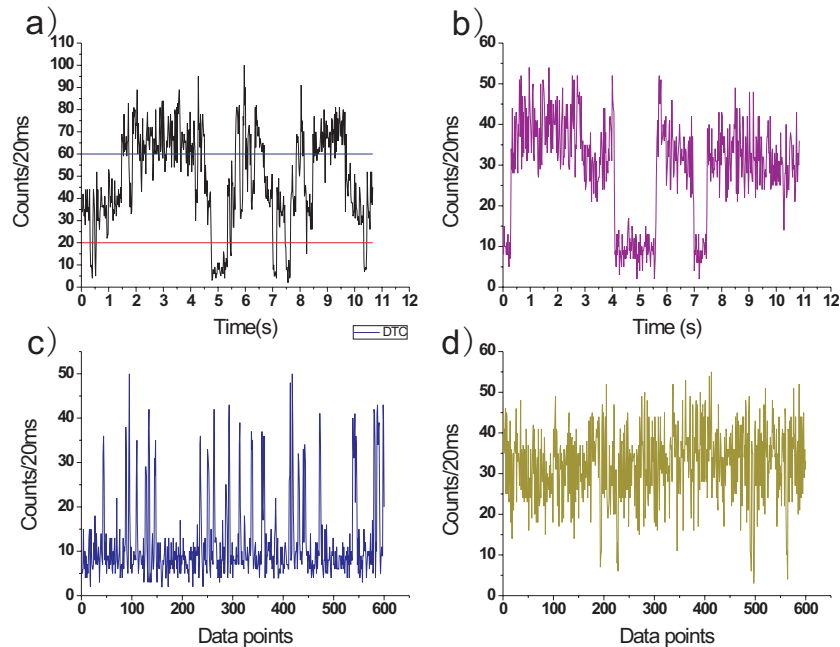


Fig. 3. (color online) Observed fluorescence of single atoms. Each point corresponds to a 20 ms time bin. Shown in (a) is the fluorescence signal from the whole two traps in the double well ring lattice. (b) is the fluorescence signal from atom in the single Gaussian trap. (c) is the accumulated fluorescence signal from single trap after two atoms trapped in the ring lattice being injected into single trap, total 200 shots in the signal, 3 points in each shot. (d) is the the accumulated fluorescence signal from single trap after single atoms trapped in either part of the ring lattice being inserted into the single trap, total 200 shots in the data, 3 points for each shot.

interactions lead to dephasing of the Rabi oscillations between ground and Rydberg States, and elucidate the role of Förster zero states in the dephasing [28]. Further, the technique can make possible many fascinating experiments, e.g. making single trapped diatomic molecules by using photoassociation, preparing an entangled Bell pair of atoms by exploiting coherent spin-changing collisions between two atoms trapped in a single trap, provided that motional state control of the atoms can be achieved. All of these works will finally lead to the quantum information processing with neutral atoms.

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