Two-component Bose-Einstein condensate on an atom chip

R. Anderson, B. V. Hall, P. Hannaford, and A. I. Sidorov
ACQAO, Swinburne University of Technology, Australia

Atom chips provide a flexible and scalable platform for applications of cold atoms and Bose-Einstein condensates (BECs) in future quantum technologies including miniaturised atomic clocks, quantum information processing and quantum sensors. Our project studies the coherent properties of a two-component BEC prepared on a magnetic film atom chip [1] using a two-photon microwave/radio-frequency transition. At a particular value 3.23 G of the magnetic field two hyperfine states $|F = 1, m_F = -1>$ and $|F = 2, m_F = 1>$ in ^{87}Rb exhibit a low differential Zeeman shift (431 Hz/G^2) and can be trapped simultaneously with long dephasing times. The coherent superposition of these two states has a long coherence time [2] and is attractive for applications in quantum atom devices.

We produce a Bose condensate of 10^5 rubidium atoms either in the $|F = 1, m_F = -1>$ state or in the $|F = 2, m_F = 2>$ state using a standard arrangement of a Z-shaped current and a bias magnetic field on the hybrid atom chip [1]. The microwave field of frequency 6.83 GHz is generated by a programmable Agilent E8257D signal generator, amplified by 40 dB and delivered to a helical antenna located outside the vacuum chamber. The radiofrequency radiation is applied to a side wire on the chip. We have characterized the coupling of RF and microwave fields to the corresponding transitions and observed Ramsey fringes in the time domain. Using RF outcoupling of the trapped $|F = 2, m_F = 2>$ BEC we observed Rabi oscillations of the atoms between five Zeeman levels of the $F = 2$ state (Fig. 1) and estimate a resonance single-photon Rabi frequency of 10 kHz. When we applied a pulse of microwave/radiofrequency fields of variable duration to the BEC in the $|F = 1, m_F = -1>$ state we observed Rabi oscillations and evaluated a two-photon Rabi frequency of 736 Hz. We applied two time-separated $\pi/2$ pulses of microwave/RF fields to a cold thermal cloud of atoms trapped in the $|F = 1, m_F = -1>$ state and observed Ramsey oscillations with a decay time of 800 ms (Fig. 2).

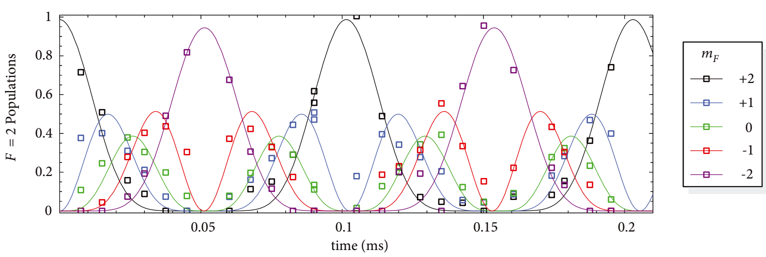

Figure 1: Rabi oscillations of BEC between five Zeeman levels of the $|F = 2>$ state. Squares are experimental results and curves are the results of numerical simulations.

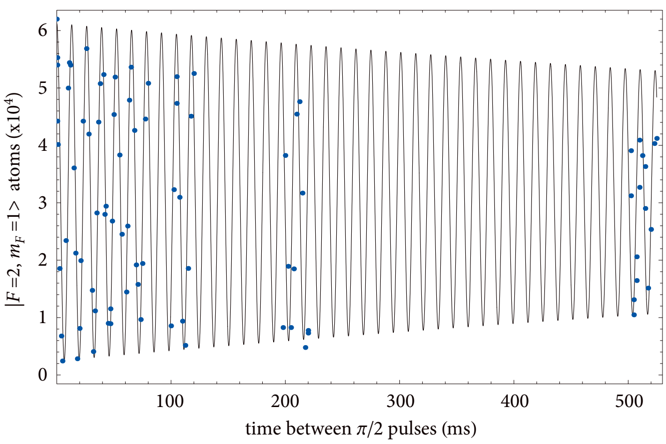

Figure 2: Ramsey oscillations of the cold atomic cloud, initially prepared in the $|F = 1, m_F = -1>$ state. The measurable signal is the population of the atoms detected in the upper $|F = 2, m_F = 1>$ state. Dots are experimental results and the curve is the fit.

References

[1] B.V. Hall, S. Whitlock, F. Scharnberg, P. Hannaford and A. Sidorov, J. Phys. B **39**, 27 (2006).
[2] P. Treutlein *et al*, Phys. Rev. Lett. **92**, 203005 (2004).