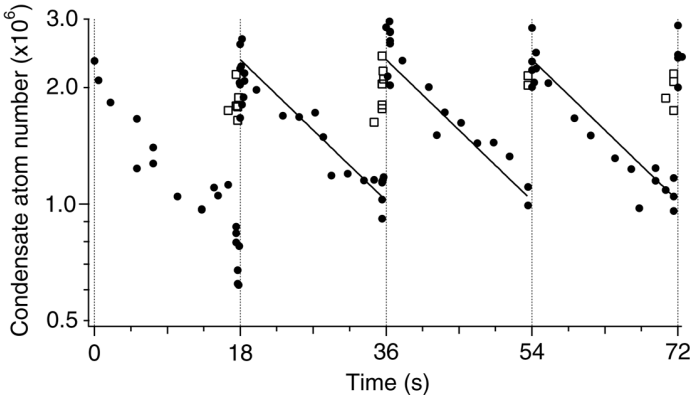
A continuous source of Bose-Einstein condensed atoms

Unlike other macroscopic quantum systems such as superfluid ^{4}He and optical lasers, dilute gas Bose-Einstein Condensates have so far been only produced in a pulsed mode. We have realized a continuous BEC source by periodically replenishing a condensate held in an optical dipole trap with new condensates [1]. A moving optical tweezers for Bose-Einstein condensates [2] was used to transport condensates from where they were produced into a reservoir optical trap. The freshly produced condensates periodically replenished the condensate in the reservoir trap, thereby continuously maintaining a condensate of more than 10^6 atoms (see figure).

The crucial step in realizing a continuous BEC source was to make sure that the new cooling cycle did not destroy the condensate held in the reservoir trap. This involved shielding it from light during laser cooling, keeping it far away from the incoming hot atoms, and to hold it in an optical trap which made it immune against stray magnetic fields which were created during the evaporative cooling phase.

An interesting aspect of the continuous BEC is its phase. The freshly prepared condensates have a random phase relative to the condensate in the reservoir trap, and therefore, in the current experiment, the phase of the source after replenishment was random relative to the phase before the merger. In principle, it would be possible to replenish a stationary continuous BEC source with an incoming moving condensate using phase coherent amplification [3, 4]. By outcoupling atoms from a continuous BEC source one can realize continuous atom lasers.



A continuous source of Bose-Einstein condensed atoms. The solid circles in the semi-log plot represent the atom number in the continuous reservoir and the open squares show the number of condensate atoms transferred from the production chamber. The dashed lines indicate the beginning of a new cycle and the solid lines are exponentially decaying curves determined by a simultaneous fit to the three cycles after the first cycle. The number of atoms for each data point was obtained from separate absorption images.

1. A.P. Chikkatur, Y. Shin, A.E. Leanhardt, D. Kielpinski, E. Tsikata, T.L. Gustavson, D.E. Pritchard, and W. Ketterle, *A Continuous Source of Bose-Einstein Condensed Atoms*, Science **296**, 2193 (2002), published online in Science Express on May 16, 2002.

2. T.L. Gustavson, A.P. Chikkatur, A.E. Leanhardt, A. Görlitz, S. Gupta, D.E. Pritchard, and W. Ketterle, *Transport of Bose-Einstein Condensates with Optical Tweezers*, Phys. Rev. Lett. **88**, 020401 (2002).
3. S. Inouye, T. Pfau, S. Gupta, A.P. Chikkatur, A. Görlitz, D.E. Pritchard, and W. Ketterle, *Observation of phase-coherent amplification of atomic matter waves*, Nature **402**, 641 (1999).
4. M. Kozuma, Y. Suzuki, Y. Torii, T. Sugiura, T. Kuga, E.W. Hagley, and L. Deng, *Phase coherent amplification of matter waves*, Science **286**, 2309 (1999).