Ultra-high flux atom-lasers

V. Bolpasi[1,2], N.K. Efremidis[1,3], M.J. Morrissey[1,4], P.C. Condylis[1,5], D. Sahagun[1,5], M. Baker[1,6], and W. von Klitzing[1]

[1] *IESL-FORTH, Vassilika Vouton, GR-71110 Heraklion, Greece*
[2] *Physics Department, University of Crete, GR711 03, Heraklion, Crete, Greece*
[3] *Applied Mathematics Department, University of Crete, P.O. Box 2208, 71003, Heraklion, Greece*
[4] *Quantum Research Group, University of KwaZulu Natal, Westville, Durban 4000, South Africa*
[5] *Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543, Singapore*
[6] *School of Mathematics and Physics, The University of Queensland, Brisbane QLD 4072, Australia*

Presenting Author: atomlaser@bec.gr

We couple strongly the magnetic hyperfine states of the atoms using a strong rf-field and use this to trap Bose-Einstein condensates in time-dependent adiabatic potentials (TDAP). We manipulate these potentials such that a well collimated, extremely bright atom laser emerges from a small spot just below the condensate.

Traditionally atom lasers are produced by a weak rf-field or a weak Raman beam, which resonantly outcouples a small fraction from within the BEC. The atoms then traverse the BEC and accelerate downwards under the influence of gravity. The maximum flux achievable from a given condensate increases with the strength of the coupling field. At high field strengths, however, it is fundamentally limited by the emergence of bound states [1].

The flux of the TDAP atom laser does not suffer from such limits, which allowed us to demonstrate a record flux of 7.4×10^7 atoms/s. In therm of flux per trapped atom this is more than an order of magnitude larger than any other continuously outcoupled atom laser achieved so far [1].

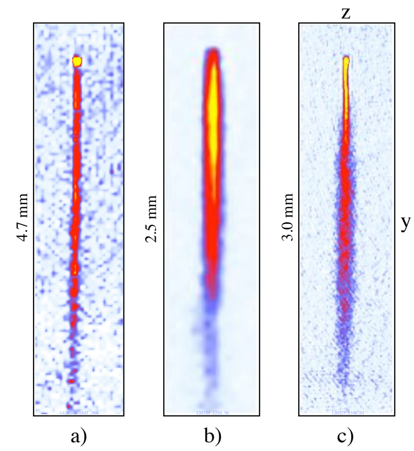

Figure 1: *Images of atom-lasers after time-of-flight expansion. a) Pure atom laser of 2 ms duration with a divergence of only 10 mrad. b) Atom laser with a flux of up to 7.4×10^7 atoms/s. c) Atom beam combining atom laser and thermal emissionPlease note the different vertical scales in the three plots. Supplementary material can be found here [2].*

Furthermore, we produce the coldest thermal beam to date (200 nK). Finally, we observe, for the first time, an atom beam containing both an atom laser and a thermal atom beam.

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References

[1] J. E. Debs *et al.* Phys. Rev. A **8**1:2 013618 (2010)

[2] Supplementary material at `http://www.bec.gr/publication`