Towards a Steady-State Atom Laser

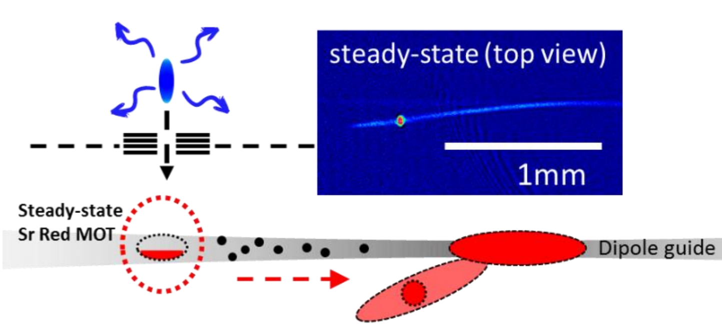
R. G. Escudero, C.-C. Chen, S. Bennetts, J. Samland, B. Pasquiou, and F. Schreck
Van der Waals - Zeeman Institute, Institute of Physics, University of Amsterdam

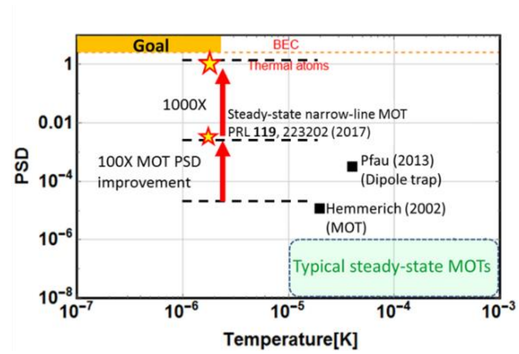
So far BEC and atom lasers have only been demonstrated as the product of a time sequential, pulsed cooling sequence. For applications such as next generation atomic clocks, super-radiant lasers or atom-interferometers for gravitational wave detection, a steady-state source of degenerate atoms offers great advantages.

However, the goal of producing a steady-state BEC or atom laser has long been thwarted by the incompatibility of laser cooling with evaporative cooling.

In this work we demonstrate creation of a steady-state strontium sample with a phase-space density approaching degeneracy, reaching, a critical step towards demonstrating steady-state atom lasers.

We achieve this by cooling atoms on a broad 30-MHz and narrow 7.4-kHz linewidth Sr transitions, in two spatially separated regions [1]. To obtain colder and denser samples, we continuously load the atomic cloud into a dipole guide beam transporting the atoms out of the MOT region. Next, we decelerate the atoms to load a dimple trap which we protect from laser cooling light by using a “Transparency beam” which stark shifts atoms in the dimple region out of resonance from the laser cooling light [2]. This experimental architecture allows us to reach unprecedented steady-state phase-space densities approaching quantum degeneracy.





[1] S. Bennetts et al., Phys. Rev. Lett. 119, 223202 (2017).

[2] S. Stellmer et al, Phys. Rev. Lett. 110, 263003 (2013).