Actively stabilising the output of an atom laser

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Atom lasers have the potential to revolutionise future atom optic devices where a high brightness source of atoms is required. Indeed, continuous atom lasers may prove superior in precision measurements where presently optical and mechanical techniques are conventionally used. For this to become a reality, however, frequency and amplitude noise on the atom laser beam which limit its stability will need to be eliminated. As is the case for the optical laser active stabilisation offers a possible solution to reduce noise on the output of an atom laser.

Here we report the first implementation of active feedback to stabilise a continuous wave (CW) RF atom laser[1]. An error signal derived from ions produced during the formation of the atom laser, with appropriate gains and sign, is fed back to the RF output-coupler, locking the output-coupling surface inside the condensate. The noise we are correcting for is fluctuations in the magnetic trap bias which result directly in frequency fluctuations that manifest themselves as amplitude fluctuations on the atom laser mode. By actively compensating for this noise the scheme reduces both frequency and amplitude noise on the atom laser and, in principle, also stabilises the spatial mode.

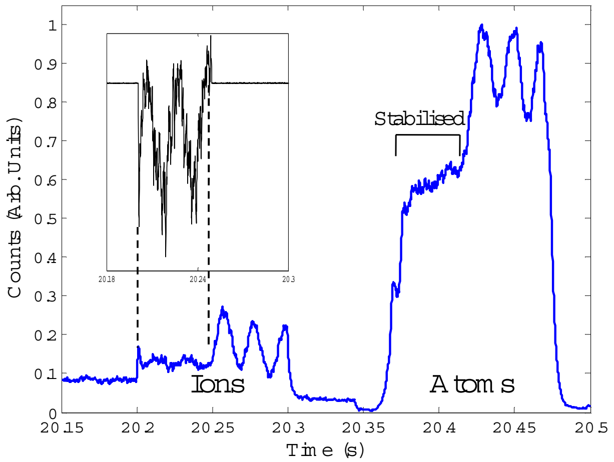

Fig. 1: Electron multiplier trace, averaged over four runs of the experiment, demonstrating stabilisation of the atom laser beam. The ion signal is first to arrive on the left of the trace, while the atom signal arrives $\sim$ 150 ms later which is the time of flight from the BEC to the EM. Shown in the inset is the output of our control circuitry.

In summary we have demonstrated the first successful atom laser stabilisation scheme. Besides being able to stabilise the output of an atom laser, a similar technique might be used to stabilise oscillations in a BEC. In many BEC experiments the trap frequency is altered and under some circumstances this can lead to excitation of unwanted modes. Since these oscillations can lead to density changes they should be detectable in an ion signal, which could then be used to feedback to the relevant magnetic trap currents.

References

[1] M.-O. Mewes *et al.*, Phys. Rev. Lett. **78**, 582 (1997).