Experimental comparison of outcouplers for high flux atom lasers

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Atoms interact strongly with their environment, and this sensitivity to, for example, inertial and electro-magnetic forces makes atom interferometers a promising choice for applications as ultra-sensitive detectors of magnetic, optical, and inertial effects. Measurement devices consisting of atom interferometers based around the coherent atomic samples known as Bose-Einstein condensates (BECs) and atom laser beams outcoupled from a BEC are of particular interest due to the possibility of using squeezing to enhance the interferometric sensitivity [1, 2]. In order to fully explore the potential of atom lasers for interferometry, there are stringent requirements on the beam properties, and hence the outcoupler used to achieve this. As with optical interferometry, we desire high flux, low divergence and a simple spatial mode.

In this work, we compare the properties of three differently outcoupled atom laser beams. One outcoupler is based on multi-state radio frequency transitions and two others are based on Raman transitions capable of imparting momentum to the beam.

We have experimentally verified that a two-state Raman outcoupling scheme which imparts momentum to the atoms, results in a larger maximum flux than rf outcoupling or outcoupling from multi-level systems. Coupled with the previous work on divergence and the spatial mode of Raman outcoupled beams [3, 4], it is now clear that a two-level Raman outcoupler produces the highest brightness atom laser beam of any outcoupler to date for magnetically confined samples.

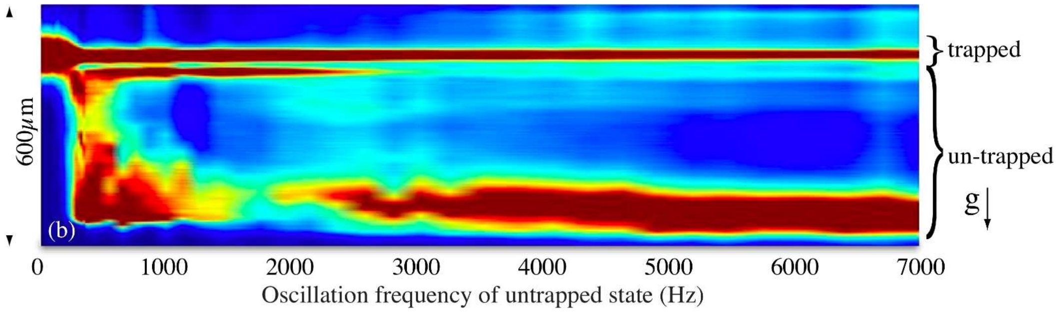

Fig. 1: Absorption image data for a Raman outcoupler operating between Zeeman states of the $F = 1$ ground state of ^{87}Rb. Red (blue) represents a high (low) atom density, and the vertical scale gives the vertical extent in space. These data represent absorption images taken for 14 ms of outcoupling, and different coupling strengths. Each column of pixels corresponds to a single absorption image that has been integrated (summed) in the direction perpendicular to propagation of the atom laser beam. Hence, each column represents the linear atomic density in the vertical direction for a different coupling strength. In the left most columns, a smooth continuous beam is visible for low coupling strengths. As coupling strength is increased, atom laser shutdown can be seen in the form complex density profiles at intermediate coupling strength, and then the clear effect of the dressed states at the highest coupling strengths (right most columns).

References

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