Light transmission through a tapered optical fibre

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1. Introduction

Recently, tapered optical fibres are finding applications in laser cooling and trapping experiments with the goal of using the evanescent field of the nanofibre to trap and manipulate cold atoms outside the fibre.

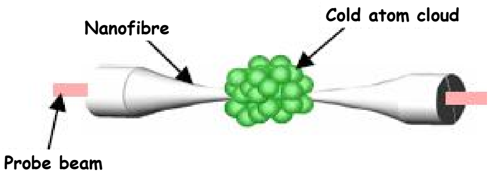

Fig. 1 Schematic of a cloud of cold atoms around a nanofibre

In this work,[1] we describe how the coupling of spontaneous emission from laser-cooled rubidium atoms into the guided modes of a nanofibre provides us with a tool for probing MOT characteristics such as lifetime, loading and cloud profile.

2. Tapered Optical Fibres

In our nanofibre fabrication, an oxy-butane flame is used to heat a stripped area of 780 nm single mode optical fibre and two translational stages simultaneously pull the fibre in opposite directions.

This has the effect of reducing the diameter as a function of pull length and hot zone size according to the adiabatic condition.

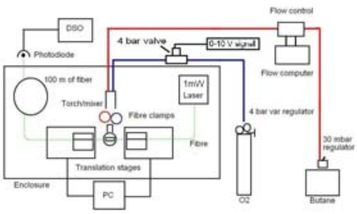

Fig. 2 Schematic of fabrication rig

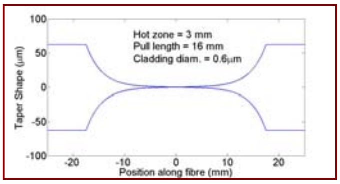

Fig. 3 Nanofibre profile

3. MOT Fluorescence Coupling

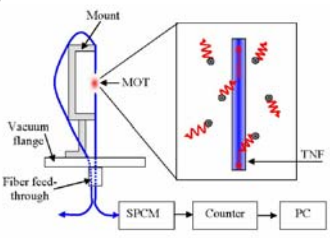

Fig. 4 Schematic of setup

Our experimental ^{85}Rb MOT setup:

- Cooling Laser: $5S_{1/2}, F=3 \rightarrow 5S_{3/2}, F'=4$
- Repump Laser: $5S_{1/2}, F=2 \rightarrow 5S_{3/2}, F'=3$
- Magnetic Field Gradient: 10 G/cm
- MOT dimensions: 1/e vertical length = 2mm & horizontal length = 1.3 mm
- Average density: 4 x 10^6 atoms/mm^3

The count rate detected by a single photon counting module can be determined by

$$\eta_P = N_{eff}\eta_f \gamma_{sc}\eta_D T$$

where we use $\gamma_{sc} = 6.5\times10^{5}\, s^{-1}$

This results in a rate of 3.74 x 10^5 s^{-1} which is in very good agreement with the results shown in Fig. 5.

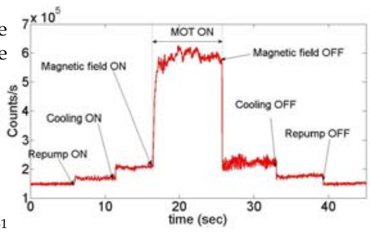

Fig. 5 Photon count rate coupled into the nanofibre.

4. Atom Cloud Profile

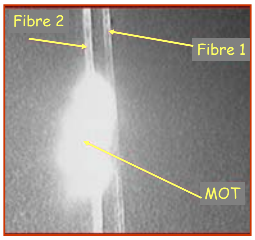

Fig. 6 Image of MOT & fibres

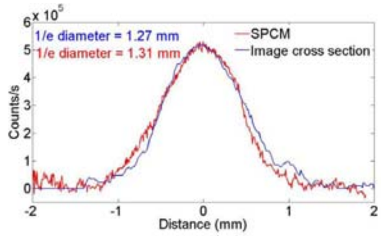

Fig. 7 Estimation of atom cloud profile

We determine the MOT profile by moving the cloud of cold atoms across the waist of the fibre. We use a single photon counter (SPCM) at the output end of the fibre to measure the coupled photon count rate as a function of fibre position.

In Fig. 7, we compare the nanofibre technique to a standard approach which involves extracting data from a video which records the fluorescence from the cloud imaged onto a photodiode.

5. MOT Loading & Lifetime

In terms of MOT loading time, the nanofibre method does not require compensation for background fluorescence, in contrast to measurements made using the standard photodiode technique.

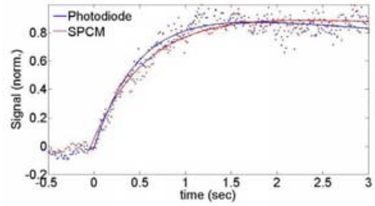

Fig. 8 Loading of the MOT

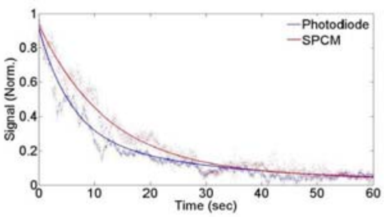

Fig. 9 Lifetime of the MOT

For the lifetime of the MOT, our technique yields a result that is longer by 3.6 s. This is mainly attributed to the slow decay rate of the MOT centre.

6. Future Prospects

Pump light is coupled into the whispering gallery modes (WGM) of microsphere resonators (IOG2, Er:Yb-codoped phosphate glass) using tapered fibres.[2] Tuning of the WGM across the ^{85}Rb cooling transition can be achieved by heating the sphere with very low pump light powers.[3]

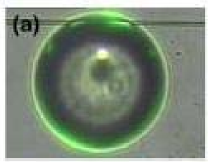

Fig. 10 Taper fused to 95 μm diameter microsphere.

We plan to incorporate this system into a rubidium vapour cell to explore the dependency of WGMs on the vapour pressure.

References

[1] M. J. Morrissey, K. Deasy, Y. Wu, S. Chakrabarti and S. Nic Chormaic submitted (2008).

[2] J. Ward, P. Féron and S. Nic Chormaic, *IEEE Photon. Technol. Lett.* **20**, 392 (2008).

[3] J. Ward, M. Morrissey and S. Nic Chormaic, to be submitted (2009)

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