Characterisation and spectroscopy of laser-cooled atoms with an optical nanofibre

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Abstract

In this thesis, a magneto-optical trap setup is used to laser cool and confine a cloud of ^{85}Rb. The cloud typically contains 10^8 atoms in a 1 mm^3 volume at a temperature in the region of the Doppler Limit (146 μK for ^{85}Rb). To study the cold cloud, a subwavelength optical fibre – a nanofibre, or ONF – is positioned inside the cloud. The ONF can be used in two ways. Firstly, it is an efficient fluorescence collection tool for the cold atoms. Loading times, lifetimes and temperatures can be measured by coupling the atomic fluorescence to the evanescent region of the ONF. Secondly, the ONF is used as a probe beam delivery tool using the evanescent field properties of the device, allowing one to perform spectroscopy on few numbers of near-surface atoms. With improvements in optical density of the cloud, this system is an ideal candidate in which to generate electromagnetically induced transparency and slow light. A theoretical study of the van der Waals and Casimir-Polder interactions between an atom and a dielectric surface is also presented in this work in order to understand their effects in the spectroscopy of near-surface atoms.