Measurement of ^{6}Li Atomic Beam Properties

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1. Introduction

Laser cooling is used for frequency standards, quantum simulators, research of ultracold gases and etc. To get large number of ultracold atoms in magneto-optical trap (MOT) atomic beam with small collimation angle and substantial particle flux is required. Optimal parameters of atomic beam are defined by setup of MOT and Zeeman slower and limited by configuration of oven and collimation tube, which are used for melting solid lithium into vapor and focusing it into a beam. Objective of this work was to find optimal temperatures of existing oven and measure atomic beam properties.

2. Experiment

Experimental setup to measure collimation angle and flux is shown on fig.1. Laser beam perpendicular to atomic beam was used to get spectrum of fluorescence of $^{2}S_{1/2} \rightarrow {}^{2}P_{3/2}$ transition. Fitting this spectrum by sum of two Voigt profiles yields Doppler broadening, which was used to calculate perpendicular velocities and subsequently the collimation angle. In order to control that the beams were perpendicular to each other maximums of signals from “moving” atoms and “fixed” atoms in saturated absorption spectroscopy were aligned. Additional laser directed towards atomic beam was used to measure longitudinal speed by means of Doppler shift.

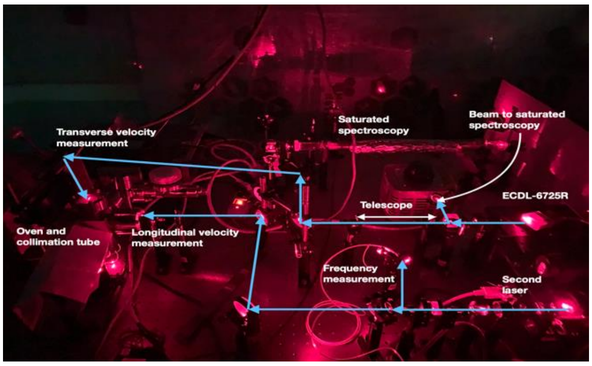

Fig.1: *Experimental setup*

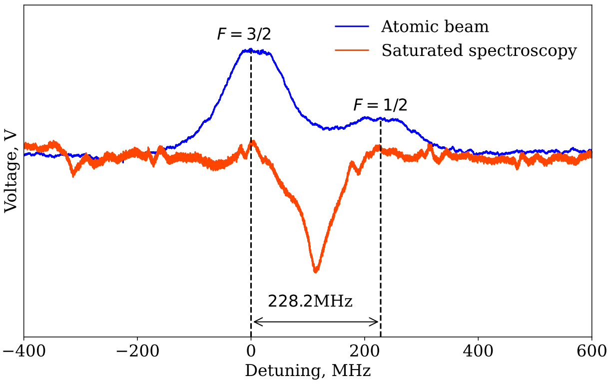

Fig.2: *^{6}Li fluorescense spectrum for $^{2}S_{1/2} \rightarrow {}^{2}P_{3/2}$ transition*

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3. Results

Treating $^2S_{1/2} \longrightarrow {}^2P_{3/2}$ transition as Λ-system it was shown that power of spontaneous fluorescence can be approximated by $A\left(1-e^{-\alpha\sqrt{s}}\right)$, which gives A to calculate flux of atomic beam a $N = \frac{3}{4}\frac{A}{\hbar\omega}\frac{4\pi}{\Omega}$, where ω – resonant frequency, Ω – solid angle detected by photomultiplier, s – saturation parameter. Due to its asymptotic nature A can be defined with $<$ 1% error. We can also obtain some information about the system using,

$$\alpha = \frac{C_1 C_2}{\sqrt{2\left(C_1^2 + C_2^2\right)}} \frac{\Gamma}{\sigma} \sqrt{\frac{t}{\tau}}$$

where C_1, C_2 – coupling coefficients, σ – Doppler broadening, Γ – natural linewidth, t – time of interaction with laser, τ – excited state lifetime.

Temperatures of oven that yield theoretically optimal collimation angle were found. Number of atoms per second was calculated in two ways: integrating the spectrum and using the asymptotic formula. Asymptotic approach showed to be more precise for counting flux of atomic beam.

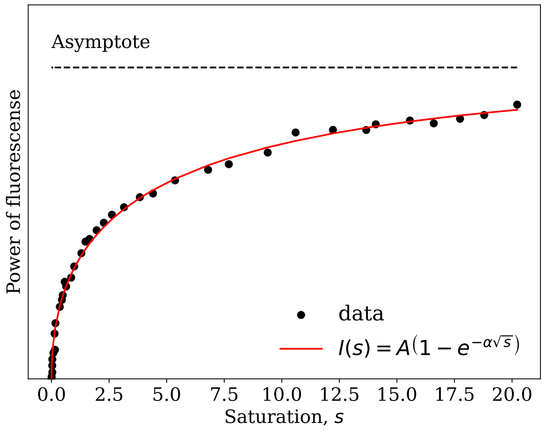

Fig.3: *Power of fluorescence*

The spectra of fluorescence were approximated by sum of two Voigt profiles to calculate collimation angle via Doppler broadening of atomic beam. Doppler shift was measured to calculate the longitudinal velocity.