Diffraction Grating Wavelength Meter using a High-resolution Webcam with Sub-gigahertz Sensitivity

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1. Introduction

Nowadays tunable lasers are widely used in various fields of science, for example, in laser cooling of atoms. Laser cooling is a technique based on the fact that particles change their momentum after re-emitting photons which they have absorbed due to laser irradiation. In aforementioned technique it is crucial to use a beam tuned to a specific atomic transition. Also, analyzing atomic spectra requires the ability to measure a number of optical signals with close frequencies simultaneously, for instance, D1 and D2 transitions in ^{6}Li atoms have frequencies differing by 10 GHz while having wavelength around 670 nm (relative difference $\sim 2 \cdot 10^{-5}$). Objective of this work is to construct a wavelength meter having properties mentioned above.

2. Experimental setup

Principle of operation of the device is based on diffraction grating properties which allow for spatially splitting beams with different frequencies. Acquired spectrum of a gaussian-mode beam is registered by a high-resolution webcam with pixel size 3.45 × 3.45 μm. Scheme of the constructed device is shown on fig. 1. To compensate the sensitivity to environmental conditions in the laboratory, such as temperature and humidity, and mechanical disturbances, we calibrated the device before every series of experiments. Calibration of the constructed wavelength meter is carried out by using another commercial wavemeter with higher accuracy and a single-mode tunable laser, alternatively, setup can be calibrated with reference to known atomic transitions frequencies.

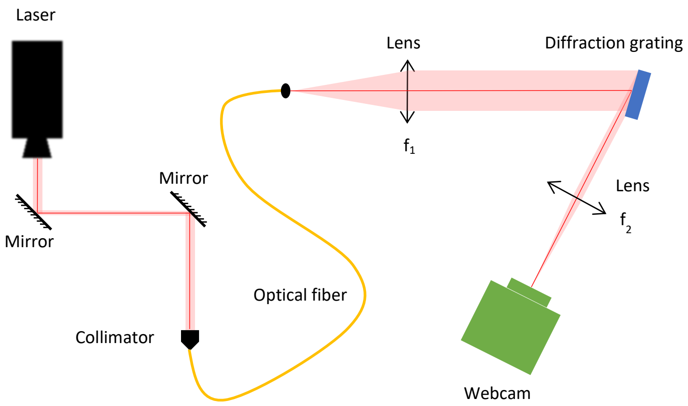

Fig. 1: *Schematic representation of the device*

3. Results

After several series of experiments with wavelengths near 670 nm measured frequency resolution of acquired wavemeter turned out to be 0.6 GHz per pixel while maximum measurement error is equal to 1.5 GHz. Constructed wavelength meter has shown the ability to distinguish frequencies differing by 9 GHz while measured simultaneously and the ability to determine whether laser is in multiple frequency mode.

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