Dual Laser Frequency Stabilization for a Yb^+ single ion trap

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***Abstract*— We present the frequency stabilization of 370 nm and 935 nm lasers using a coupled optical resonance method with a hollow cathode lamp. This method achieves a fractional frequency instability below 5×10^{-10} at 1 second for both lasers, which is essential for efficient ion cooling and manipulation.**

Keywords—atomic clock; single-ion trapping, ion cooling, laser stabilization.

I. Introduction

Frequency stabilized lasers play a crucial role in numerous atomic physics experiments, including single-ion traps. The cooling laser frequency must be stabilized to a fraction of the natural line width of an atomic transition to facilitate efficient ion cooling and manipulation of states. Additional stabilized lasers are necessary to "repump" the ion from metastable states, ensuring high scattering rates on the cooling transition, or to optically pump the ion in a specific state.

II. Methods/Results

We achieved the frequency stabilization of a 370 nm and a 935 nm lasers on a hollow cathode lamp with a fractional frequency stability below $5\cdot10^{-10}$ at 1 second. The optical setup (shown Fig. 1) is part of a single-ion optical compact clock based on a surface-electrode trap that we will operate with $^{171}Yb^+$ ions on the electric quadrupole transition at 436 nm [1]. In this experiment, we have simultaneously stabilized a 370 nm and a 935 nm laser to the $^2S_{1/2}\rightarrow{}^2P_{1/2}$ and $^2D_{3/2}\rightarrow{}^3D_{[3/2]1/2}$ transitions of Yb^+ ions produced within a hollow cathode discharge lamp [2,3]. In this way, both the cooling and repumper lasers can be locked to the same atomic sample. This dual-laser lock results in fractional frequency instabilities of $1.7\cdot10^{-10}$ and $6.5\cdot10^{-10}$ at 1 and 1000s for the 370 nm laser, and $5\cdot10^{-10}$ and $1\cdot10^{-9}$ at 1 s and 1000 s for the 935 nm laser. Fractional frequency instabilities are measured using a wavemeter. Mid-term stability measurements are limited by the drift of the wavemeter, and constitute an upper bound.

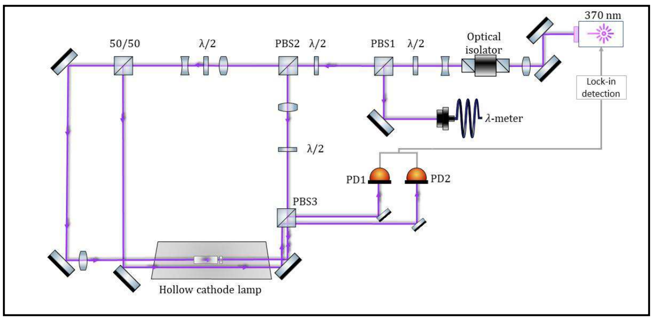

Fig. 1. Optical scheme for saturated absorption spectroscopy on atomic sample generated in hollow cathode lamp. PBS - Polarization Beam Splitter, PD – Photodiode, λ-meter: Wavemeter.

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