Dual Laser Frequency Stabilization

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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[1]. Typically, additional stabilized lasers are necessary to prevent the ion from remaining in metastable states, ensuring high scattering rates on the primary cooling transition, or intentionally placing the ion in a specific state.

We present the laser stabilization of a 369.5 nm laser[2] on hollow cathode lamp with the goal of achieving fractional frequency stability below $5 \cdot 10^{-10}$ at 1 second. The optical setup (shown Fig. 1) is part of 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 435.5 nm. In the experiment, the goal is to simultaneously stabilize a 369.5 nm and a 935 nm laser to target 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[3]. The locking of two lasers will be done on the same atomic sample. These precisely locked lasers are indispensable for cooling and confining Yb^+ ions, essential for quantum information studies and high-precision metrology experiments.

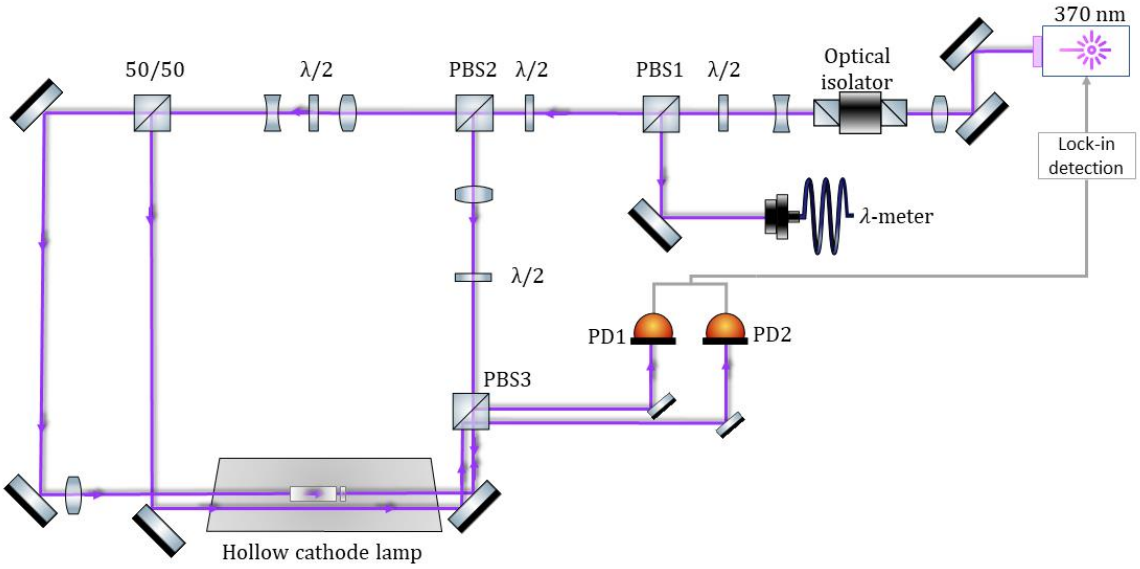

Fig. 1: Optical scheme for saturated absorption spectroscopy on atomic sample generated in hollow cathode lamp. PBS - Polarization Beam Splitter, PD – Photodiode, λ-meter: Wavemeter .

[1] H. J. Metcalf and P. van der Straten, *Laser Cooling and Trapping* (Springer, 1999).

[2] E. Streed, T.Weinhold, and D. Kielpinski, "Frequency stabilization of an ultraviolet laser to ions in a discharge,"Appl. Phys. Lett. **93**, 071103 (2008).

[3] S. C. Burd, P. J. W. du Toit, and H. Uys, "Coupled optical resonance laser locking," Opt. Express 22, 25043-25052 (2014)