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► **To cite this version:**

Josipa Madunic, Alan Boudrias, Moustafa Abdel Hafiz, Yann Kersalé, Clément Lacroûte. Dual Laser Frequency Stabilization for a Yb + Single Ion Trap. 2024 European Frequency and Time Forum (EFTF), Jun 2024, Neuchâtel, Switzerland. pp.350-350, 10.1109/EFTF61992.2024.10722613 . hal-04767648

HAL Id: hal-04767648

<https://hal.science/hal-04767648v1>

Submitted on 5 Nov 2024

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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 states¹. 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 laser² 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 $^{171}\text{Yb}^+$ 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 $^2\text{S}_{1/2} \rightarrow ^2\text{P}_{1/2}$ and $^2\text{D}_{3/2} \rightarrow ^3\text{D}_{[3/2]1/2}$ transitions of Yb^+ ions produced within a hollow cathode discharge lamp³. 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.

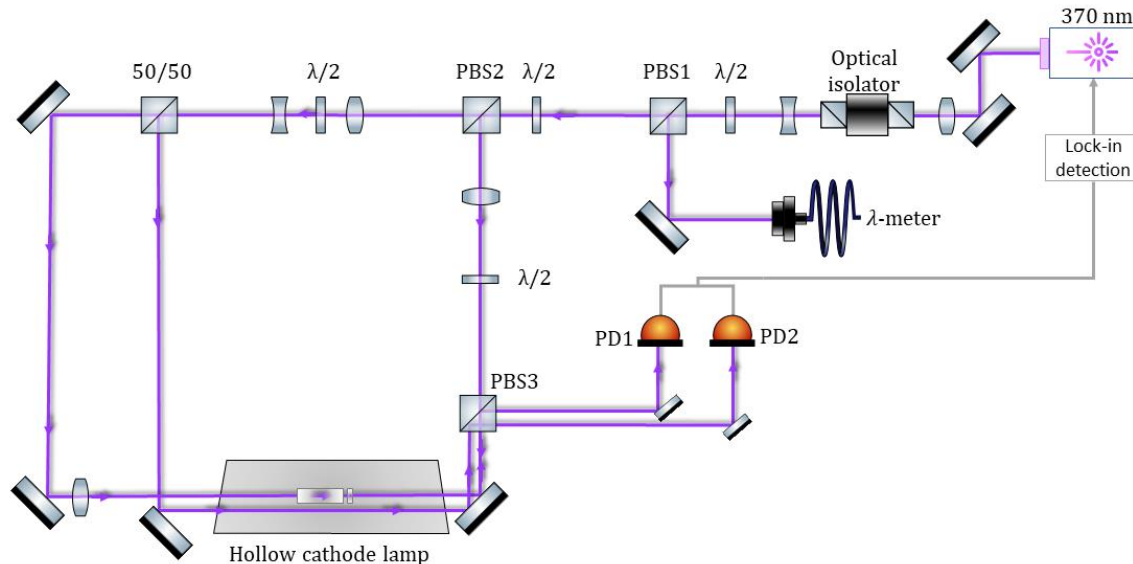


Fig. 1: Optical scheme for saturated absorption spectroscopy on atomic sample generated in hollow cathode lamp. PBS - Polarization Beam Splitter, PD – Photodiode, λ -meter: Wavemeter .

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)