



Dual Laser Frequency Stabilization for a Yb + Single Ion Trap

Josipa Madunic, Alan Boudrias, Moustafa Abdel Hafiz, Yann Kersalé, Clément Lacroûte

► 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

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

Dual Laser Frequency Stabilization

J. Madunic¹, A. Boudrias¹, M. Abdel Hafiz¹, Y. Kersalé¹ and C. Lacroûte¹

¹FEMTO-ST Institute, univ. Bourgogne Franche-Comté, CNRS, SUPMICROTECH-ENSMM,
26 rue de l'Épitaphe, 25000 Besançon, France

Email: clement.lacroute@femto-st.fr

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.

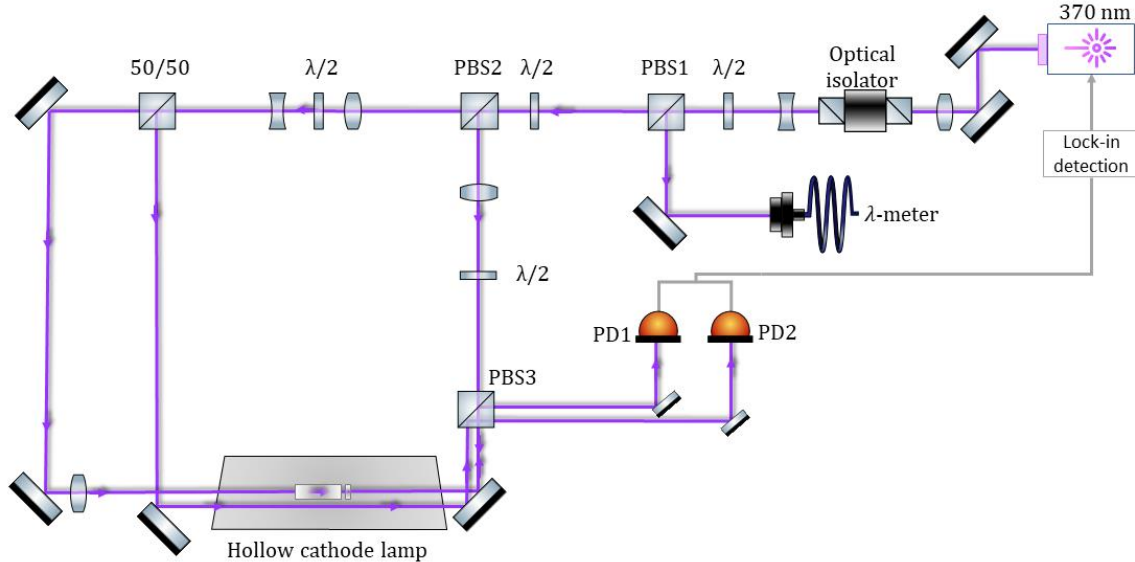


Fig. 1: Optical scheme for saturated absorption spectroscopy on atomic sample generated in hollow cathode lamp. PBS - Polarization Beam Splitter, PD – Photodiode, λ-meter: Wavemeter .

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)