Laser Diode Aging Studies for Rubidium Atomic Clocks

Florian Gruet, Christoph Affolderbach, Gaetano Mileti

Laboratoire Temps-Fréquence, Institut de Physique, Université de Neuchâtel, 2000 Neuchâtel, Switzerland

Email: florian.gruet@unine.ch

Rubidium atomic clocks for space applications usually need to have a lifetime of up to 20 years and their components need de facto to fulfill their purpose during this time period. Laser diodes are one of the key components for such atomic clocks and their spectral properties play an important role in the overall clock frequency instability budget[1].

In order to study the evolution of the lasers' spectral properties on long-term timescales, we developed a long-term laser diode aging test bench that measures the spectral behavior of laser diodes over several years. Three laser diodes are currently under test, two 780 nm DFB lasers and one frequency-doubled 1560 nm DFB laser. We measure the laser drive current needed to keep the laser emission frequency at the precise resonance of the ^{87}Rb D2 transition as well as their threshold currents. The lasers' temperatures are fixed close to room temperature meaning that this aging study does not consist in high temperature accelerated aging. Measurements of frequency noise and relative intensity noise have also been performed. The measurement has now been running since July 2021.

Compared to our previous laser aging study based on a 780 nm DFB laser[2], the aging rate of the lasers in this study is lower by a factor of 2 to 30. This might hint to an improvement of the aging behavior of these laser diodes produced during these last ten years and tends to confirm their compatibility for implementation in advanced atomic clocks with at least 20 years lifetime.

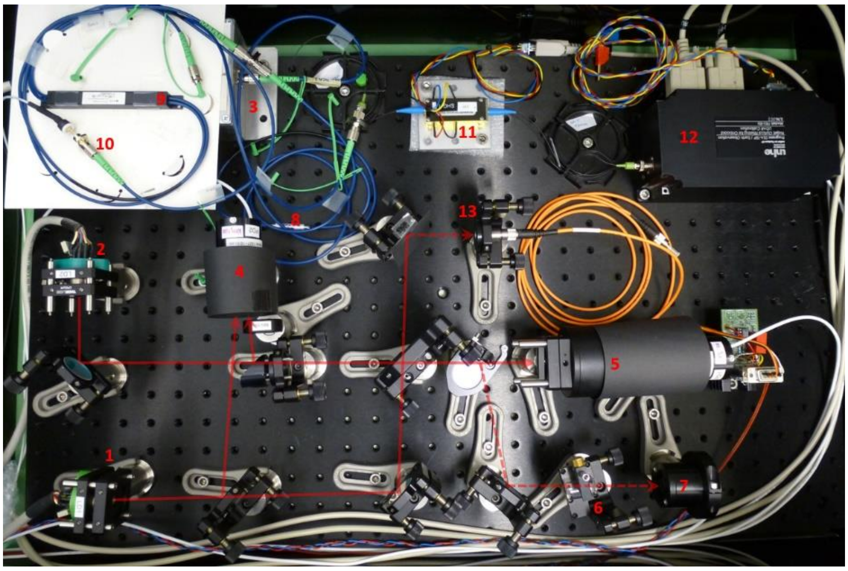

Fig. 1: Picture of the laser diode aging test bench. 1.&2. 780 nm DFB lasers; 3. 1560 nm DFB laser; 4. Threshold current measurement (780 nm); 5. Current at resonance measurement (780 nm); 6.&7. Noise measurement; 8. Fibered optical isolator; 9. Fibered beamsplitter; 10. Threshold current measurement (1560 nm); 11. PPLN SHG; 12. Current at resonance measurement (1560 nm); 13. Fiber coupler.

[1] N. Almat et al., "Long-Term Stability Analysis Toward $<10^{-14}$ Level for a Highly Compact POP Rb Cell Atomic Clock", IEEE TUFFC, Vol 67, Issue 1, Pages 207-216 (2020)

[2] R. Matthey et al., "Methods and evaluation of frequency aging in distributed-feedback laser diodes for rubidium atomic clocks", Opt. Lett., Vol 36, No 17, Pages 3311-3313 (2011)