Pulsed optically pumped Rb clock: recent results and future perspectives

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The pulsed optically pumped (POP) Rb clock [1] is a vapor cell frequency standard with unprecedented frequency stability performances. Our prototype developed at INRIM exhibits a frequency stability (standard Allan deviation) $\sigma_y(\tau) = 2 \times 10^{-13}\ {-1/2}$, remaining below 10^{-14} up to integration times $\approx 10^5$ s and with a relative frequency drift below 10^{-14}/day. Proper engineering of such a clock would then be extremely interesting not only in a variety of technological applications such as radio-navigation systems and synchronization of telecommunication networks but also in basic research as a local oscillator (LO) for primary frequency standards.

The POP operation is based on the time separation of the three phases (preparation, interrogation and detection) that usually rule the operation of an atomic clock. Specifically, an intense laser pulse initially prepares the atomic sample, producing a population imbalance in the two ground-state hyperfine levels of ^{87}Rb. The atoms are then interrogated with a couple of microwave pulses resonant with the clock transition (6.834 GHz) and separated by a time T (Ramsey interaction). Finally, a detection window is enabled in order to detect the atoms that have made the transition. The main feature of this technique is that the atoms make the clock transition in the dark, when the laser is turned off and a significant reduction of the light-shift occurs in comparison with the more traditional double-resonance continuous approach or with the coherent population trapping (CPT) technique. Two challenging tasks characterize the current research activity on the POP clock at INRIM. The first one is mainly a technological task: the reduction of the physics package size by means of a loaded microwave cavity. The goal of this task is to develop a microwave cavity with a volume which is one third that of a traditional cavity, with great benefit for the size and weight of the overall clock. At the same time, the clock is expected to reproduce the same frequency stability performances previously reported. The second task is the analytical study of the phenomena that affect the short as well as the long term clock stability. In particular, the physics of laser noise conversions is under investigation.

[1] S. Micalizio et al., Metrological characterization of the pulsed Rb clock with optical detection, Metrologia, vol. 49, p. 425-436 (2012).