New generation of optical clock at INRiM

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The $^1S_0 \rightarrow {}^3P_0$ transition of the neutral atom ^{171}Yb is one of the frequency standards recommended by CCTF candidates for an optical redefinition of the second.IT-Yb1 is the optical lattice clock based on this atom developed and maintained by INRiM: the performances of this clock have been characterized in term of relative uncertainty at the level of $1.9 \cdot 10^{-17}$with a typical instability of $2 \cdot 10^{-15}\sqrt{\tau/s}$ at 1s limited by the ultrastable cavity[1]. We continuously operated the system for 16 consecutive months, from February 2022 to May 2023,and during this time we performed a Yb absolute frequency measurement[2] comparing directly with the Caesium fountain IT-CsF2: we measured f(IT-Yb1) = 518 295 836 590 863.44(14) Hz with a fractional uncertainty of $2.7 \cdot 10^{-16}$. At the same time the data collected during the last years have been provided to the BIPM for the calibration of the International Atomic Time (TAI), obtaining a continuous presence on the Circular T. Finally, IT-Yb1 data has been used to generate a local time scale with sub-nanosecond accuracy over months-long period[3].

We are working on multiple strategies to reduce both the instability and the uncertainty of the standard: we are implementing a new 30 cm long ULE ultrastable cavity with fused silica dielectric mirrors, estimating an improvement of the clock instability at the level of few parts in 10^{-16}. We are upgrading the experimental system by using a new Titanium:Sapphire laser 3 times more powerful than the previous one, allowing us to explore stronger trapping depth to characterize with higher accuracy the lattice light shift [4]. Moreover the higher power will enable a larger trap waist, thereby mitigating atomic collisions and minimizing density shift. We are also developing a sideband cooling scheme to reduce the atomic temperature below 1 μK increasing the confinement of the atoms in the lattice. Beyond this activities aimed at improving the already existing experimental apparatus, we are also designing a new version of this ytterbium optical lattice clock (Fig.1) to overcome the structural limits of IT-Yb1 that restrict our ability in reducing the systematic uncertainty at the level of 10^{-18} : in this perspective we are going to implement some additional features such as a lattice enhancement cavity and a metal shield to decrease the uncertainty resulting from the black body radiation and the static charges[5].

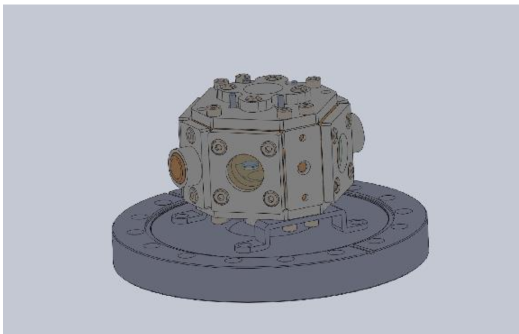

Fig.1: Render of the IT-Yb2 atomic chamber with DC Stark and BBR shield

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