Abstract

During my PhD at the Politecnico di Torino, I worked at the Italian National Institute of Metrological Research (INRiM) in the field of frequency standards. In particular, in these three years, my research activity has been focused on the improvement and characterization of IT-Yb1, a Ytterbium optical lattice clock developed at INRiM.
In the last decades, a great effort has been made to develop optical clocks, which are considered the most promising candidates for the redefinition of the second in the International System of Units (SI). Indeed, optical clocks have the potential to improve by several orders of magnitude the accuracy of the current definition of the second, which is based on the hyperfine transition of the ground state of the Caesium atom.
During these three years, I have succeeded in improving both the accuracy of IT-Yb1 and its robustness. In particular, I have characterized IT-Yb1, achieving a fractional frequency systematic uncertainty of 2e-17, the smallest uncertainty ever reported for our clock. To reach this goal, I worked on the implementation of an upgraded optical setup for the realization of a vertical optical lattice and on the characterization of several systematic shifts affecting the clock frequency, such as the lattice shift and the DC Stark shift. Moreover, I worked on the robustness and the clock's reliability, trying to make its operation as continuous as possible. Significantly, in the last two years, IT-Yb1 has proven to be very reliable, operating almost continually for 14 months with an uptime of up to 75% in some weeks.
The highlights of my PhD are summarized in the following. First, an absolute frequency of IT-Yb1 was performed against the primary frequency standard developed at INRiM, the Caesium fountain clock IT-CsF2. In addition, in the last few years, IT-Yb1 has participated in several international comparison campaigns in collaboration with other European and Asian National Metrology Institutes.

Furthermore, IT-Yb1 is among the eight optical clocks that have ever submitted data to the Bureau International des Poids et Mesures (BIPM) to contribute to the calibration of the International Atomic Time (TAI). Remarkably, in the last year, IT-Yb1 has regularly contributed to the steering of TAI for 14 consecutive months, showing impressive continuity and robustness. All these results are a clear demonstration of the importance of IT-Yb1 in the international scenario of optical clocks and represent a significant contribution to the future redefinition of the SI second based on an optical standard.
Finally, during the third year of the Ph.D., I spent four months with an Erasmus+Traineeship fellowship at the Laboratoire Charles Fabry in Palaiseau (France), where I worked on the Cyclopix project. In this experiment, the light-scattering of a Rb atomic sample trapped in an optical dipole trap is studied to observe the collective effects in the light emitted by the atoms. This internship was a great opportunity to learn new cooling and trapping techniques, such as optical tweezers, that can be useful for the realization of a new generation of optical clocks.