Towards a single-ion compact optical clock: experimental apparatus and current status

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Outstanding performances have been obtained by optical atomic clocks: fractional frequency instabilities and accuracies of single-ion optical clocks are now as low as $3\times10^{-15}\ \tau^{-1/2}$ for the former [1] and $3\times10^{-18}\ \tau^{-1/2}$ for the latter [2], while optical lattice clocks have reached instabilities and inaccuracies as low as $6\times10^{-17}\ \tau^{-1/2}$ [3] and $2\times10^{-18}\ \tau^{-1/2}$ [4] respectively. Optical clocks are exquisite measuring tools, useful to various domains of precision science, and many proposals require to bring optical clocks into the field. For this purpose, a number of laboratories worldwide are now building transportable optical clocks. The first operational setups have been reported recently, for both a strontium lattice clock [5], [6] and a single-ion calcium clock [7].

Optical lattice clocks can reach lower fractional instability, thanks to the high atom number, but the frequent reloading required induces an increased susceptibility to the Dick effect [8]. They also require a complex loading scheme into the optical lattice trap, starting with a 2D magneto-optical trap (MOT) or a Zeeman slower. On the other hand, single-ion optical clocks involve a simpler loading scheme and lower optical powers, leading to potentially more compact and less power-consuming systems.

We are developing a compact optical atomic clock based on trapped Yb^+ single ions [9]. The clock should reach a fractional frequency instability around $10^{-14}\ \tau^{-1/2}$ in an overall volume below 500 L. This clock would therefore exhibit a stability 10 times better than an active Hydrogen Maser in a similar volume. We will present the details of our experimental apparatus, which includes a miniature single ion-trap based on surface-electrodes (SE) [10].

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