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A Multi-ion Clock with In+/Yb+ Coulomb Crystals

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In 2012, we proposed multi-ion spectroscopy to improve the stability of optical ion clocks which is fundamentally limited by the quantum projection noise of the single ion. Multi-ion clocks will not only improve the stability by exploiting the higher signal to noise of multiple ions or their uncertainty by allowing for sympathetic cooling of clock ions using a separate ion species, but will be the basis for future entangled clocks and cascaded clocks. For the multi-ion approach we have developed and qualified scalable high-precision ion traps, which are already in use in several experiments. A challenge is the high level of control of systematic shifts when scaling up a single trapped ion to a complex many-body system. I will discuss our results in characterizing the shifts in multiple trapped ions and from lessons learned the potential of multi-ion spectroscopy. The multi-ion clock is operated in a recent dedicated experiment, where 115In+ ions are sympathetically cooled by 172Yb+ ions. Here, I will report on the status of clock operation and international clock comparisons. Last but not least, I will briefly discuss new limits we obtained in our work on an improved test of local Lorentz invariance using 172Yb+ ions and the search for new physics using the even Yb+ isotopes.

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