Multi-Ion-Clocks with In^+ and Yb^+ Ions

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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 compact and portable devices multi-ion clocks have the benefit of relaxed clock laser requirements.

For the multi-ion approach we have developed and qualified scalable high-precision ion traps, which are 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.

We operate two experimental setups where scaling of precision spectroscopy is pursued. In the multi-ion indium clock $^{115}In^+$ ions are sympathetically cooled by $^{172}Yb^+$ ions. I will report on the status of clock operation and it's characterization by local and international clock comparisons. In the multi-ion ytterbium setup we have demonstrated precision spectroscopy on even isotopes of Yb^+ and obtained new limits on fifth forces by precise evaluation of the isotope shifts. In the future we aim at multi-ion operation in Yb^+ in novel ion traps with integrated optics.