Absolute frequency measurement of the $^{88}Sr^+$ single ion clock at the NRC

Claude Marceau[1], Scott Beattie[1], Bin Jian[1], Kosuke Kato[1], Pierre Dubé[1], and Marina Gertsvolf[1]

[1]National Research Council Canada, Ottawa, Ontario, Canada

Email: claude.marceau@nrc-cnrc.gc.ca

With the upcoming redefinition of the SI second[1,2], it is now necessary to measure the absolute frequency of candidate optical clocks with uncertainties below 3×10^{-16}. For the $^{88}Sr^+$ single ion clock, only a single measurement[3] was published achieving this accuracy level.

In this work, we measured the absolute frequency of NRC's $^{88}Sr^+$ single ion clock using an optical fibre link between the $^{88}Sr^+$ clock and the NRC-FCs2 caesium fountain clock. The live data stream from the $^{88}Sr^+$ clock was used to dedrift the probe laser in real time by slowly moving the RF target beat frequency of the fibre-noise cancellation modules used to reach each clock from the ultrastable laser. An optical frequency comb locked to the dedrifted probe laser was used to generate ultrastable microwave for the fountain clock operation. This mode of operation resulted in high stability fountain measurements (Fig. 1), around $\sigma_y = 7.5\times10^{-14}/\tau^{1/2}$ in clock mode, limited essentially by NRC-FCs2 signal-to-noise ratio. Our preliminary unperturbed $^{88}Sr^+$ transition frequency from 3.3 days of data is (Fig. 2): $f = 444\ 779\ 044\ 095\ 485.33 \pm 0.11$ Hz, $u_{total} = 2.5\times10^{-16}$

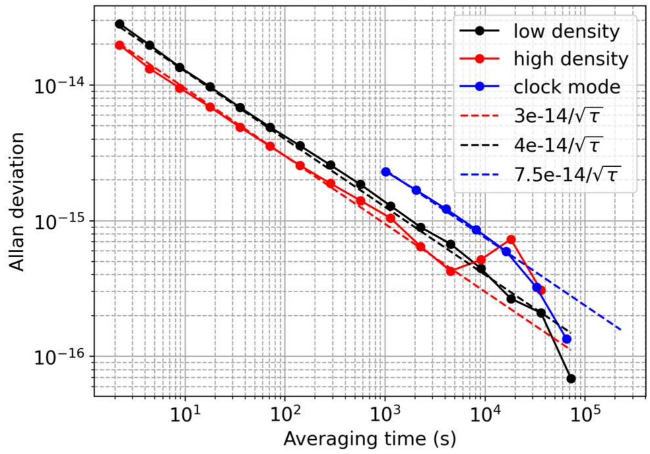

Fig. 1: Allan deviation of NRC-FCs2 against the dedrifted probe laser. NRC-FCs2 makes 150 pairs of interrogations with a high atom density (red circles) followed by 300 pairs of interrogations at low density (black circles). An extrapolation to zero density follows (clock mode, blue circles). Dashed lines are fits.

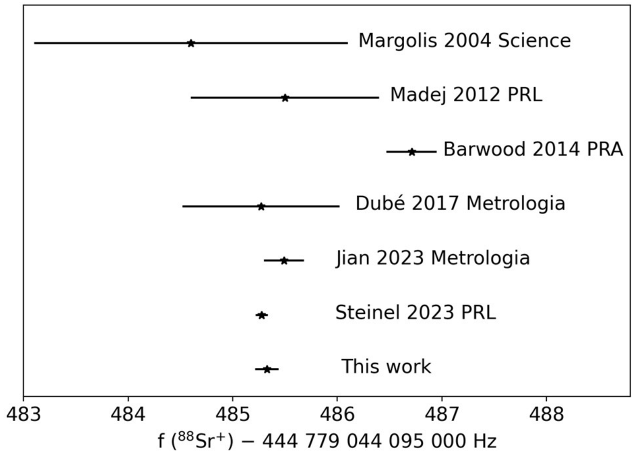

Fig. 2: Measurements of $^{88}Sr^+$ clock unperturbed transition frequency by NRC, NPL and PTB. Error bars extend one standard deviation on each side of the measurement. The result of this work is compatible with both Steinel[3] and Jian[4]. Earlier measurements [5,6,7,8] are also shown for comparison.

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