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Advances of the Sr Optical Lattice Clock at NIM

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Optical clocks have shown great potentials to be much more accurate than the best microwave clocks, and are the candidates to redefine the SI time unit, the second. A Sr optical lattice clock is being constructed at NIM to prepare for the upcoming redefinition of the SI second.

The first evaluation of NIM's Sr optical clock is conducted in 2015. The total systematic shifts uncertainty is 2.3E-16. In order to evaluate some of the systematic shifts uncertainty, a time interleaved self comparison method is adopted[1]. The stability of the clock laser (2E-15 @ 1 s)limited the measurement uncertainty within a reasonable measurement time.

In order to improve the stability of the clock, a new clock laser based on a 30 cm long reference cavity is built. The cavity spacer is made of ultra-low expansion(ULE) glass, and the substrates of the two cavity mirrors are fused silica. The cavity is installed in a commercial vacuum house on an active vibration isolation platform. The short term stability of the clock laser is evaluated to be at E-16 level by comparing its frequency with the Sr clock transition.

An energy filtering method is used to select the atoms with lower temperature to improve the Rabi frequency homogeneity. After the spin polarization of the atomic sample, the trap depth of the 1-dimensional optical lattice is ramped from 29 μK down to 5 μK and then ramped up to 29 μK again in 46 ms. The average temperature of the remained atoms is 2.5 μK(3.8 μK) along the axial(radial) direction of the optical lattice. The atoms are then interrogated by the clock laser with a probe pulse width of 500 ms and the corresponding atomic transition linewidth is 1.8 Hz. With the time interleaved self comparison method and the improved clock system, we measured the collisional shift of the clock. The self comparison measurement stability is $4.2E\text{-}15/\sqrt{\tau}$, and the shift is 2.0E-16 with a measurement uncertainty of 7.8E-18, as shown in Figure 1.

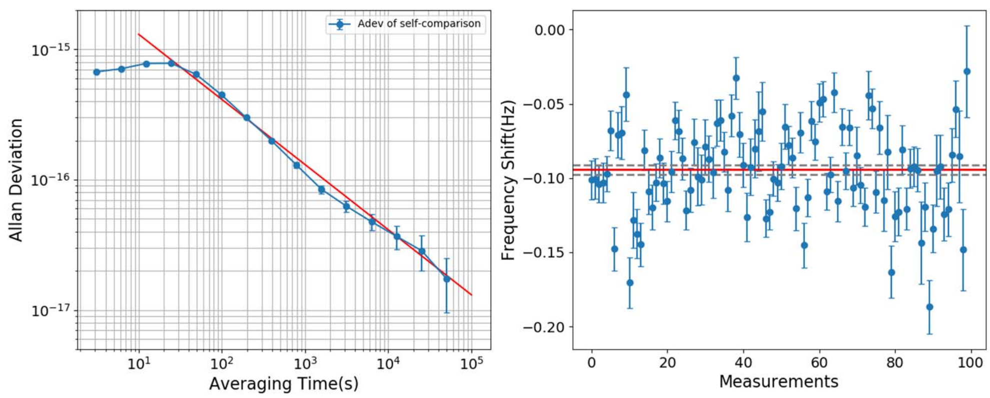

Figure 1. Collisonal shift measurement. (a) the self comparison measurement stability. (b) the collisional shift

1. Y.-G. Lin et al., "First Evaluation and Frequency Measurement of the Strontium Optical Lattice Clock at NIM," *Chinese Physics Letters*, **32**, 9, September 2015, pp. 090601, doi:10.1088/0256-307X/32/9/090601.