Frequency combs for differential spectroscopy of atomic clocks

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Over the past 20 years optical frequency combs [1], with atomic clocks [2], have been a powerful and enabling technology in the context of time and frequency measurement [1,2]. Impressively, optical atomic clocks have yielded an 8 order of magnitude improvement in accuracy in the past 30 years. These improvements are fueling a push toward redefinition of the SI second to optical atomic references [3], as well as application of atomic clocks to tests of fundamental physics [4] and as relativistic gravitational sensors [5-6]. Unfortunately, the long measurement times needed to average down clock quantum projection noise and local oscillator noise to reach measurement stabilities at and beyond the 10^{-18} level, limit the feasibility of next-generation applications.

I will present the improved instability results for an inter-species optical atomic clock comparison using a differential measurement technique, Figure 1. In this technique, the single ion $^{27}Al^{+}$ clock near and the ^{171}Yb lattice clock shared a common local oscillator using the phase coherent wavelength conversion with an optical frequency comb. This technique enabled nearly a factor of 10 improvement in 1-s measurement resolution and a 100-time improvement in averaging time to reach a measurement instability of 10^{-18}. Improvements in the measurement stability was achieved via a minimization of laser noise aliasing, and via improvement in the $^{27}Al^{+}$ clock quantum projection noise by increasing its probe time by mitigating laser-atomic decoherence [7].

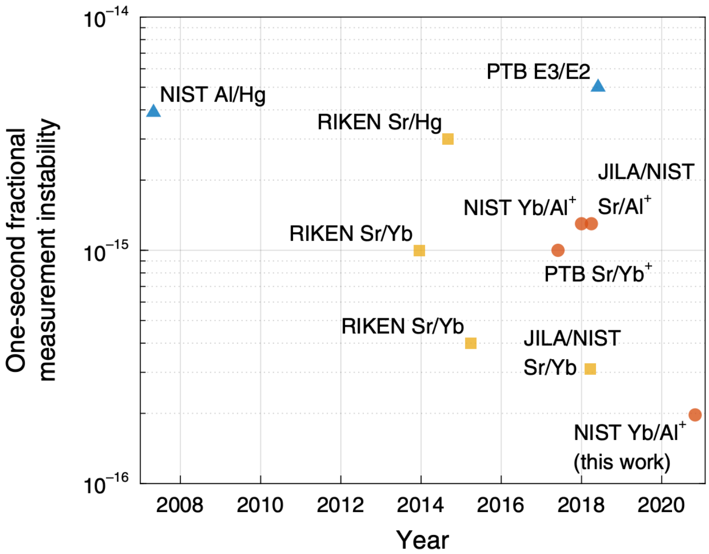

Figure 1. One-second instability of various interspecies optical clock comparisons plotted by their measurement date.

References

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