Operation of the NIM5 primary frequency standard in 2019

The NIM5 Cs fountain primary frequency standard at NIM was operated for 7 months and the average frequencies of the hydrogen maser H50 (1404850) against NIM5 were measured and the results, including all relevant biases and uncertainties, were reported to the BIPM and published in Circular T as shown in the following table.

MJD periods	$d/10^{-15}$	$u_A/10^{-15}$	$u_B/10^{-15}$	$U_{l/lab}/10^{-15}$	$U_{l/TAI}/10^{-15}$	$u/10^{-15}$
58544.0-58569.0	-0.14	0.20	0.90	0.20	0.31	0.99
58634.0-58659.0	0.55	0.20	0.90	0.20	0.23	0.97
58679.0-58694.0	-0.25	0.30	0.90	0.20	0.37	1.04
58694.0-58719.0	-0.21	0.20	0.90	0.20	0.23	0.97
58729.0-58749.0	-0.41	0.20	0.90	0.20	0.28	0.98
58764.0-58784.0	-0.14	0.20	0.90	0.20	0.28	0.98
58819.0-58849.0	-0.58	0.20	0.90	0.20	0.20	0.96

During a formal evaluation, NIM5 operated alternatively in the high and low densities with a ratio about 2 to determine frequencies at zero density.

The new NIM6 fountain clock has been built and evaluated, the preliminary result of type B evaluation is 6×10^{-16} limited by the microwave-related frequency shift. With an ultra-stable microwave local oscillator generated from an optical comb which locked to an ultra-stable laser, the frequency instability of NIM6 fountain clock reached $5\times10^{-14}/\tau^{1/2}$ at high density. The direct comparison of two fountain clocks has also been done, a relative frequency difference of 4.4×10^{-16} was obtained for 20 days averaging time, consistent with the total uncertainties of the two clocks [1].

Meanwhile, a Rb fountain clock is also under developing and aiming to achieve a robust and high stability. The design of this new fountain is different from the Cs fountain clocks. The Ramsey cavity is used as the vacuum seal to simplify the system and the cooling laser is obtained from frequency doubling of the 1.5 μ DBR laser which has a linewidth about 300 kHz and is working much more robust compared with a ECLD. The clock signal has been obtained with a instability of 2×10^{-13} at 1 s. The evaluation and further improvement is undergoing. The fountain clock will be used in NIM to steer a H-maser directly.

[1] F. Fang, et al, “Advances in the NIM Cs fountain clocks”, IFCS-EFTF Proceedings, Orlando, 14-16 (2019),