Analysis towards generation of UTC(NMIJ) steered by a near continuously operating Yb optical lattice clock

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Several institutes have recently started to make use of optical clocks in their local time scales[1]. Since optical clocks are commonly operated for short periods with low uptimes, these previous works mostly rely on stable flywheel oscillators (e.g., hydrogen masers) to bridge the gaps in the operations of optical clocks. In the previous methods, however, the stabilities of time scales are ultimately limited by stochastic fluctuations of the flywheels during the dead times of optical clocks. Therefore, it is worth considering a use of an optical clock with a high uptime to take full advantage of its frequency stability.

Towards this goal, we here report on post-processing generation[2] of our local time scale: Coordinated Universal Time of National Metrology Institute of Japan (UTC(NMIJ)) for 230 days from 12 November 2019 to 29 June 2020 assisted by an Yb optical lattice clock NMIJ-Yb1 operated with an uptime of 81.6 %. UTC(NMIJ) is generated by a flywheel hydrogen maser HM1 with its fractional frequency stability limited by a flicker floor of 2×10^{-15} and an auxiliary output generator for frequency steering. The frequency of UTC(NMIJ) is steered by NMIJ-Yb1 with a steering frequency determined by a Kalman filter algorithm[3]. The resulting virtual UTC(NMIJ) exhibits a root mean square time variation of 0.5 ns with respect to UTC during the 230-day period, which is better than those of time scales steered by Cs or Rb microwave fountain clocks.

We also simulate a projected performance of UTC(NMIJ) using our better hydrogen maser HM2 that reaches a flicker floor of 5×10^{-16}. With the high uptime of NMIJ-Yb1, our simulation implies that UTC(NMIJ) can achieve a time variation of < 0.1 ns with respect to an ideal (noiseless) reference time scale over a month. This performance level is comparable to that of a time scale generated with a highly stable optical flywheel based on a silicon cavity[4].

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