Report of the operation of NICT-Sr1 in 2020

The frequency standard NICT-Sr1 is an ^{87}Sr optical lattice clock operated at NICT. Utilizing the method of intermittent evaluation [1, 2], NICT-Sr1 contributed to TAI calibration as published in the *Circular T* for the following intervals*:*

MJD 58914 to 58934 (20 days) for March 2020, *Circular T* 387

This contains two measurements on MJD 58918 to 58929 and MJD 58932, with a 62.9% coverage of the earlier 12 day period and with a total uptime 38.5%.

Measurements of the scale interval use an optical frequency comb to down-convert the optical frequency of 429 THz stabilized to NICT-Sr1 to a signal in the microwave domain. This then serves as a reference to evaluate the frequency of a hydrogen maser (HM). In typical intermittent evaluation, the HM frequency is measured for three hours approximately once per week, and the mean frequency of the HM with respect to the frequency of NICT-Sr1 is determined from several such data blocks distributed over the target period. The uncertainty due to non-operation time of NICT-Sr1 [3-5] is then included in ulA/Lab. Additionally, an average over multiple HMs mitigates the effect of sporadic phase excursions of a specific HM [4]. Intermittent evaluation makes it easier to extend the evaluation interval, reducing the uncertainty ul/Tai of the satellite link to TAI. At shorter evaluation intervals, this uncertainty ul/Tai tends to limit the overall uncertainty.

Table 1 summarizes the uncertainty contributions for the evaluation. uA/Lab and uB/Lab indicate the uncertainties due to the link between NICT-Sr1 and the local HM. The Type A uncertainty uA/Lab represents the linear trend estimation in addition to the uncertainty due to the stochastic noise of the HM during unobserved intervals, and the Type B uncertainty uB/Lab is due to the frequency comparison between microwave and optical signals, including distribution of the microwave signals.

Period of evaluation (MJD)	Evaluation mode	uA	uB	uA/Lab	uB/Lab	ul/Tai	u	uSrep
58914 – 58934 (20 days)	Intermittent	0.09	0.72	0.86	0.32	2.8	3.0	4

Table 1: Reported uncertainty contributions applying the method of intermittent evaluation. Part of the evaluation period was covered by a near-continuous measurement of 12 days. Values are given in units of 10^{-16}.

The typical systematic corrections and their uncertainties for NICT-Sr1 as previously published [4] are summarized as follows:

Effect	Correction (10^{-17})	Uncertainty (10^{-17})
Blackbody radiation	512.8	2.5
Lattice scalar / tensor	0	5.3
Lattice hyperpolarizability	–0.2	0.1
Lattice E2/M1	0	0.5
Probe light	0.1	0.1
Dc Stark	0.1	0.2
Quadratic Zeeman	50.9	0.6
Density	0.4	0.6
Background gas collisions	0	1.8
Line pulling	0	0.1
Servo error	–1.3	2.9
Total	562.8	6.9
Gravitational redshift	–834.1	2.2
Total (with gravitational effect)	–271.3	7.2

Table 2. Systematic corrections and their uncertainties for NICT-Sr1 between MJD 58914 and 58934.

References
[1] H. Hachisu and T. Ido, “Intermittent optical frequency measurements to reduce the dead time uncertainty of frequency link,” Jpn. J. Appl. Phys. **54**, 112401 (2015).
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