Operation of IT-CsF2 in 2020

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IT-CsF2 is the primary atomic frequency standard operated at INRIM. The frequency standard is based on a laser cooled Cs fountain apparatus operating at cryogenic temperature (88.5K), in order to reduce the blackbody radiation shift. The formal evaluation of the frequency standard is published in [1], while TAI calibration data are reported to BIPM since the end of 2013 and are published in the Circular T. The accuracy evaluation of the PFS involves periodical checks and validations of the whole set of parameters affecting the standard frequency: i.e. Zeeman shift, spectral purity of the microwave synthesis chain, interaction region temperature, atomic density shift, gravitational potential, and laser and microwave leakage. During 2020 we reported to BIPM nine formal TAI evaluations of the standard hereafter summarized. The total operating time of IT-CsF2 as PFS during 2020 was 165 days.

Circ T	Period	days	d(ITCsF2)-d(BIPM) (10^{-15})	uA (10^{-15})	uB (10^{-15})	Ul/Lab (10^{-15})	Ul/Tai (10^{-15})	Up time	u (10^{-15})
388	58899 58914	15	-0.39	0.64	0.17	0.36	0.37	80%	0.84
388	58919 58934	15	0.45	0.71	0.17	0.51	0.37	56%	0.96
388	58939 58954	15	0.43	0.64	0.17	0.18	0.37	88%	0.78
389	58964 58974	10	-0.31	0.66	0.17	0.22	0.53	83%	0.89
389	58989 58999	10	-1.35	0.67	0.17	0.14	0.53	97%	0.88
390	59019 59029	10	0.04	0.56	0.17	0.10	0.53	97%	0.79
391	59029 59054	25	-0.58	0.29	0.17	0.14	0.23	89%	0.43
393	59089 59119	30	-0.42	0.37	0.17	0.22	0.20	78%	0.50
396	59179 59214	35	0.73	0.17	0.36	0.18	0.17	87%	0.47

The weighted mean associated to the difference between the d(ITCsF2) and d(BIPM) has a value of

$$[\, d(ITCsF2) - d(BIPM) \,] = -0.13 \pm 0.37$$

showing a good agreement with the other frequency standards. The accuracy of ITCsF2 is nearly the same that was reported in [1] and it is summarized in the following table. Starting with the December evaluation, the way of reporting the uncertainty from the atomic density was changed from the type A (before December) to the type B. It is worth mentioning that the statistical uncertainty associated with the atomic density is obtained with long measurement time and thus vary from case to case according to the available set of data. Typically the low density uncertainty can reach ~3×10^{-16}.

1. Typical accuracy evaluation reported for Circ T 393

Physical effect	Bias (10^{-16})	Uncert. (10^{-16})
Zeeman effect	1099.3	0.8
Blackbody radiation	-1.45	0.12
Gravitational redshift	260.4	0.1
Microwave leakage	-1.2	1.4
DCP	-	0.2
2nd order cavity pulling	-	0.3
Background gas	**-**	0.5
Total Type B	**1357.1**	**1.7**
Atomic density (typical LD)*	-10.6	1.9

[1] Accuracy evaluation of ITCsF2: a nitrogen cooled caesium fountain, F. Levi, D. Calonico, C.E. Calosso, A. Godone, S. Micalizio and G.A. Costanzo; Metrologia 51 (2014) 270–284