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FREQUENCY COMPARISON
(H–MASER 40 3853) — (SU–CsFO2)
For the period MJD 60884 to MJD 60914.

The primary frequency standard SU–CsFO2 has been compared to the hydrogen Maser 40 3853 of the laboratory, during a measurement campaign between MJD 60884 and 60914 (28th July 2025 — 27th August 2025). The fountain operation covers $\sim 64.7\%$ of the total measurement duration for the period MJD 60884 – 60914. The mean frequency difference at the middle date of the period is given in the following table:

Period (MJD)	**Date of the estimation**	y (H–Maser 40 3853 — CsFO2)	u_B	u_A	$u_{\text{Link\_Maser}}$
60884 – 60914	60899.0	-1440.7	2.2	1.4	1.3

Table 1: Results of the comparison in $1 * 10^{-16}$.

For the uncertainty due to the clock link $u_{\text{Link\_Lab}} = 0.1 * 10^{-15}$ is obtained by taking into account the actual measurement time.

The CsFO2 standard uncertainty u_A is estimated as $0.14 * 10^{-15}$ (1σ) for the relevant periods.

Accuracy

The following table summarizes the budget of systematic effects and their associated uncertainties. The accuracy is the quadratic sum of all the systematic uncertainties.

Physical Effect	**Shifts** (10^{-16})	**Uncertainty** (10^{-16})
Second-order Zeeman effect	1064.5	0.1
Black-body radiation	-165.4	0.5
Gravitational shift	244.3	0.5
Resonator pulling	0	0.1
Purity of probe signal spectrum	0	0.1
Light shift	0	0.1
Tilting (DCP)	0	0.1

Physical Effect	**Shifts** (10^{-16})	**Uncertainty** (10^{-16})
Collisions with residual gas	0	1
Microwave power dependence	0	1.8
Spin exchange shift (mean density)*	0.19*	0.19*
Total (not including spin exchange)	1143.4	2.2

Table 2: Budget of systematic effects and uncertainties for VNIIFTRI–CsFO2 fountain for the MJD 60884 – 60914 period.

$$\boxed{u_B = 2.2 * 10^{-16}}$$

Uncertainty due to the dead times

During the evaluation period there were gaps in the data collection (dead time) due to both intentional and unintentional breaks. Most of the unintentional breaks were caused by failures of the laser locking systems (due to rapid change barometric pressure).

The standard deviation of the fluctuations of frequency due to the dead times in measurements is estimated by the ratio $\frac{\sqrt{\sum_i \sigma_{x_i}^2}}{T} = \sigma_{\text{Dead\_Time}}$.

Period (MJD)	$\sigma_{\text{Dead\_Time}}$
60884 – 60914	$7.9 * 10^{-17}$

The uncertainty on the link Maser is obtained by the quadratic sum of the link lab uncertainty and the uncertainty due to the dead times calculated above:

$$u_{\text{Link\_Lab}} = 1 * 10^{-16},$$
$$u_{\text{Link\_Maser}} = \sqrt{(\sigma_{\text{Dead\_Time}})^2 + (\sigma_{\text{Link\_Lab}})^2}.$$

Period (MJD)	$u_{\text{Link\_Maser}}$
60884 – 60914	$1.3 * 10^{-16}$

References

[1] Domnin Yu., Baryshev V., Boyko A., Elkin G., Novoselov A., Kopylov L., Kupalov D. The MTsR–F2 fountain-type cesium frequency standard // Measurement Techniques. 2013. Vol. 55. № 10. PP. 1155–1162.

[2] Blinov I., Boiko A., Domnin Yu., Kostromin V., Kupalova O., Kupalov D. Budget of uncertainties in the cesium frequency frame of fountain type // Measurement Techniques. 2017. Vol. 60. № 1. PP. 30–36.