

IENCsF1 TAI EVALUATION

MJD 53404-53414 (3February-13February 2005)

During the period MJD 53404.0-53414.0, IEN has evaluated the frequency of its Hydrogen Maser IEN-HM2 (BIPM code 1401102) using the Cs fountain IEN-CsF1. The evaluation of the fountain standard follows the procedures reported in [1].

The collisional shift was corrected using the differential technique reported in [1]. The sensitivity of the IEN-CsF1 frequency versus the number of detected atoms has been evaluated with two differential measurements, performed just before and after the reported evaluation period. Then the raw fountain data have been corrected with respect to the number of detected atoms.

The frequency values, already corrected for the collisions shift, have then been corrected for the Blackbody radiation, Gravitational and Zeeman shifts. The fountain operation temperature was not changed during the run, but it was carefully surveyed to ensure the stability of the Blackbody radiation shift.

Final values for Circular T are reported in Table 3.

[1] F. Levi, L. Lorini, D. Calonico, A. Godone, "IEN-CsF1 accuracy evaluation and Two-Way frequency comparison". IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 51, no. 10, pp. 1216-1224 (October 2004)

Black Body Radiation

$$\Delta v_{\text{BBR}} = \beta (T/300)^4 \times [1 + \epsilon(T/300)^2]$$

$$\beta = (-1.711 \pm 0.003) \times 10^{-14}$$

$$\epsilon = 0.014$$

$$T = 69.9 \pm 0.5 \text{ }^\circ\text{C} = 343.1 \pm 0.5 \text{ K}$$

$$\Delta v_{\text{BBR}} = (-29.8 \pm 0.1) \times 10^{-15}$$

Gravitational Red Shift

$$\Delta v_{\text{RS}} = \gamma \times h$$

$$\gamma = 1.09 \times 10^{-16} \text{ m}^{-1}$$

$$h = 242 \pm 1 \text{ m}$$

$$\Delta v_{\text{RS}} = (26.4 \pm 0.1) \times 10^{-15}$$

Quadratic Zeeman Shift

$$\Delta v_{\text{Z}} = K \times B_0^2$$

$$K = 427.45 \text{ Hz/T}^2$$

B_0 , C-field

$$\Delta v_{\text{Z}} = (46.0 \pm 0.4) \times 10^{-15}$$

Collisional Shift

$$\Delta v_{\text{C}} = (-1.7 \pm 1.0) \times 10^{-15} \text{ (*)}$$

Evaluation as described in [1]

(*) Average value calculated on the fountain operation accumulated time in the period MJD 53404-53414

Effect	Bias ($\times 10^{-15}$)	Uncertainty ($\times 10^{-15}$)
2 nd order Zeeman Shift	46.0	0.4
Blackbody Radiation	-29.8	0.1
Gravitational Potential	26.4	0.1
Collisions	-1.7	1.0
Total	40.9	1.1

Table 2. Summary of corrected biases and uncertainty budget in IEN-CsF1, for the run MJD 53404-53414

Ev. Period	y[IENCsF1-HM2]	uA	uB	ul/lab
53404-53414	$+127.1 \times 10^{-15}$	0.4×10^{-15}	1.1×10^{-15}	0.4×10^{-15} (**)

Table 3. Final results of IEN-CsF1 evaluation

(**) IEN-CsF1 Dead Time < 1% over the period MJD 53404-53414