# Evaluation of the frequency of the H-maser 1401708 by the primary frequency standard NPL-CsF2

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*26 November 2010*

The primary frequency standard NPL-CsF2 was used to measure the frequency of the H-maser HM2 identified by the clock code 1401708 during an evaluation campaign in October and November 2010. The clock 1401708 is a physical realisation of UTC(NPL). The evaluation was performed by measuring mean frequency differences over the reporting periods.

No changes to the physics package of NPL-CsF2 have been introduced since the previous reported evaluation.

The fountain was run in an alternating mode between high and low atomic densities with an optimised high-low density duty cycle. Similarly, the density (atom number) ratio $k = N_H / N_L$ was optimised for the current NPL-CsF2 operational parameters.

An additional alternation was introduced between optimum and elevated microwave power in order to gather data for a future re-evaluation of power-dependent shifts (e.g. distributed cavity phase shift). Data for the elevated powers were not taken into account in the TAI step interval evaluation reported here. The operation of the fountain at the elevated powers did not have any effect on the results obtained for the optimum power, other than the overall shortening of the effective measurement period and the introduction of additional dead time. Note, however, that the dead time introduced in this way had small effect on the final uncertainty (see below), because it was evenly distributed with individual gaps of the order of one to several hours.

Results of the frequency measurements are listed in the table below. Frequency biases are given for information only. The given fractional frequency difference *y(CsF2 – HM2)* is a value corrected for those biases. Note that the values for the collisional shift and its uncertainty vary, and so vary the total type B uncertainties $u_B$ for particular campaigns. The value of collisional shift is a time-averaged value for the high and low densities. The total uncertainty $u_{total}$ of the measurement is defined as:

$$(u_{total})^2 = (u_A)^2 + (u_B)^2 + (u_{l/lab})^2$$

| Period | (date) | 15 Oct 2010 – 09 Nov 2010 |
|---|---|---|
| Start | MJD | 55484 |
| Stop | MJD | 55509 |
| Duration | days | 25 |
| duty cycle | % | 39.7 |
| *Biases:* | $\times 10^{-15}$ | |
| 2nd order Zeeman | | 336.33 |
| BBR shift | | –16.62 |
| cold collisions | | 2.05 |
| gravity | | 1.30 |
| ***y(CsF2 - HM2)*** | $\times 10^{-15}$ | **–0.87** |
| $u_A$ | $\times 10^{-15}$ | 0.41 |
| $u_B$ | $\times 10^{-15}$ | 0.49 |
| $u_{l/lab}$ | $\times 10^{-15}$ | 0.05 |
| $\boldsymbol{u_{total}}$ | $\times 10^{-15}$ | **0.64** |