Evaluation of the frequency of UTC(NPL) by primary frequency standard NPL-CsF2

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The primary frequency standard NPL-CsF2 was used to measure the frequency of a hydrogen maser, HM6, during an evaluation period in March 2022. The output of this maser is linked to UTC(NPL) by a time interval logger, enabling us to obtain a measurement of the mean frequency of UTC(NPL) over the entire reported period. The mean frequency of the maser was determined by fitting to the data a function consisting of linear drift terms and steps corresponding to any applied frequency steers.

The local oscillator used for the synthesis of the interrogated microwave signal was based on a femtosecond frequency comb and derives its low phase noise characteristics from an ultra-stable laser. No other changes to NPL-CsF2 or its associated operating protocols have been introduced since the evaluation report accompanying circular-T 394 (October 2020). A breakdown of the systematic uncertainties from this report is reproduced in Table 1. The procedure for determining the frequency of UTC(NPL) from maser measurements, together with the corresponding contribution to the $u_{A/lab}$ and $u_{B/lab}$ uncertainties, was described in the report accompanying circular-T 399 (March 2021).

	uncertainty / 10^{-16}
Second order Zeeman	0.8
Blackbody radiation	1.0
AC Stark (lasers)	0.1
Microwave spectrum	0.1
Gravity	0.5
Cold collisions	0.4†
Background gas collisions	0.3
Rabi, Ramsey pulling	0.1
Cavity phase (distributed)	1.0
Cavity phase (dynamic)	0.1
Cavity pulling	0.6
Microwave leakage	0.6
Microwave lensing	0.3
2nd-order Doppler	0.1
Total u_B (1σ)	**2.0**

Table 1: Results of the most recent accuracy evaluation of NPL-CsF2.

† The value presented here is exemplary. A specific value for the given measurement period has been computed and included in the measurement results.

Measurement results

Results of the frequency measurement are listed in Table 2 below. Frequency biases are given for information only and represent the mean values of the biases over the measurement interval. The listed fractional frequency difference y(CsF2-UTC(NPL)) is a value corrected for these biases. The total uncertainty u_{total} is defined as:

$$(u_{\text{total}})^2 = (u_{\text{A}})^2 + (u_{\text{B}})^2 + \left(u_{\text{A/lab}}\right)^2 + \left(u_{\text{B/lab}}\right)^2$$

The cold collisions frequency shift was not well cancelled during this measurement period. The resulting systematic uncertainty due to this effect was 0.59×10^{-15}, making the overall systematic uncertainty u_{B} larger than usual.

		1 Mar 2022 – 31 Mar 2022
Period start	MJD	59639
Period end	MJD	59669
Duration	days	30
Measurement uptime	%	92.2
Biases:	$\times 10^{-15}$	
cold collisions		-3.65
2nd order Zeeman		247.51
BBR shift		-16.33
gravity		1.30
microwave lensing		0.06
DCP		0.02
***y*(CsF2-UTC(NPL))**	**$\times 10^{-15}$**	**-0.46**
u_{A}	$\times 10^{-15}$	0.07
u_{B}	$\times 10^{-15}$	0.62
$u_{\text{A/lab}}$	$\times 10^{-15}$	0.05
$u_{\text{B/lab}}$	$\times 10^{-15}$	0.03
$\boldsymbol{u_{\text{total}}}$	**$\times 10^{-15}$**	**0.63**

Table 2: Results of the evaluation of the frequency of UTC(NPL) by primary frequency standard NPL-CsF2.