

# 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, over an evaluation period in August 2021. The output of HM6 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 reported period.

The mean frequency of HM6 over the period is determined by fitting to the data a function consisting of a linear drift term and steps corresponding to any applied frequency steers.

NPL-CsF2 was taken out of operation in the week before the reported period, whilst its caesium reservoir was refilled. 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 measurements of HM6, 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 <sup>†</sup>
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
2 <sup>nd</sup> -order Doppler	0.1
<b>Total <math>u_B</math> (1<math>\sigma</math>)</b>	<b>2.0</b>

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

<sup>†</sup> 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  $y(\text{CsF2-UTC(NPL)})$  is a value corrected for these biases. The total uncertainty  $u_{\text{total}}$  is defined as:

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

		13 Aug 2021 – 28 Aug 2021
Period start	MJD	59439
Period end	MJD	59454
Duration	days	15
Measurement uptime	%	92.6
Biases:	$\times 10^{-15}$	
cold collisions		0.00
2 <sup>nd</sup> order Zeeman		247.57
BBR shift		-16.33
gravity		1.30
microwave lensing		0.06
DCP		0.02
<b><math>y(\text{CsF2-UTC(NPL)})</math></b>	<b><math>\times 10^{-15}</math></b>	<b>-0.55</b>
$u_A$	$\times 10^{-15}$	0.21
$u_B$	$\times 10^{-15}$	0.20
$u_{A/\text{lab}}$	$\times 10^{-15}$	0.13
$u_{B/\text{lab}}$	$\times 10^{-15}$	0.05
<b><math>u_{\text{total}}</math></b>	<b><math>\times 10^{-15}</math></b>	<b>0.32</b>

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