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

National Physical Laboratory

3rd June 2021

The primary frequency standard NPL-CsF2 was used to measure the frequency of a hydrogen maser HM6 over an evaluation period in April and May 2021. HM6 was not steered during this time. 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.

No 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	$0.4^{†}$
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 exemplary value here corresponds to the type B uncertainty contribution for a ratio of high to low atom density of 8 and a measured frequency difference between the two of below 2.5×10^{-15}. A specific value for the given measurement period is presented together with 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:

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

		30 Apr 2021 – 30 May 2021
Period start	MJD	59334
Period end	MJD	59364
Duration	days	30
Measurement uptime	%	98.6
Biases:	$\times 10^{-15}$	
cold collisions		0.01
2$^{\text{nd}}$ order Zeeman		247.57
BBR shift		-16.33
gravity		1.30
microwave lensing		0.06
DCP		0.02
y(CsF2-UTC(NPL))	**$\times 10^{-15}$**	**-0.23**
u_{A}	$\times 10^{-15}$	0.19
u_{B}	$\times 10^{-15}$	0.20
$u_{\text{A/lab}}$	$\times 10^{-15}$	0.01
$u_{\text{B/lab}}$	$\times 10^{-15}$	0.03
u_{total}	**$\times 10^{-15}$**	**0.27**

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