**RECOMMENDATION CCTF PSFS 2 (2021)**

**Updates to the CIPM list of standard frequencies**

The Consultative Committee for Time and Frequency (CCTF), at its 22nd session in 2020 and 2021,

considering that

- a common list of “Recommended values of standard frequencies for applications including the practical realization of the metre and secondary representations of the second” has been established,
- the CCL-CCTF Frequency Standards Working Group (WGFS) has reviewed several candidates for updating the list;

recommends

that the following transition frequencies shall be updated in the list of recommended values of standard frequencies:

- the unperturbed optical transition $5s^2 \, ^1S_0 - 5s5p \, ^3P_0$ of the $^{115}$In$^+$ ion with a frequency of $f_{115\text{In}^+} = 1\,267\,402\,452\,901\,041.3$ Hz and an estimated relative standard uncertainty of $4.3 \times 10^{-15}$;
- the unperturbed optical transition $6s^2 \, ^1S_0 - 6s6p \, ^3P_0$ of the $^{199}$Hg neutral atom with a frequency of $f_{199\text{Hg}} = 1\,128\,575\,290\,808\,154.32$ Hz and an estimated relative standard uncertainty of $2.4 \times 10^{-16}$ (this radiation is already endorsed as a secondary representation of the second);
- the unperturbed optical transition $3s^2 \, ^1S_0 - 3s3p \, ^3P_0$ of the $^{27}$Al$^+$ ion with a frequency of $f_{27\text{Al}^+} = 1\,064\,721\,609\,899\,146.96$ Hz and an estimated relative standard uncertainty of $1.9 \times 10^{-16}$ (this radiation is already endorsed as a secondary representation of the second);
- the unperturbed optical transition $5d^{10}6s \, ^2S_{1/2} - 5d^96s^2 \, ^2D_{5/2}$ of the $^{199}$Hg$^+$ ion with a frequency of $f_{199\text{Hg}^+} = 1\,064\,721\,609\,899\,146.96$ Hz and an estimated relative standard uncertainty of $2.2 \times 10^{-16}$ (this radiation is already endorsed as a secondary representation of the second);
- the unperturbed optical transition $6s \, ^2S_{1/2} (F = 0, m_F = 0) - 5d \, ^2D_{3/2} (F = 2, m_F = 0)$ of the $^{171}$Yb$^+$ ion with a frequency of $f_{171\text{Yb}^+}$ (quadrupole) = $688\,358\,979\,309\,308.24$ Hz and an estimated relative standard uncertainty of $2.0 \times 10^{-16}$ (this radiation is already endorsed as a secondary representation of the second);
- the unperturbed optical transition $6s \, ^2S_{1/2} - 4f^{13}6s^2 \, ^2F_{7/2}$ of the $^{171}$Yb$^+$ ion with a frequency of $f_{171\text{Yb}^+}$ (octupole) = $642\,121\,496\,772\,645.12$ Hz and an estimated relative standard uncertainty of $1.9 \times 10^{-16}$ (this radiation is already endorsed as a secondary representation of the second);
- the unperturbed optical transition $6s^2 \, ^1S_0 - 6s6p \, ^3P_0$ of the $^{171}$Yb neutral atom with a frequency of $f_{171\text{Yb}} = 518\,295\,836\,590\,863.63$ Hz and an estimated relative standard uncertainty of $1.9 \times 10^{-16}$ (this radiation is already endorsed as a secondary representation of the second);
- the unperturbed optical transition $5s \, ^2S_{1/2} - 4d \, ^2D_{5/2}$ of the $^{88}$Sr$^+$ ion with a frequency of $f_{88\text{Sr}^+} = 444\,779\,044\,095\,486.3$ Hz and an estimated relative standard uncertainty of $1.3 \times 10^{-15}$ (this radiation is already endorsed as a secondary representation of the second);

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1 These values were agreed by the CCTF in March 2021 and became active on April 13, 2022
- the unperturbed optical transition $5s^2 \, ^1S_0 - 5s5p \, ^3P_0$ of the $^{88}$Sr neutral atom with a frequency of $f_{88Sr} = 429 228 066 418.007.01$ Hz and an estimated relative standard uncertainty of $2.0 \times 10^{-16}$; This radiation is now endorsed as a secondary representation of the second;

- the unperturbed optical transition $5s^2 \, ^1S_0 - 5s5p \, ^3P_0$ of the $^{87}$Sr neutral atom with a frequency of $f_{87Sr} = 429 228 004 229.872.99$ Hz and an estimated relative standard uncertainty of $1.9 \times 10^{-16}$ (this radiation is already endorsed as a secondary representation of the second);

- the unperturbed optical transition $4s^2 \, ^2S_{1/2} - 3d \, ^2D_{5/2}$ of the $^{40}$Ca$^+$ ion with a frequency of $f_{40Ca^+} = 411 042 129 776.400.4$ Hz and an estimated relative standard uncertainty of $1.8 \times 10^{-15}$; This radiation is now endorsed as a secondary representation of the second;

- the unperturbed ground-state hyperfine transition of $^{87}$Rb with an unchanged frequency of $f_{87Rb} = 6 834 682 610.904 312.6$ Hz and an estimated relative standard uncertainty of $3.4 \times 10^{-16}$ (this radiation is already endorsed as a secondary representation of the second).

that the BIPM publish in electronic form:

- the list of recommended values of standard frequencies updated accordingly,
- the list of publications reporting measurements from which these values are obtained by least square fit adjustment,
- the output covariance matrix derived from this least square adjustment

and informs the CIPM accordingly.