Questionnaire previous to the 2005 meeting of the CCL/CCTF joint working group

The CIPM on its meeting in autumn 2004 has decided that the unperturbed ground-state hyperfine quantum transition of ^{87}Rb
may be used as a secondary representation of the second with a frequency of
f_{Rb}= 6 834 682 610.904 324 Hz
and an estimated relative standard uncertainty (1σ) of 3 x 10^{-15}

1. Frequency sources in the microwave domain

   1.1. Have you made or are you aware of new absolute frequency measurements of the Rb hyperfine transition?

   No

   If yes, please list the values and uncertainties obtained and refer to the publication in which they may be found. Please be sure to include measurements made in other laboratories.

   1.2. Are you aware of absolute frequency measurements of other microwave standards that should be proposed as secondary representations of the second?

   No

   If yes, please list the values and uncertainties obtained and the method used and refer to the publication in which they may be found. Please be sure to include measurements made in other laboratories in your country.

   1.3. Are you currently developing new frequency sources in the microwave domain?

   No

   If yes, please give a brief description of your experiment.

2. Frequency sources in the optical domain

   2.1. Have you made or are you aware of new absolute optical frequency measurements suitable to serve as secondary representations of the second?

   Yes

We believe the single $^{88}Sr^+$ ion $^2S_{1/2} - {}^2D_{5/2}$ quadrupole clock transition at 674 nm is suitable to serve as a secondary representation of the second. This follows from absolute frequency measurements that we made during 2004 of the single $^{88}Sr^+$ ion $^2S_{1/2} - {}^2D_{5/2}$ quadrupole clock transition at 674 nm, by means of a self-referenced femtosecond frequency comb, referenced to the NPL Cs fountain. The value for this strontium quadrupole line centre frequency is:

$$f\,(^{88}Sr^+\ {}^2S_{1/2} - {}^2D_{5/2}) = 444\ 779\ 044\ 095\ 484.6\ (1.5)\ \mathrm{Hz}$$

Full details of these measurements are given in the following paper:

H S Margolis, G P Barwood, G Huang, H A Klein, S N Lea, K Szymaniec, P Gill *Science* **306** 1355-8 (2004).

This value is in excellent agreement with the most recent value from NRC for this transition which is 444 779 044 095 484 (15) Hz [Dube et al *Phys Rev. Lett*. **95** 033001 (2005)]. *More recently in 2005, we have some preliminary measurements with larger statistical uncertainty but with greatly reduced 422 nm ac Stark shift which corroborate our 2004 value.*

2.2: Are you currently developing new frequency sources in the optical domain? Yes

We are also developing the single $^{171}Yb^+$ ion $^2S_{1/2} - {}^2F_{7/2}$ octupole clock transition at 467 nm as an optical frequency standard. No new measurements of this transition have been made since the last CCL in 2003. However, the frequency value measured with a maser–referenced femtosecond comb and reported at that meeting was

$$f\,(^{171}Yb^+\ {}^2S_{1/2} - {}^2F_{7/2}) = 642\ 121\ 496\ 772.3\ (0.6)\ \mathrm{kHz}$$

and this has now been fully published in the following reference:

K Hosaka, S A Webster, P J Blythe, A Stannard, D Beaton, H S Margolis, S N Lea and P Gill *IEEE Trans. Instrum. Meas*. **54** 759-62 (2005)

Recently, we reduced the Ti:sapphire probe laser linewidth to the 5 Hz @ 1 second timescale (20 Hz over 40 s), and are currently engaged in setting up a second ytterbium ion end-cap trap, where we hope to scan and lock to the octupole transition in the near future. This should lead to a new improved frequency measurement of the octupole transition, and enable a study of stability and systematic frequency shift determinations by means of two-trap comparisons

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