Questionnaire
previous to the 2007 meeting of the
CCL-CCTF Frequency Standards Working Group

Note: Results will be considered only if there is a publication or at least acceptance for publication at the date of the meeting.

1. Have you made absolute frequency measurements of radiations included in the CCL list of recommended radiations (Mise en Pratique 2005)?

   Yes [ ] No [X]

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

   1.1. If yes, indicate for each one whether you think that any of these measurements should modify the current value and uncertainty already on the list.

   Yes [ ] No [ ]

   (add as many lines as necessary)

2. Have you made absolute frequency measurements of radiations included in the CCTF list of secondary representations of the second?

   Yes [ ] No [X]

   2.1. If yes, please list the values and uncertainties obtained and the methods 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.

   2.2. If yes, indicate for each one whether you think that any of these measurements should be proposed as an update of existing value and uncertainty to be considered at the next CCL-CCTF Joint WG meeting just prior to the CCTF (2008/2009).

   Yes [ ] No [ ]

   (add as many lines as necessary)

3. Have you made absolute frequency measurements of other radiations <u>not</u> included in these lists?

   Yes [X] No [ ]

   If yes, please list the values and uncertainties obtained and the methods 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.

Hyperfine structures of three iodine transitions have been measured by using Doppler-free modulation transfer spectroscopy. The uncertainty of these measurements is about 100 Hz. However, taking into account the frequency dependence on the cell quality and other effects, an uncertainty of 5 kHz may be applied.

Ref.1: F.-L. Hong, Y. Zhang, J. Ishikawa, A. Onae, H. Matsumoto, “Hyperfine structure and absolute frequency determination of the R(121)35-0 and P(142)37-0 transitions of $^{127}I_2$ near 532 nm,” Opt. Commun. 212 (2002) 89–95.
Ref.2: F.-L. Hong, S. Diddams, R. Guo, Z.-Y. Bi, A. Onae, H. Inaba, J. Ishikawa, K. Okumura, D. Katsuragi, J. Hirata, T. Shimizu, T. Kurosu, Y. Koga, and H. Matsumoto, “Frequency measurements and hyperfine structure of the R(85)33– 0 transition of molecular iodine with a femtosecond optical comb,” J. Opt. Soc. Am. B 21 (2004) 88-95.

Line	Assignment	f_{interval} (kHz)
1113	R(1 2 1)35-0:a_1	27 539 228.6
1112	P(1 4 2)37-0:a_1	20 123 511.4
1110	R(5 6)32-0:a_{10}	0.0

Line	Assignment	f_{interval} (kHz)
1114	$R(85)33-0:a_1$	46 496 559.1
1110	$R(56)32-0:a_{10}$	0.0

Hyperfine Splittings of the R(121)35-0 Transition

Hyperfine component	Observed (kHz)
a_1	0
a_2	78094.0
a_3	154328.5
a_4	291034.5
a_5	351499.2
a_6	374970.5
a_7	433704.3
a_8	456783.2
a_9	476593.6
a_{10}	534662.3
a_{11}	553248.7
a_{12}	594812.8
a_{13}	648394.2
a_{14}	702090.3
a_{15}	749153.7
a_{16}	773429.2
a_{17}	808079.0
a_{18}	831410.9
a_{19}	914362.6
a_{20}	932813.8
a_{21}	952564.0

Hyperfine Splittings of the P(142)27-0 Transition

Hyperfine component	Observed (kHz)
a_1	0
a_2	201862.3
a_3	266700.6
a_4	302571.3
a_5	361836.0
a_6	366696.9
a_7	386204.6
a_8	467369.1
a_9	491394.9
a_{10}	569318.6
a_{11}	669162.1
a_{12}	688963.6
a_{13}	734239.7
a_{14}	754848.4
a_{15}	854522.3

Hyperfine Splittings of the R(85)33– 0 Transition

Hyperfine Component	Observed (kHz)
a_1	0
a_2	50732.5
a_3	99742.3
a_4	281946.2
a_5	331678.7
a_6	341087.6
a_7	389099.9
a_8	445205.3
a_9	461608.4
a_{10}	496293.9
a_{11}	510619.4
a_{12}	582132.0
a_{13}	621988.5
a_{14}	662825.5
a_{15}	729463.3
a_{16}	751718.8
a_{17}	777078.3
a_{18}	798584.8
a_{19}	892318.3
a_{20}	906642.5
a_{21}	922692.5

3.1. If yes, indicate if any of these sources should be included in a updated list of "Recommended values of standard frequencies for applications including the practical realization of the metre and secondary representations of the second, and present your arguments for a positive assessment.

Recommended for the MeP:

Yes [X] No [ ]

The practical iodine-stabilized Nd:YVO_4 laser has a much wider gain curve in frequency than that of the Nd:YAG laser. It is important to provide enough choice of absorption lines for the practical laser.

Recommended for secondary representation of the second

Yes [ ] No [X]

(add as many lines as necessary)

4. Are you currently developing new frequency sources or are you aware of such sources developed in your country?

Yes [X] No [ ]

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

1) In NMIJ

We have been developing the Yb optical lattice clock at NMIJ. We are developing all the light sources for the Yb lattice clock. We have obtained a blue MOT (399nm).

One of our fiber combs was recently shipped to NMIA in Australia to perform a comb comparison with the NMIA fiber comb. As a result, agreements within 4×10^{-13} at 1 s averaging, and 3×10^{-16} at 10000 s averaging were obtained in the comparison.

2) In the University of Tokyo

Two optical lattice clocks, which based on spin-polarized fermionic ^{87}Sr trapped in a one-dimensional optical lattice and on bosonic ^{88}Sr in a three-dimensional lattice, were operated simultaneously. The optical beat note of these two clocks indicated a stability of $2\times10^{-14} / t^{1/2}$ for an averaging time up to 1000 s. Construction of optical lattice clocks based on Yb and Hg atoms are in progress.

3) In NICT

Ca+ single ion, 729nm clock transition was measured with an uncertainty of 600 kHz (PTTI 2006 proceedings). We have also started the development of a Sr optical lattice clock since 2006.

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INSTITUTE: ……NMIJ…………………………………………………………………

Note: After the decision of the CIPM in autumn 2006

that

- the CCL-*Mise en Pratique* WG and CCL/CCTF JWG be combined into a single CCL-CCTF frequency standards working group,
- the *Mise en Pratique*-CCL list of Recommended Radiations and CCTF Secondary Representation list be combined into a single new list of "Recommended values of standard frequencies for applications including the practical realization of the metre and secondary representations of the second",
- other frequencies may be proposed, evaluated and maintained on the frequency standards list by the CCL-CCTF frequency standards WG, not all of which are adopted as CCL-preferred radiations or CCTF-accepted representations,
- the CCTF consider and recommends those frequencies which it proposes the CIPM to accept as secondary representations of the second,
- the CCL considers and recommends those frequencies which it deems important for use in high accuracy length metrology, and
- the frequency values list is maintained on the BIPM website.

the CCL-CCTF frequency standards working group at its meeting in September 2007 will thus be required

1. to recommend to the CCL, frequency standards to be added to the list of recommended radiations,
2. to follow the development of frequency standards to be considered at the next CCTF as possible secondary representations of the second (no decision before the next CCTF),
3. to recommend other frequencies relevant for science or technology.

Additional information:

The current list of recommended frequencies as secondary representations of the second contains

- the unperturbed ground-state hyperfine quantum transition of ^{87}Rb with a frequency of f (^{87}Rb) = 6 834 682 610.904 324 Hz
  and an estimated relative standard uncertainty of 3 × 10^{-15},

- the unperturbed optical 5d^{10} 6s $^2S_{1/2}$ (F = 0) – 5d^9 6s^2 $^2D_{5/2}$ (F =2) transition of the ^{199}Hg+ ion with a frequency of
  f (^{199}Hg+) = 1 064 721 609 899 145 Hz
  and a relative standard uncertainty of 3 x 10^{-15},

- the unperturbed optical 5s $^2S_{1/2}$ – 4d $^2D_{5/2}$ transition of the $^{88}Sr^+$ ion with a frequency of f ($^{88}Sr^+$) = 444 779 044 095 484 Hz
  and a relative uncertainty of 7 x 10^{-15},

- the unperturbed optical 6s $^2S_{1/2}$ (F = 0) – 5d $^2D_{3/2}$ (F =2) transition of the $^{171}Yb^+$ ion
  with a frequency of f ($^{171}Yb^+$) = 688 358 979 309 308 Hz
  and a relative standard uncertainty of 9 x 10^{-15},

- the unperturbed optical transition 5s^2 $^1S_0$ – 5s5p $^3P_0$ ^{87}Sr neutral atom with a frequency of f (^{87}Sr) = 429 228 004 229 877 Hz
  and a relative standard uncertainty of 1.5 x 10^{-14}.