CCL-CCTF/05-06
August 9, 2005

Report to the CCL/CCTF joint working group meeting from Japan

--- NMIJ/AIST ---

Question 1.1: No

Question 1.2: No

Question 1.3: No

Question 2.1: No

As the result of a joint research project between the University of Tokyo and the NMIJ/AIST, we have measured the absolute frequency of a Sr optical lattice clock. The current measurement uncertainty is 3×10^{-14}. Although this uncertainty does not meet the criterion for the secondary representation of the second, the lattice clock has a huge potential for future improvements. We report the measurement result of the Sr lattice clock in the answer to the next question.

Question 2.2: Yes

We report the activities of three optical frequency standards in Japan.

1) Sr optical lattice clock (location: the University of Tokyo)

In the lattice clock scheme, the ultracold Sr atoms were confined in periodic trapping potentials. The measured linewidth of the clock transition was 27 Hz [1]. The determined 'magic' wavelength for the Sr lattice clock was 813.420(7) nm [1]. For measuring the absolute frequency of the Sr lattice clock, we have established a transportable frequency measurement system using an optical frequency comb linked to a commercial Cs atomic clock, which is in turn linked to international atomic time (TAI) through global positioning system (GPS) time [2]. An iodine-stabilized Nd:YAG laser is used as a flywheel in the frequency measurement system. The obtained absolute frequency of the $^1S_0 - {}^3P_0$ transition of ^{87}Sr atoms in an optical lattice is 429,228,004,229,952(15) Hz (fractional uncertainty 3×10^{-14}) [1, 2].

We have a plan to measure this transition again in autumn of 2005 with improved measurement uncertainty.

References:

[1] M. Takamoto, F.-L. Hong, R. Higashi, and H. Katori, "An optical lattice clock," Nature 435, 321 (2005).

[2] F.-L. Hong, M. Takamoto, R. Higashi, Y. Fukuyama, J. Jiang, and H. Katori, "Frequency measurement of a Sr lattice clock using an SI-second-referenced optical frequency comb linked by a global positioning system (GPS)," Opt. Express 13, 5253 (2005).

2) Yb optical lattice clock (location: the NMIJ/AIST)

We have started to build an Yb optical lattice clock at the NMIJ/AIST in cooperation with the University of Tokyo. The clock transition is at the wavelength of 578 nm with a natural linewidth of 10 mHz. The 'magic' wavelength of the Yb lattice clock was calculated to be around 752 nm [1]. The clock transition of two odd isotopes of Yb was measured with an uncertainty of 4.4 kHz (fractional uncertainty 8×10^{-12}) by the NIST team [2].

References:

[1] S. G. Porsev, A. Derevianko, E. N. Fortson, "Possibility of an optical clock using the 6 $^1S_0$ – 6 $^3P_0$ transition in $^{171, 173}$Yb atoms held in an optical lattice," Phys. Rev. A 69, 021403(R) (2005).

[2] C. W. Hoyt, Z. W. Barber, C. W. Oates, T. M. Fortier, S. A. Diddams, L. Hollberg, "Observation and absolute frequency measurements of the $^1S_0$ – $^3P_0$ optical clock transition in ytterbium," arXiv:physics/0503240 v1.

3) Calcium ion trap (location: NICT)

A single Calcium ion optical frequency standard has been developed in National Institute of Information and Communications Technology (NICT). Recently, S-D electric quadrupole quantum jump signals of the single 40Ca+ ion were observed in a miniature trap. The linewidth of the developed clock laser has been narrowed to several tens Hz. The central frequency of the S-D transition will be measured soon.