

## Commission A (Electromagnetic Metrology) Activity Report

March 2009 - July 2009

## 1. Activities in the field of electromagnetic metrology

At National Metrology Institute of Japan (National Institute of Advanced Industrial Science and Technology), research and developments related with the time and frequency field are performed by three sections. Time Standards Section is operating the cesium atomic fountain frequency standard, NMIJ-F1, with the uncertainty of  $4 \times 10^{-15}$ . The second fountain frequency standard, NMIJ-F2, is being developed with the target uncertainty of  $10^{-16}$  level. Wavelength Standards Section has achieved the absolute frequency measurement of the clock transition of Yb atoms with the uncertainty of  $5 \times 10^{-14}$ , and also collaborated with a group at the University of Tokyo and the University of Electro-Communications to evaluate the absolute frequency of the  $^{87}\text{Sr}$  optical lattice clock developed by the University of Tokyo. These results were reported to the CCL-CCTF Frequency Standards Working Group meeting held on the beginning of June 2009. Frequency Measurement Systems Section is performing research and developments for precise time keeping, dissemination of standards, and traceability.

Standards related with electromagnetic waves are performed at Electricity and Magnetism Division and Electromagnetic Waves Division. The former division is dealing with standards such as electric current, magnetic resistance, and power of electric power lines. The later division is performing research on power standards, noise standards, attenuation standards, and impedance standards. The antenna calibration for precise measurement is also performed at the same division.

At National Institute of Information and Communications Technology, research and developments related with time and frequency are currently conducted by the Space-Time Standards Group of the New Generation Network Research Center. The objectives of this group are to establish standards and reference of space and time as the fundamental basis for various fields of activities in science, engineering, and social activities, and to provide easy access to these foundations from wide range of communities. Single ion trap system of the  $\text{Ca}^+$  ion and optical lattice system of Sr atoms are currently developed to evaluate the accurate clock transition frequencies. The Electromagnetic Compatibility Group of the Applied Electromagnetic Research

Center is performing various research related with EMC problems which include standards of electromagnetic measurement methods and calibrations.

At University of Electro-Communications, a stable transfer system for frequency standard signals by using optical fiber has been developed and was used to evaluate the absolute frequency of the clock transition of  $^{87}\text{Sr}$  atoms. At Kyoto University, developments of small size trap systems for multiple ions of  $\text{Yb}^+$  and  $\text{Ba}^+$  ions are being performed. At Yokohama National University, software GNSS/GPS receiver systems for common view time and frequency transfer are being developed. At Tokyo Metropolitan University, developments of small size atomic oscillator are being performed. An experimental system with  $^{85}\text{Rb}$  has been developed and very good performance of long interval frequency stability was demonstrated. A low phase noise crystal oscillator system with the performance of  $-120\text{dBc}/\text{Hz}@1\text{Hz}$  has also been developed.

## 2. International meetings

18th meeting of the CCTF (Consultive Committee for Time and Frequency) was held for two days from June 4, 2009, at BIPM in Sevres, France. Before the main meeting, second meeting of the CCL-CCTF Frequency Standards Working Group (June 2) and eighth meeting of representatives of laboratories contributing to TAI (June 3) were also held. During these meetings, various fields relating with time and frequency were discussed. Due to the recent rapid developments of the optical frequency standards, optical clocks are now considered to be superior to the best primary cesium clocks with respect to stability and accuracy. For the possible new definition of the second, it was emphasized that the strategic cooperation and improvements of the time and frequency transfer methods are necessary.

The 26th meeting of the CCEM was also held at the Pavillon du Mail in BIPM on 12 and 13 March 2009. The CCEM working groups met during the days before the CCEM meeting. The main WGs are the WGLF and the GTRF. The CCEM WG on radio frequency quantities is the GTRF. The major topic in the meetings was the management of Key Comparisons of miscellaneous electric and electromagnetic quantities, namely power, attenuation, impedance and so on, to keep the Calibration and Measurement Capabilities (CMC) registered in the BIPM database of Appendix-C which were important to be used to show the equivalency and conformity of the national metrology standards made by the National Metrology Institute (NMI) of each country.