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Activities of NMIJ, AIST towards the Redefinition of the Second

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Recent activities of the Time Standards group at NMIJ, AIST towards the redefinition of the SI second will be presented. The first topic is the development of the robust ytterbium (Yb) optical lattice clock for the future optical time scale. Newly developed compact laser systems, compact vacuum systems, and the calm environment enabled a long-time regularly operation, which also led to an unprecedented level of uncertainty evaluation for the second order Zeeman effect [1]. The second topic is the development of the Yb/Sr dual optical lattice clock. Both atomic species are contained in a single vacuum chamber, leading to a partial compensation of the environmental perturbation due to the room-temperature blackbody radiation. This system can be used to investigate the ultracold Yb-Sr interaction [2]. The third topic is the development of the laser-controlled cold Yb atomic beam source for the transportable optical lattice clock. We demonstrated the cold emission of Yb atomic vapors from ytterbium oxide (Yb_2O_3) irradiated with a simple ultraviolet diode laser. Slow atoms are trapped by a magneto-optical trap using a dipole-allowed transition at 399 nm [3]. Finally, we will present our preliminary study on a machine learning technique for predicting the frequency fluctuation of the hydrogen maser, which is used as a master oscillator for generating UTC(NMIJ), for investigating the possibility of improving the frequency stability of the standards by a “AI-based method”. This versatile method may be applicable for any frequency standards, hopefully for the optical flywheel in case when the ultracold atoms in an optical lattice are not temporally available.

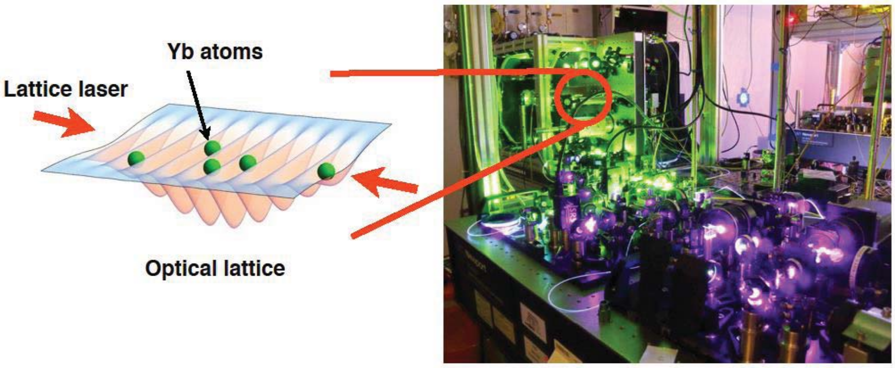

Figure 1. Robust Yb optical lattice clock system for contributing the optical time scale

1. T. Kobayashi, D. Akamatsu, Y. Hisai, T. Tanabe, H. Inaba, T. Suzuyama, F.-L. Hong, K. Hosaka, and M. Yasuda, “Uncertainty evaluation of an ^{171}Yb optical lattice clock at NMIJ” IEEE Trans. Ultrason. Ferroelectr. Freq. Control, **65,** 12, September 2018, pp. 2449-2458, doi:10.1109/TUFFC.2018.2870937.

2. D. Akamatsu, T. Kobayashi, Y. Hisai, T. Tanabe, K. Hosaka, M. Yasuda, and F.-L. Hong, “Dual-mode operation of an optical lattice clock using strontium and ytterbium” IEEE Trans. Ultrason. Ferroelectr. Freq. Control, **65**, 6, March 2018, pp. 1069-1075, doi:10.1109/TUFFC.2018.2819888.

3. M. Yasuda, T. Tanabe, T. Kobayashi, D. Akamatsu, T. Sato, A. Hatakeyama, “Laser-Controlled Cold Ytterbium Source for Transportable Optical Clocks” J. Phys. Soc. Jpn. **86**, 125001, November 2017, doi:10.7566/JPSJ.86.125001.