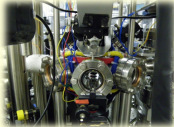
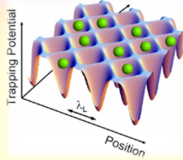


Frequency metrology at NMIJ and possible collaborations with Europe

Hajime INABA, Feng-Lei HONG, Takeshi IKEGAMI, Shinya YANAGIMACHI, Tomonari SUZUYAMA, Masami YASUDA, Masaki AMEMIYA, and Michito IMAE
National Institute of Advanced Industrial Science and Technology (AIST), Japan

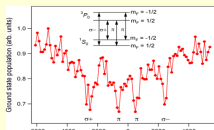
Frequency metrology at NMIJ

Yb Optical Lattice Clock:
A candidate for the next frequency standard

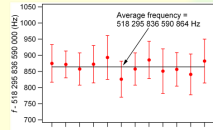


Vacuum chamber for trapping atoms

Ultracold Yb atoms in the MOT



Observed spectrum of the clock transition in ^{171}Yb

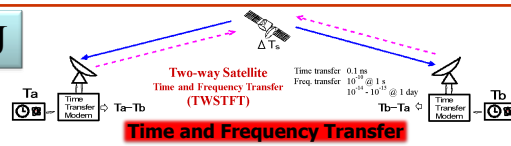


Absolute frequency measurement of the clock transition in ^{171}Yb

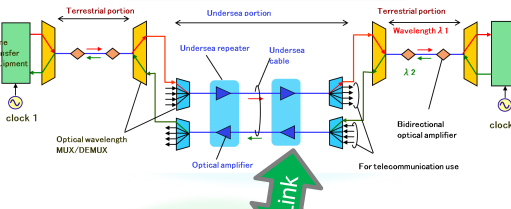
Source of uncertainty	Bias (Hz)	Uncertainty (Hz)
Blackbody radiation	+1.32	0.13
Gravitation	-1.19	0.03
2nd order Zeeman	+0.4	0.05
Scalar light shift	0	0.14
Clock laser light shift	-0.04	-0.01
Paper lock error	0	23
UTC(NMIJ)	0	5
Total	+0.49	27

Frequency biases and uncertainties in NMIJ Yb optical lattice clock (Very small corrections!)

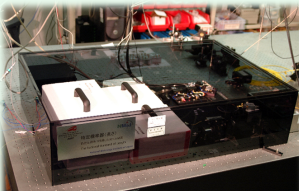
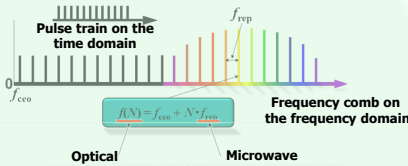
Our value was listed up in the *Mise en pratique* list of recommended radiations to realize meter (C2-2009).



Two-way Satellite Time and Frequency Transfer (TWSTFT)



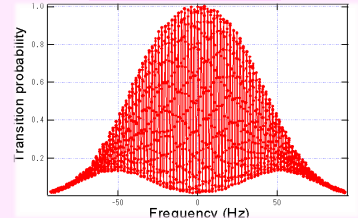
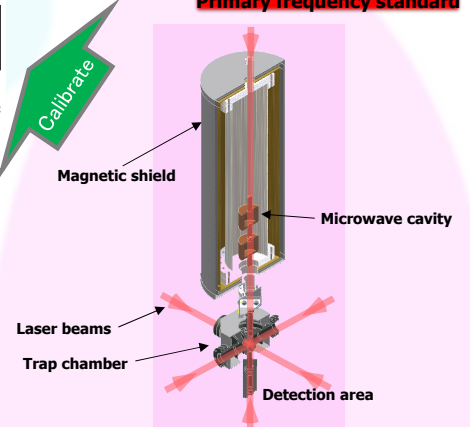
Optical Frequency Comb:
Frequency linker between optical and microwave



Japanese National Standard of "Length"

Length metrology

Cs fountain:
Primary frequency standard



Ramsey fringe of NMIJ-F1

Source of uncertainty	Bias	Uncertainty
2nd order Zeeman	185	0.5
Black body radiation	-17.8	1.4
Gravitation	1.6	0.1
Cold collisions	0.0	3.3
Distributed Cavity Phase	0.0	1.2
Microwave power dependence	0.0	0.7
Total	168.8	3.9

Frequency biases and uncertainties in NMIJ-F1 (typical)

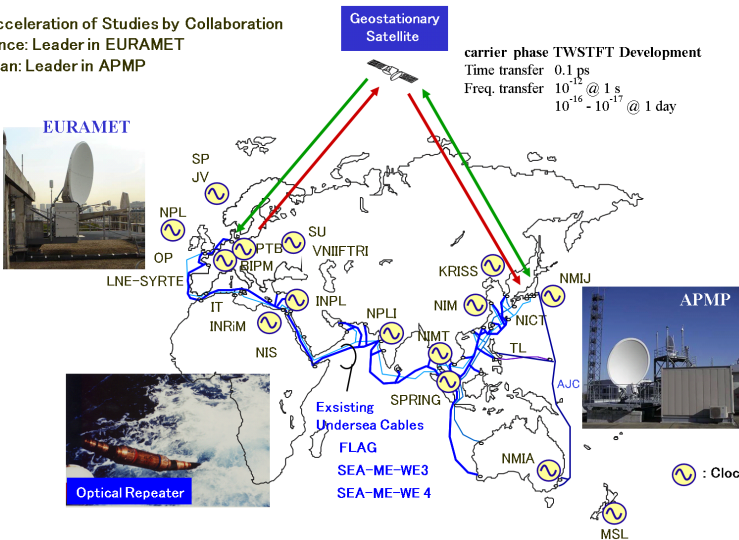
Establishment of a global scheme is required to accelerate collaboration between EURAMET and APMP in the frame of the Metre Convention.

Possible collaboration with Europe (1)

Construction of time and frequency transfer system between Europe and Japan

◆ Global T&F Transfer by Satellites and Undersea Cables

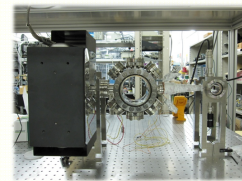
◆ Acceleration of Studies by Collaboration
France: Leader in EURAMET
Japan: Leader in APMP



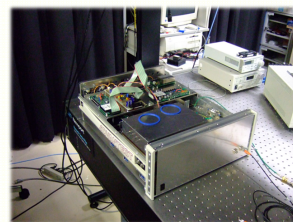
carrier phase TWSTFT Development
Time transfer 0.1 ps
Freq. transfer 10^{-12} @ 1 s
 $10^{-16} - 10^{-17}$ @ 1 day

Possible collaboration with Europe (2)

International comparison using "portable" standards



Portable optical lattice clock
Intercontinental frequency comparison
Space clock



Portable optical frequency comb
Intercontinental comb comparison



Portable fountain
Intercontinental frequency comparison