Status Report from NIM

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Since last CCTF meeting, we have gotten some progresses in the time and frequency field at NIM China.

Development of a Sr lattice clock in NIM: We have started to build a Strontium lattice optical clock since 2007 targeted for the next generation frequency standard. The physical system of the clock (including Sr oven, Zeeman slower, Magnetic Optical Trap (MOT)), part of the laser/optical system and part of the electronics/control system for the blue and red MOT have been constructed as showed in Figure 1 left. In July, 2008 we observed the blue MOT atom cloud for the first time, see Figure 1 right, and about 50 million atoms are captured in the MOT up to now with 2D cooling and repumping. We are preparing the next step of this Sr clock: to realize the red MOT atoms.

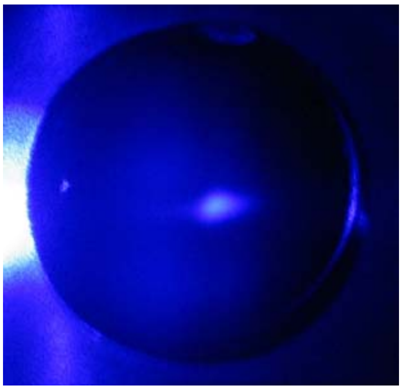

Fig1. Pictures of optical clock and captured blue MOT atoms.

Primary frequency standard: The second laser cooling - Cesium fountain clock NIM5 adopts the (1,1,1) configuration and prepares cold atoms in direct OM (Optical Molasses). NIM5 has been running with an operation ratio of 99% and stability of 2×10^{-15}/d since 2007. Recent frequency evaluations of NIM5 in 2009 showed a typical combined uncertainty of 2×10^{-15}. The frequency of NIM5 is compared with UTC through GPS P3 from 20 Feb. To 27 Apr. 2009 and the difference turned out to be less than 2e-15, which is within one deviation of the combined uncertainty of the NIM5, the UTC and the GPS P3 link. We are preparing to apply to the WGPFS to report the NIM5 data to BIPM so contribute to the international atomic time before too long.

	Physical Effect	Shift (10^{-15})	U (10^{-15})	
1	2nd Zeeman:	76.2	0.4	H_C=128.0 nT
2	Atom collisions at kiw density:	-0.72*	1.1	
3	Microwave power related:	0.0	0.7	
4	Blackbody:	-23.2	1.0	Temperature: 51±0.7°C
5	Gravitation:	3.76	0.1	Above sea: 34.5 m
6	Majorana:	0.0	0.1	
7	Light shift:	0.0	0.2	
8	Cavity pulling:	0.0	0.1	
9	Cavity phase difference:	0.0	0.1	Phase difference: 4 μradian
	Combined:	56.04	1.7	

Figure 2. The NIM5 (left) and a typical frequency evaluation (right).

Updating of TA (NIM): As a experiment phase of new NIM time scale the NIM5 clock has been used to steer the frequency of the H-maser H1 to generate the calculated NIM atomic time TA-c(NIM) since Oct. 2008.

Up to now the new TA-c(NIM) uses one active hydrogen maser as a reference clock, the maser is steered by an algorithm to keep the frequency of TA-c(NIM) the same with NIM5 fountain clock, which is NIM's primary frequency standard. The time and the frequency between TA-c(NIM) and UTC are compared and the difference is less than 2e-15 in the last 60 days of 2009. Details of TA-c(NIM) can be found in the Proceeding of 5th International Algorism of Atomic Time Scale. We are going to use a H-maser assembly to replace the one H-maser to improve the TA-c(NIM) in due time.

In order to measure frequency fluctuations among H masers, we have developed a DMTD instrument cooperated with a local company. It has features as: input frequency 5/10 MHz; 8 channel; beat frequency of 10 Hz; noise bottom of 2e-13/1 s, 2e-16/1000 s.

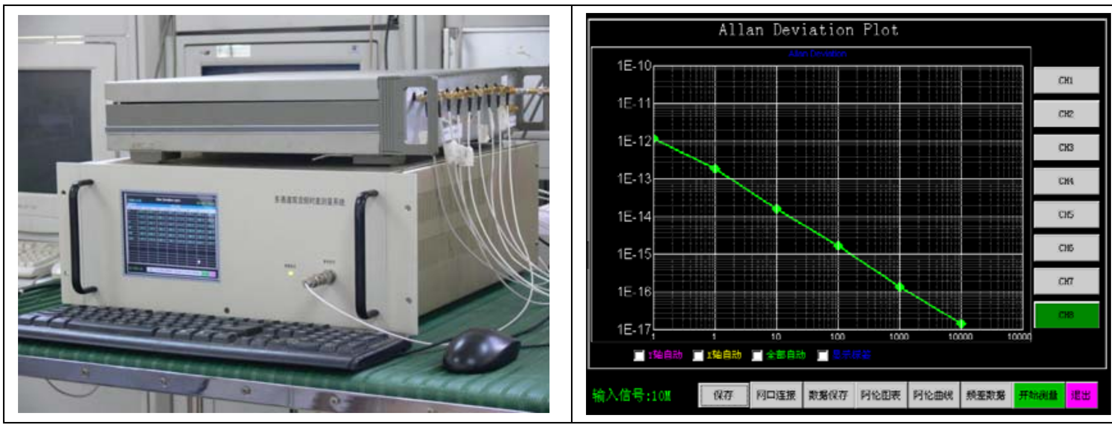

Figure 3. A photo of DMDT instrument and the measurement result of noise bottom for channel 8

Development of P3 code GPS receiver: NIM has been equipped with two different types of P3 code GPS receivers. One is Septentrio PolaRx2/2e and another was developed by us based on Euro 160 engine. It can display CGGTTS format data and relative frequency difference between GPS and reference in real time. We compared the two P3 code GPS receivers in zero base line condition. Standard deviation is 2.11 ns for 330 points in 4 days from MJD 54754 to MJD 54757. Fig4 shows our portable receiver and the comparison result. Both two receivers have running very well in the international atomic time collaboration.

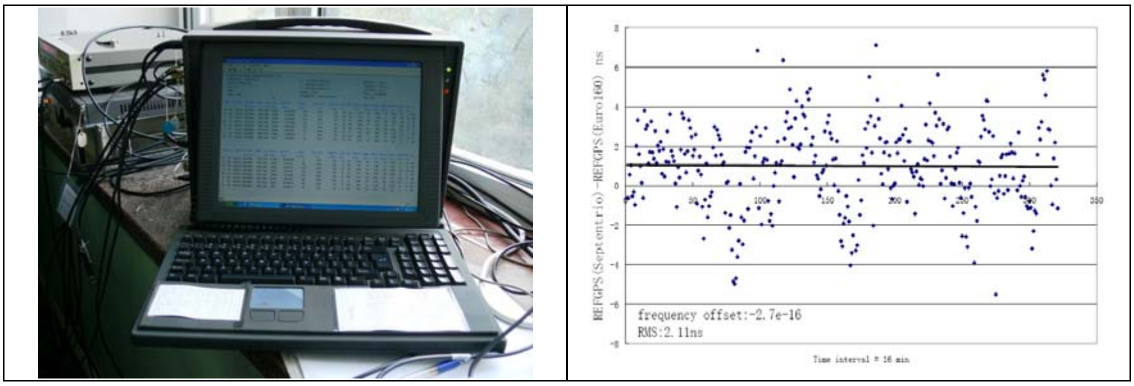

Figure 4. The photo of P3 code GPS receiver and the result of comparison.

Time and frequency transfer by GPS carrier phase: We started the research on GPS carrier phase time transfer technique from the beginning of this year. Several different time transfer experiments, including zero baseline, short baseline and long baseline experiments with the same references and/or the different references, were conducted using GPS carrier phase rather than PN codes. The data were obtained from two different geodetic receivers in RINIE format. In the datum processing, the professional GPS process software GAMIT and the self-developed software was used. The results of zero baseline and short baseline experiments show that GPS carrier phase time transfer has a stability of about 100 picoseconds, which translates into a frequency stability of less than two parts in 10^{15} for a sampling time of one day. But in the long baseline experiments, time transfer using GPS carrier phase has a stability of about 1 nanosecond, which translates into a frequency stability of about one part in 10^{14} for a sampling time of one day. Figure 5 shows the result of the zero baseline experiment with the same references in the day 230 of 2008.

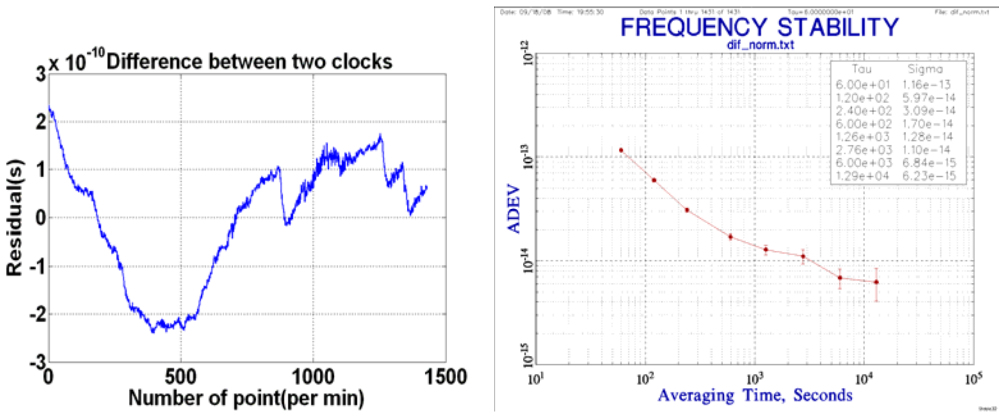

Figure The result of GPS carrier phase in the condition of zero base line and same reference.

Preparation of Two Way Satellite Time and Frequency Transfer (TWSTFT): NIM has joined the TWSTFT international collaboration since this April. The ground station, including amplifier, modem, antenna and up/down converter, has been installed in NIM new campus already. Some tests and experiment are doing with PTB and NICT. After short term experiment, two way time links will be set up normally between NIM and PTB under the infrastructure of Asia-Euro co-operation.

Future Plan: NIM will still insist on research in the field of time and frequency as mentioned above. Most of our facilities will be moved to our new campus, one optical fiber link will be set up between two campuses to compare frequency of fountains NIM4 and NIM5, the distance is about 40 km. Some experimental research work has begun. After we set up the two way link with PTB, the calibration of the system will be an issue that we have to solve. We hope to make close collaboration with other Labs.