The Current status in Shanghai SLR station

Zhang Haifeng, Wu Zhibo, Li Pu, Deng Huarong, Chen Juping, Zhang zhongping

(*Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China*)

Corresponding author: wzb@shao.ac.cn

Abstract: The paper gives a short overview about the experiment with the different laser systems to range ILRS satellites and uncooperative space targets at Shanghai SLR Station. The laser systems include 1kHz/1W/20ps, 10kHz/5W/30ps and 200Hz/60W/8ns. Achievements of developing SLR techniques have been made with the good performance through performing different laser measurement experiments.

Introduction

Since September 2009, Chinese SLR network, including Shanghai SLR station, imported pico-seconds kHz Laser system from PI Company of USA to perform routine SLR measurement and the laser measurement to space debris were successfully performed by using high pulse energy of laser system (1J@10Hz) from Spectrum Physics Company.

For promoting development and application of Chinese-made laser system in the field of high precise laser ranging to space objects, one set of kHz repetition rate laser system with the pulse width of 20 pico-seconds and the power of 1W and one set of 10kHz laser with the power of 5W and the pulse width of 30ps have been adopted to do measurement experiments for satellite laser ranging at Shanghai SLR station and the measurements to HEO satellites in daylight have been performed routinely and the single shot measuring precision and calibration is to centimeters and sub centimeters respectively. For the 8W laser system, we have tried to measure space debris in order to check the measurement precision and characteristics of objects.

In addition the new set of less than 10ns pulse width 60W laser system at the frequency of 200Hz have been developed and used for space debris tracking and some measurement results have been obtained with excellent performance and reliability.

Fig.1 The setup of Shanghai SLR station

Routine SLR measurements with high repetition rate laser system

Compared to SLR with low repetition rate, high repetition rate SLR has the advantages of larger quantity, better precision, faster acquisition and higher reliability, etc., which has become the prevailing trend of SLR technology development. In 2009, some key instruments such as a kHz laser with 1W power and 50ps pulse width, an event timer with less than 10ps precision, a servo system to realize a tracking precision of 1″ (RMS), have been adapted and updated for the Shanghai SLR system. Routine SLR measurements with kHz repetition rate have been implementing, and the mass of data has been growing ever since. With the development of kHz

SLR techniques, the future SLR station in China will adopt kHz laser system. For enhancing the maintainability of laser system, it is necessary to use domestic kHz laser system. So Shanghai SLR station actively performs the experiments of SLR measurements through adopting domestic kHz laser system to verify the performances of laser system.

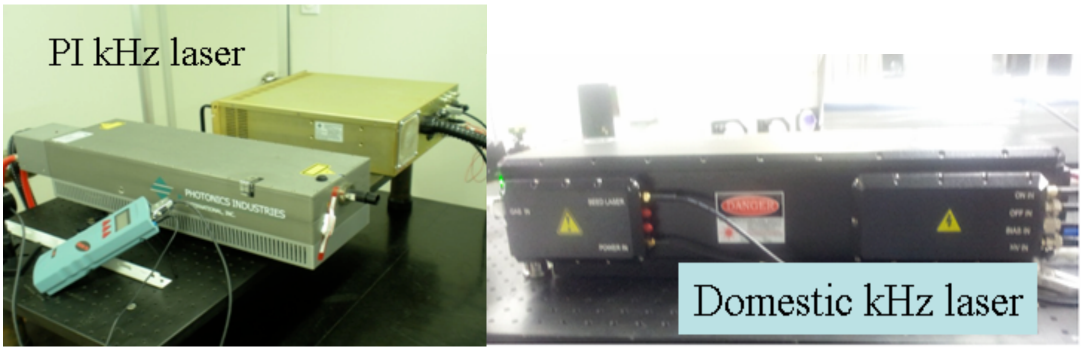

Fig.2 The kHz Laser from PI Company of USA and Chinese company

In 2012-2013, through developing a compact receiving terminal platform with adopting several techniques such as background light filter, kHz laser beam monitoring, small FOV, arc-second telescope pointing and weak-signal real-time return identification, laser ranging to geosynchronous satellites with slant range of >36000km in daytime was also realized by kHz laser system, which promotes the capability of the Shanghai SLR station.

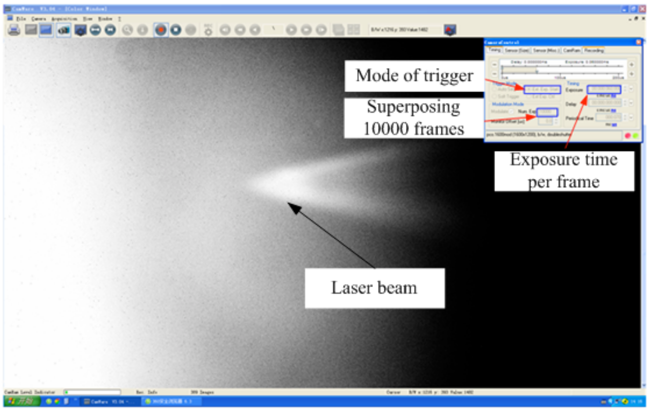

Fig.3 Monitoring the kHz repetition rate laser backscatter

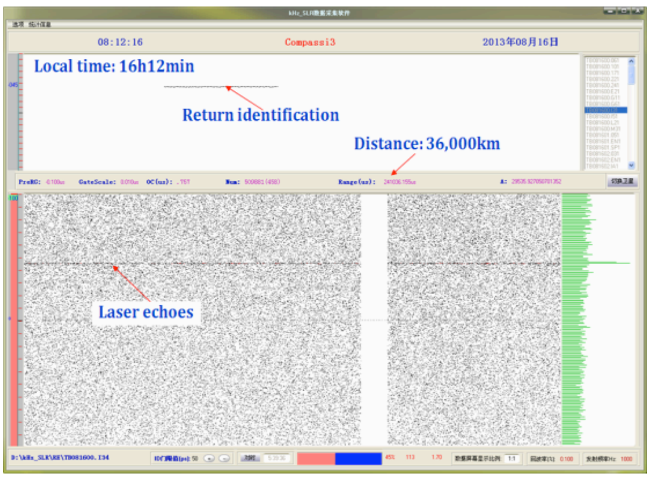

Fig.3 The results of laser measurement to GEO satellites with kHz laser in daylight

Base on the development of 1k~2 kHz SLR technique at Shanghai SLR station, we upgraded the

SLR system including the 10 kHz repetition rate laser system, Range Gate Generator, detector with low dark noise, SLR data acquisition/control and post-processing software for 10kHz SLR measurement in 2013.

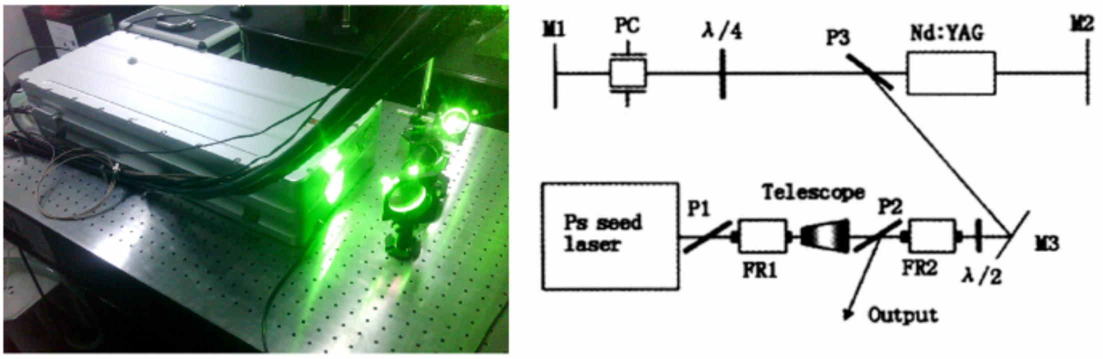

Fig.4 The setup of 10kHz repetition rate laser system and its inner optical structure

The experiment of SLR measurements at 10 kHz repetition rate was successfully carried out, in which laser returns were obtained from GLONASS satellites in daytime and GEO satellites at nighttime. The SLR measurement results indicate that laser returns at the rate of 10 kHz is several times higher than that from 1kHz SLR systems.

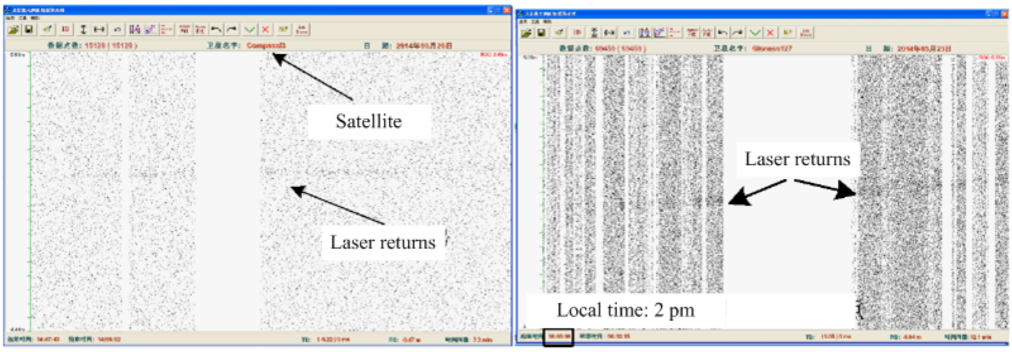

Fig.5 The results of laser measurement with 10kHz laser repetition rate at Shanghai SLR station

Currently the development of SLR technique with 10 kHz repetition rate laser is still underway and it can be expected that 10 kHz SLR measurement technique will make great achievements on increasing the amount of laser data and precision of Normal Point data.

Laser Ranging to Space Debris

The technology of laser ranging to space debris started to be developed in China since 2006, the preliminary space debris laser ranging system with 20Hz/2J repetition rate was established based on 60cm SLR system and laser data from space debris were obtained for the first time in China in July 2008. Subsequently, the key techniques for laser measurement to space debris have been developed and improved with support of national projects in the past few years.

The serial improvements have been performed through using one set of testing 50W laser with 200Hz repletion rate, a low-noise APD detector with quantum efficiency of more than 40% and high-performance spectrum filtering devices. The laser measurement to space debris with the achievements of >80% success rates for space debris with RCS of >1m^2, the maximal distance of more than 2100 km and the minimal RCS of ~ 0.5m^2 were made in 2013.

In 2014, one new set of practicable 60W laser with 200Hz repetition rate has been installed at Shanghai SLR station to routinely perform the laser measurement to space debris and the minimal

RCS of measured space targets is up to 0.2 m^2. The above results have greatly advanced the state of the art of laser measurement to space debris in China. Under the proposal of laser track campaign to space debris by global SLR stations sponsored by Space Debris Group of ILRS, Shanghai SLR station will actively participate in the campaign to develop the technology of laser measurement to space debris.

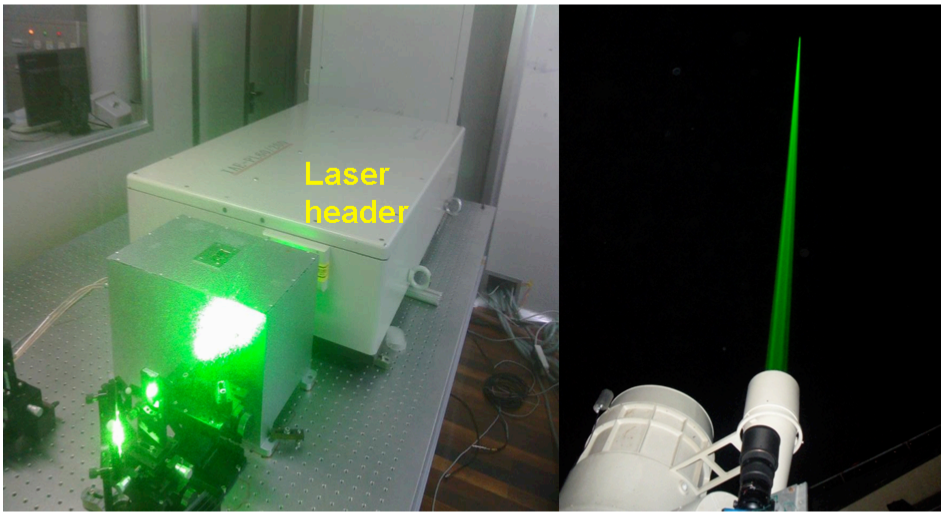

Fig.6 The setup of 60W laser system with 200Hz repetition rate

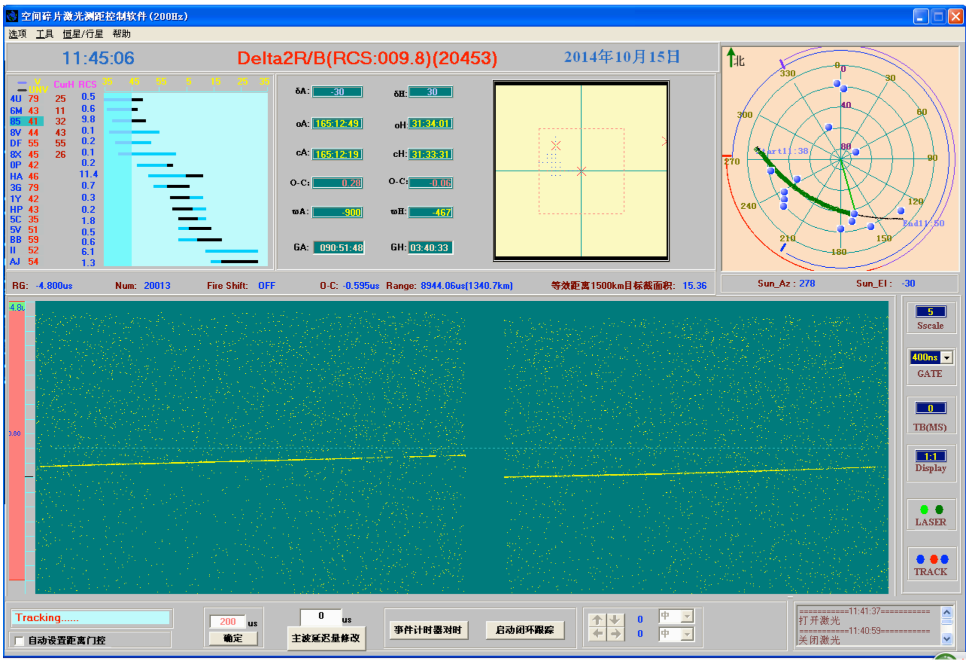

Fig.7 The results of laser measurement to space debris with 200Hz repetition rate and 60W laser

For laser measurement to space debris with the small size or far distance away, the large aperture of receiving telescope is required. According to laser ranging link equation, the number of laser echoes received by one large aperture telescopes can be equivalently achieved by the multi relative small aperture of telescopes. So the technology of multi-receiving telescopes for laser ranging to space targets was brought forward by us. In 2012, an experimental measurement system based on the 60cm SLR system and 1.56m astronomical telescope with the distance of about 50m at the Shanghai SLR station was established and the relevant measuring experiments with two-receiving telescopes were also performed. The technical feasibility of increasing the capability of echo detection was also validated. We will continue to develop laser measurement technology with multi receiving telescopes in the field of space debris observation. The multi-receiving telescope technology will also be a novel effective method for laser ranging to space debris.

Conclusion

Shanghai SLR station have been implementing the routine measurements to all the ILRS satellites by using kHz SLR in daytime and at nighttime, and firstly realized the 10 kHz SLR technology in the world. Lots of laser measurement data from space debris have been obtained by using the domestic high power laser system. Among of them, the maximal distance is more than 2100km and the minimal RCS is up to 0.2m^2, and we plan to realize laser ranging to more far and small space debris based on the multi-receiving telescope technology.

Reference

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