Research on Key Technology of 1064nm Wavelength SLR and Measurement Experiment

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Abstract

Shanghai Astronomical Observatory, CAS firstly in China performed the experiments to range satellites with 1064nm wavelength by using 60cm SLR system after updating the system. In the early 2013, the preliminary laser returns from satellites were obtained.

Introduction

Currently the laser system with wavelength of 532nm through SHG from the fundamental wavelength of 1064nm is commonly used at most SLR stations. Comparison to laser with the wavelength of 532nm, laser system at the working mode of 1064nm light has several technological advantages of : 1) Higher power ; 2) Less atmospheric attenuation; 3) Double photons per Joule; 4) Better beam quality and stability

All these characteristics are beneficial for SLR measurement and laser track to uncooperative targets. However, there also exist problems for application of l064nm light in the current SLR system: 1) invisibility for human eyes to make more difficult for optical system adjustment; 2) weak laser backscatter to make laser collimation and divergence adjustment difficult; 3) High quantum efficiency for laser detector;

Based on 532nm SLR system, through updating transmitting and receiving optical system and developing method of laser guiding with 532nm light, the preliminary experiments with 1064nm

Methods

Through analysis and calculation, some modifications have been made in order that SLR system could operate at both wavelength of 532nm and 1064nm:

1. The telescope's primary mirror and secondary mirror and most other mirrors in the transmit/ receive optical path are recoated to give the high efficiency for both 1064nm (>93%) and 532nm(>95%) light. (Fig.1.Fig.2.Fig.3)

Fig. 1 The recoated primary mirror

Fig. 2 Installation of the recoated secondary mirror

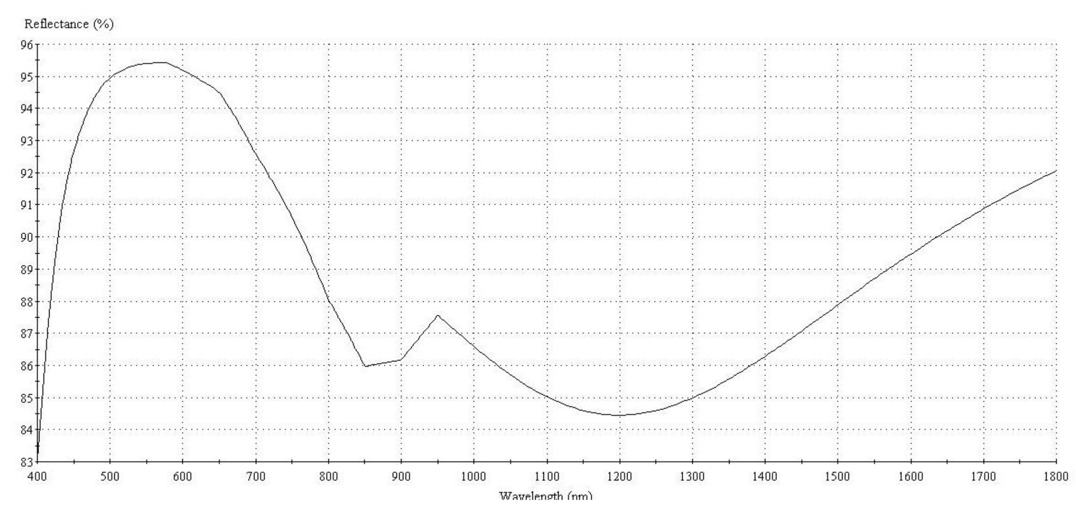

Fig. 3. The reflectance curve of the new coating of the primary and secondary mirror

To make the 1064nm laser beam aim to satellites without monitoring 1064nm backscatter light, the 1064nm laser was transmitted paralleled with 532nm laser used for guiding 1064nm laser beam (Fig.4). The both light were well collimated to a few arc seconds through light path.(Fig.5)

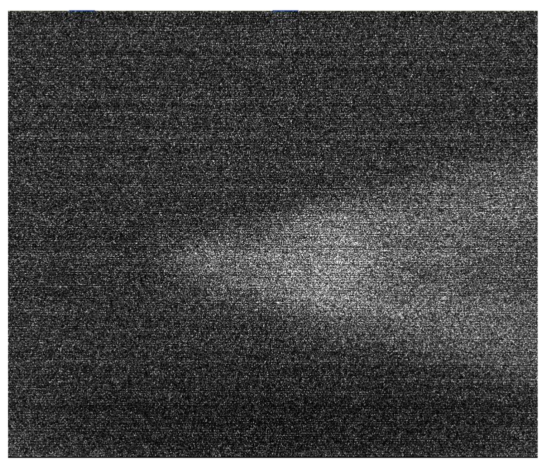

Fig. 4. The backscattering of transmitting 532nm laser beam (paralleled with 1064nm laser beam)

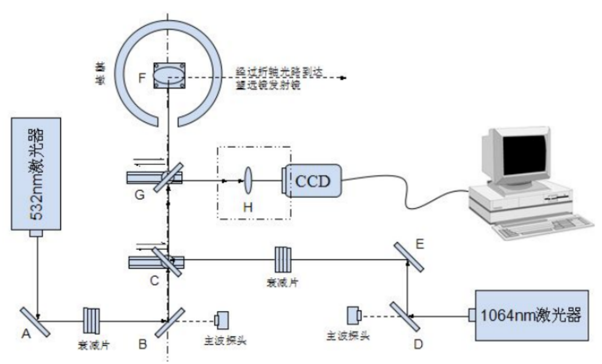

Fig. 5. The collimation of **1064nm and 532nm light path**

To adjust divergence angle of 1064nm laser beam to optical alignment, the method of utilizing the hartman mask in front of laser transmitting telescope to generate far field diffraction pattern is used to minimize the divergence by comparing the distance of laser far field pattern to holes in hartman mask.The above method has been tested by using 532nm light (Fig. 6

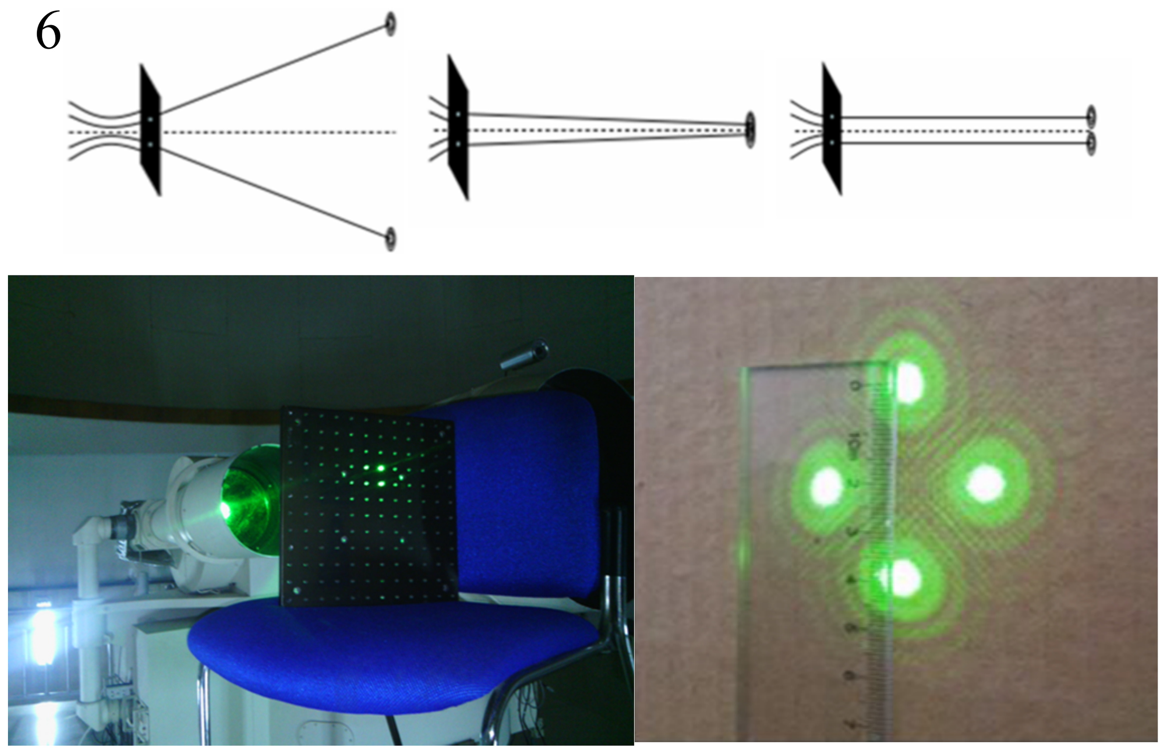

Fig. 6. **Dev. of laser beam by using the far field diffraction pattern**

Measuring Results

After the system updating and using the silicon avalanche photo diode detector (~5%@1064nm efficiency) and using 532nm laser system with SHG removal, the measuring experiments were carried out on Jan.15th, 2013 and Feb.22th, 2013.

There are 4 LEO satellites were successfully ranged (Fig.7, Fig.8, Fig.9, Fig.10).

Laser system parameters are as following:

wavelength : 1064nm

power : 1.2W

repetition frequency : 1kHz:

Pulse width: 40~60ps

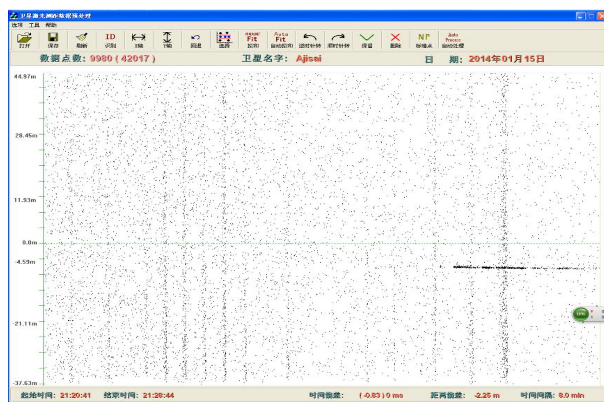

Fig. 7 **Residual of Ajisai**

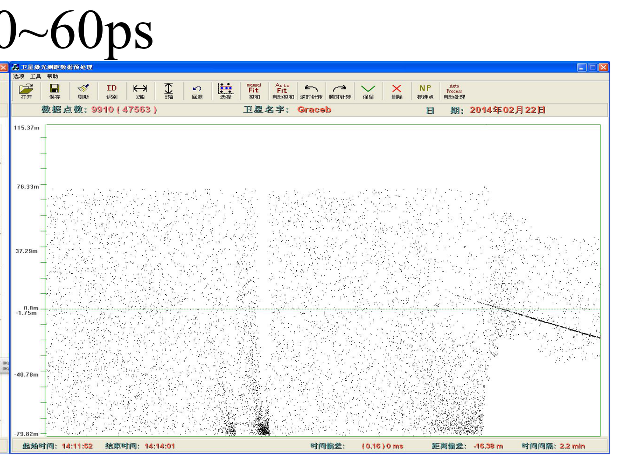

Fig. 8 **Residual of** Graceb

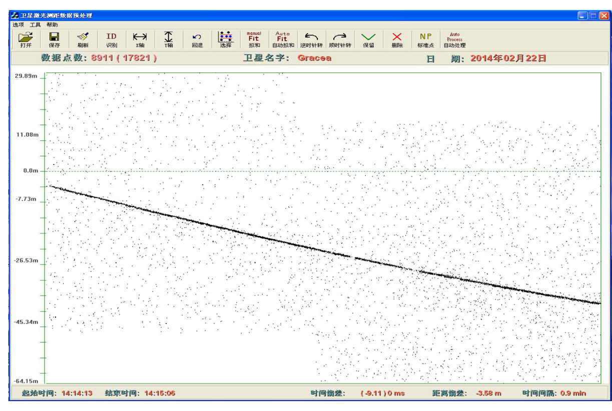

Fig. 9 **Residual of** Gracea

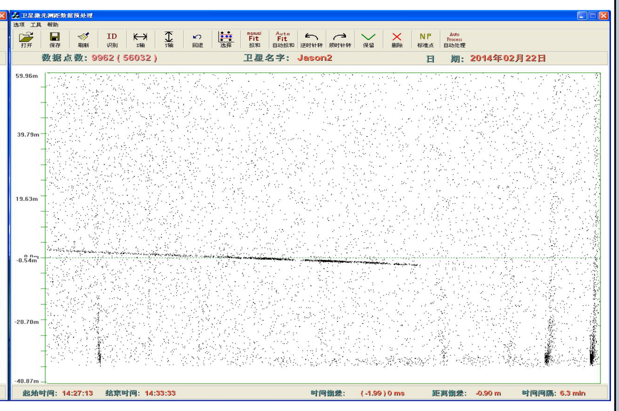

Fig. 10 **Residual of** Jason2

Due to the insufficiency of detector efficiency and consciously enlarging the divergence of laser beam for searching satellites, the results of preliminary measuring experiments do not present more superiority of 1064nm laser technology applied in SLR.

A new InGaAs APD with a hight quantum efficiency at 1064nm wavelength are being developed and some improvements of measuring system are also underway. It is believed that the advantages of 1064nm wavelength SLR technology will be realized after the further updating measurement system.

Summary

This experiments are to verify the key technologies in building up 1064nm SLR system and the results of the solutions mentioned in the paper and lay the foundation of establishing 1064nm laser ranging system and routine observation. In addition, considering the insufficiency of current work at aspect of 1064nm wavelength SLR system, the further improvements of SLR measuring system are put forward in order to provide a viable and reliable design for the application of 1064nm laser in space debris laser ranging, and even interplanetary laser ranging.

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