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4.3 LASERS AND TRANSMISSION/RECEIVING OPTICS

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ABSTRACT

Lasers are one of major components in the KSP SLR system for generating a high power and ultra-short pulse. Transmission/Receiving(T/R) optics also plays an important roll the interface between the telescope and the photon detector. The laser and T/R optical system includes a diode pumped Nd:YAG laser, a regenerative amplifier, a double stage amplifier, T/R switch optics, beam expanders, filters and mirrors. All these temperature and dust-sensitive devices are located in the optical compartment of a trailer housing unit.

Keywords: SLR, Laser, Eye-safe

1. Introduction

In the history of SLR systems, the first generation laser developed in 1960's-70's was a ruby laser. It was powerful but had a low pulse repetition rate and did not produce a short pulse width, resulting in inaccuracies of ranging measurements[1]. It was generally regarded as unable to endure continuous and high efficient operation. Highly reliable laser operations and stable optics are two of the keys for a long-life, high performance SLR system. The systems which widely used in SLR and referred as the third generation system developed in 1980's-1990's uses a flash lamp pumping Nd:YAG laser that has a repetition rate of 5 to 10 Hz.

Regular maintenance of laser is a problem for unmanned SLR system, especially in human task such as alignment, adjustment of dye concentration and cleaning of the optical components that are necessary weekly or more often. A diode pumped laser uses a solid state pumping source to excite the laser medium efficiently and has come to commercially available as a very compact and rugged device. The KSP SLR uses diode pumped Nd:YAG laser for oscillator and regenerative amplifier that operates at small energy.

A Laser with higher repetition rates has the benefit of increasing full-rate data and of minimizing the time to form normal points (the means of sub-sets of the measurements about their overall mean of full-rate data) when the system is tracking the satellite.

2. Laser and Optical Layout

Figure 1 illustrates the layout of the laser and transmission/receiving (T/R) optics on an optical table which has a base on the ground that is independent of the trailer housing in order to stabilize the geometric alignment of the optical components and the Coude path of the telescope. Laser and T/R optics are set in a compartment of the temperature controlled trailer box. The temperature in laser room is specified as 23±1 deg. C and humidity is 40 % or less.

A diode pumped Nd:YAG laser generates 100 MHz trains of laser pulse with a width of 50 ps (FWHM) and a wavelength of 1064nm. The pulses are fed to a diode pumped regenerative amplifier to obtain a single pulse. Then, it is amplified by a two-stage laser head pumped by flash lamps to obtain a nominal energy of 50 mJ in the pulse. The amplifier's wavelength is converted to 532 nm by a second harmonic generator (SHG) which also acts as a T/R shutter. The conversion efficiency of the SHG is 40 %. The laser beam is transmitted to the Coude path in the telescope by several steering mirrors through beam expanders. The diameter of laser beam in the Coude path is 10 cm.

The received light from the Coude path enters exactly the same path as the transmitted light and travels as far as the T/R shutter and guided through spectrum and spatial filters to a detector by a beam splitter and mirrors.

All surfaces of the optics will resist damage up to a power density of 3.7 GW/cm^2.

The nominal repetition rate of the laser is 20 Hz. Different rates of 10, 20, 50 and 100 Hz can be selected for different operation.

The power, the timing of the trigger signal and the temperature of the laser are monitored by the control computer.

3. Eye-Safe Operation Mode

In addition to the ranging laser (RGL), it is equipped with the second laser, the aircraft detection laser (ADL) that produces a pulse with a 1572nm wavelength (See Figure 1). The wavelength longer than 1400nm, known as the region for eye-safe, has 10^5 greater MPE (Maximum Permissible Exposure) than visible light. It is designed to protect the eyesight of aircraft passengers that may be within the ranging beam when system is operating[2]. The ADL wavelength is produced from Nd:YAG laser of the nanoseconds pulse-width and is converted from 1064 to 1572 nm by an optical parametric oscillator (OPO).

There are two operating modes for protecting eyesight.

(1) High power mode

When the flash lamp amplifier of the RGL is operating, the ADL will work simultaneously. If a 1572nm return signal is detected, ADL system automatically prevents the firing of the RGL. This mode is used for satellite tracking at elevation angles that are above ranging horizon. These angles are defined at each site.

(2) Low power mode

The RGL can be set to operate without the flash lamp amplifier. The total energy in a pulse is less than 0.2mJ in an area of 75 cm diameter. The RGL complies with the Safety of Laser Product standards, JIS 5802[3].

In the event of high power RGL transmission at an elevation angle of less than 15 degrees, human eyes are protected by a beam block that surrounds the dome.

4. Transmission and Receiving Path

The laser ranging system uses a common telescope Coude path that makes it simple for transmitting and receiving signals to pass each other.

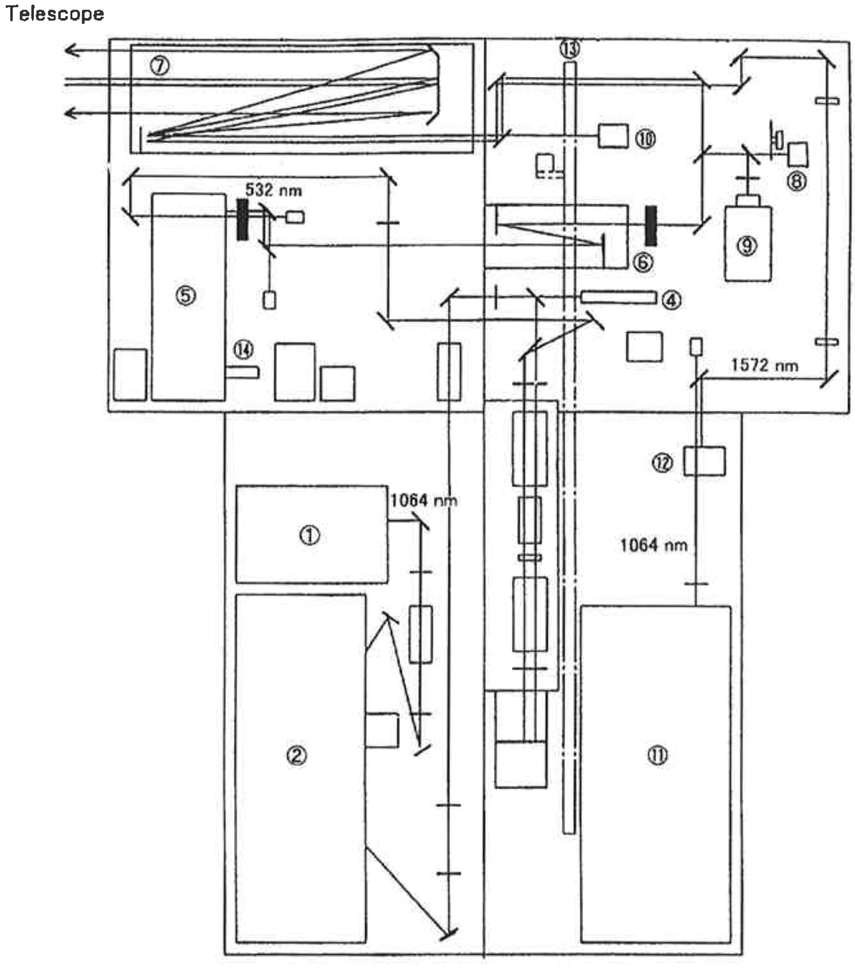
The retroreflectors for calibrating the ranging electronics are located in the telescope and on the optical table, both of which form the end of the fixed optical path. They are also used for optical axis adjustment.

Beam divergence can be set to afocal to 30 arc seconds by adjusting of secondary mirror of the telescope.

5. Detectors and Filters

A high-speed diode is used for the 'start' detector. There are three selectable 'stop' detector ports, one of which is a spare. A cooled silicon single photon avalanche diode (SPAD) and a micro channel plate (MCP) are installed.

In the received signal housing, an interference spectrum filter with an efficiency of 60% in a spectrum width of 0.3nm is set up. Neutral density filters up to 50 dB



① Diode Pumped Nd:YAG Oscillator ② Regenerative Amplifier ③ Flashlump Pumped Amplifier
④ Start diode ⑤ T/R box ⑥ X2 beam expander ⑦ X5 beam expander ⑧ Power meter
⑨ Beam profiler ⑩ Coude CCD camera ⑪ ADL (Nd:YAG Laser) ⑫ OPO ⑬ Calibration rail
⑭ Detector (SPAD)

Fig. 1 Layout of the Laser and Transmission/Receiving (T/R) optics on an optical table and spatial filters of 32 arc seconds field of view or less can also be set. These filters are important for controlling the magnitude of the light that enters the detector, especially when observing in daytime, when removing the background noise.

6. Conclusion

Lasers and T/R optics play a key role for the system to run with minimum maintenance time and with the highest productivity. These are all temperature and dust-sensitive devices and are located in the optical compartment of a trailer housing unit under temperature controlled environment. The continuous operating of the SLR system to determine station positions, and to observe their displacement, we can monitor the crustal deformation with high accuracy and high temporal resolution.

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