Preliminary Results of Laser Ranging to Un-cooperative Targets at Shanghai SLR Station

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Goals

- Investigation of the key techniques of un-cooperative target laser ranging
- Experimental laser ranging to un-cooperative targets
The returned signal strength of laser ranging on uncooperative targets can be estimated by:

\[ n_0 = \frac{\lambda \eta_q}{hc} \times \frac{E_t A_r \rho S \cos(\theta)}{\pi \theta_t^2 R^4} \times T^2 \times K_t \times K_r \times \alpha \]
Where

- \( n_0 \): Average number of photoelectrons received by detector
- \( \lambda \): Wavelength of laser, 532nm
- \( \eta_q \): Quantum efficiency of the C-SPAD detector, 0.2
- \( h \): Planck constant, \( 6.624 \times 10^{-34} \) J·S
- \( c \): Light speed, \( 2.998 \times 10^8 \) m/s
- \( E_t \): Energy of laser pulse, 2J
- \( Ar \): Effective area of receive telescope, 0.245m²
- \( \rho \): Reflectivity of the target’s surface
- \( r \): Equivalent radius of the target, 1m
- \( \cos(\theta) \): Suppose the targets are spherical, \( \cos(\theta) = 1 \)
$\theta_t$: Divergency of laser beam from telescope, 12 arcsec

R: Range of the targets, 800Km

T: Atmospheric transmission, $T^2=0.6$

$K_t$: Eff. of transmitting optics, 0.60

$K_r$: Eff. of receiving optics, 0.60

$\alpha$: Attenuation factor, 13dB

We have,

$$n_0 = 0.198 \text{ (Photoelectron)}$$
The probability of detection can be estimated:

\[ P = 1 - e^{-n_0} = 1 - e^{-0.198} = 0.18 \]

So we can get 18 return signals in 5 second by the laser with 20Hz repetition.
Diagram of the 40W laser (2J, 20Hz, 10ns)
Photo of the laser
Inner view of the laser
Laser firing at Shanghai
Some results of un-cooperative target laser ranging at the Shanghai SLR station
Returns from the discard Soviet rocket (ID 1987-38B) on July 7, 2008

Number of point: 127
RMS: 76cm
Returns from the discard US rocket (ID 2007-006G) on July 17, 2008

Number of point: 79
RMS: 83cm
Returns from the discard US rocket (ID 2007-006G) on July 18, 2008

Number of point: 170
RMS: 68cm
Ranging data of ID 1987-38B on July 7, 2008
Ranging data of ID 2007-006G on July 17, 2008
Ranging data of ID 2007-006G on July 18, 2008
Statistics of returns (5-second bin) on July 7, 2008

- 12-14 returns in 5 seconds were obtained when tracking well, and roughly coincide with the estimation of the returns signal strength.
Future Plan

- Upgrading of the prediction of the targets (now the error of range prediction is about 1km, too difficult to obtain the returns)

- Automatically scanning of range gate and rapidly identify the return signals

- To track smaller targets and assessing the ranging capability of the system
Summary

- The laser returns from the un-cooperative targets have been obtained at the Shanghai SLR Station in July 2008.

- These targets are the discard Soviet and US rockets with the ID 1987-38B and 2007-006G respectively.

- The return signals from the targets with the range of 900km were quite strong.
Thank You!