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Laser Ranging to Satellites and Space Debris

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More than 40 Satellite Laser Ranging (SLR) stations around the world routinely measure distances to about 150 retro-reflector-equipped satellites, from Low-Earth-Orbiters (LEO), up to the satellites in geostationary orbit, and determine their orbits with an accuracy of down to few millimetres. Lasers with 10 Hz up to several kHz repetition rate are used, mostly emitting at 532 nm wavelength, and with energies from a few µJ up to several 10 mJ per shot. Most SLR stations are able to detect single photons, reflected from the targets in space, even in full daylight conditions.

SLR already started in the 1960s, quite short after the first success in building an operational laser; with continuous improvements until now. This technique now is also used to range to space debris targets, like old rocket bodies, defunct satellites etc; because of their large number (> 30.000, tracked routinely by large radar systems), they are an increasing problem, and start to endanger present and future space activities. Because these bodies do not have any retro-reflectors, laser ranging has to rely here on diffuse reflection, which requires stronger lasers, and limits achieved ranging distances to about 2000 km – which however covers the most heavily populated LEO orbits. Such space debris laser ranging data allows big improvements – from several 100 m to few 10 m accuracy - for orbit determination for the next few days, assisting in decisions for possibly necessary collision avoidance manoeuvres.

Using the same single-photon detectors, it is also possible to count the flux of single sun photons reflected from space debris targets into the SLR telescopes. This allows to record high-resolution light curves, showing many details of any spin parameters.

Future developments are targeting very high laser repetition rates (up to MHz), fully automatic SLR stations, ranging at near-IR wavelengths, and setting up of a dedicated space debris laser ranging network.