SUBNANORADIAN, GROUND-BASED TRACKING OF SPACEBORNE LASERS.

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Over the next few decades, ground-based tracking of lasers on planetary spacecraft will supplement or replace tracking of radio transponders. This paper describes research on two candidate technologies for ground-based, angular, laser tracking: The infrared interferometer and the optical filled-aperture telescope. The motivation for infrared and optical tracking will be followed by a description of the current (10-50 nanoradian) and future (subnanoradian) stellar tracking demonstrations with the U. C. Berkeley Infrared Spatial Interferometer (ISI) on Mt. Wilson [1], and the U. C. San Diego Optical Ronchi Telescope on Table Mountain [2].

In the long-term lasers will replace radio transponders to increase telemetry data rates, rougly tenfold, by communication over optical channels [3]. In the short-term (next 10 years), few-nanoradian tracking of a low-power laser may outperform single-frequency radio tracking. For example, radio tracking at 3 cm wavelengths is affected by charged particle fluctuations at the 5-10 nanoradian level; charged particle effects are negligible for infrared and optical frequencies. Tracking of low-power lasers at planetary distances seems feasible with the abovementioned instruments. For example, a 0.5-watt, laser through a 10-cm aperture at Mars could be tracked by both of the above instruments, with modest upgrades to be implemented before this spring-summer observing season.

Angular tracking interferometric phase time series from ISI will be shown in this poster paper. It will be shown that new hardware, which will improve detector efficiency, will enable reliable cycle ambiguity resolution in moderate seeing. High correlations between measurements of pathlengths within ISI, and those along the paths through the atmosphere to the target star, suggest that most of the atmospheric turbulence contributing to poor seeing is occurring within about 10 meters of the ground. For the Table Mountain Ronchi telescope, signal-to-noise improvements will enable tracking of a visual magnitude 11 star. Demonstrations of this capability will occur this summer after hardware upgrades in the spring.

The above demonstrations will yield 0-50 nanoradian performance, but it has been shown tha subnanoradian performance enables many mission enhancements. For example, subnanoradian angular tracking enables detection of Jupiter's spacecraft-relative position abou 100 days before encounter. Subnanoradian tracking is largely prevented by atmospheric refractivity fluctuations for both of the above mentioned devices. Methods of minimizing atmospheric effects using optimal stochastic estimation and direct calibration wi be described

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