N73-18502

LASER TRANSIT-TIME MEASUREMENTS BETWEEN EARTH AND MOON WITH A TRANSPORTABLE SYSTEM

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January 1973

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212-092

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Abstract. A high-radiance, pulsed laser system with a transportable transmitting unit was used at Agassiz Station, Harvard College Observatory, Harvard, Massachusetts, to measure the transit times of 25-ns, 10-joule, 530-nm pulses from Earth to the Apollo 15 retroreflector on the Moon and back.

On 23 September 1972, the transit time of a laser pulse from Earth to Moon and back was measured six times at Agassiz Station, Harvard College Observatory, Harvard, Massachusetts.

The laser pulse was directed to the Apollo 15 retroreflector on the Moon by a transportable transmitting unit located 237 m from the 1.5-m telescope used to detect the returning pulse. All six transit times were measured with a combination of delay circuits and a fast oscilloscope. Three of these returns, which were stronger than the rest, were also measured more precisely with a time-interval counter.

Residuals for all the measured transit times were calculated from a special ephemeris at the University of Texas (1). These residuals (observed values minus computed values) tended to increase with epoch (time of transmission of the laser pulse) over the period from $6^h\ 36^m$ to $8^h\ 12^m$ universal time during which they were obtained.

The best-fitting straight line through the residuals from the counter readings had a slope of +0.35 ns/min with a standard deviation of 3.1 ns. The best line through the residuals of the six oscilloscope readings had a slope of +0.18 ns/min with a standard deviation of 2.5 ns. The differences in the results from the two sets of data are not significant.

The slope of the straight line through the residuals is related to the error in the station's geocentric coordinates. If one assumes the error to be entirely in latitude, the local hour angle of these observations implies that a slope of 1 ns/min corresponds to 1 arcsec, or 23 m at the station's 42°.5 latitude. Hence, the slopes are consistent with an error of about 15 m expected in the conversion of the station's coordinates from the North American Datum to a geocentric system.

The configuration of the transportable laser system, which can be used with other large telescopes, has been described previously (2). The exceptionally high radiance of the system's neodymium-glass laser permits the use of a transmitting telescope whose aperture diameter is only 0.2 m. It also increases the probability that each return generates at least one photoelectron. The system's pulse repetition rate is 0.2/min. A further report on its operation is in preparation (3).

This work was supported in part by contract NASW-2014 and grant NGR 44-012-219 from the National Aeronautics and Space Administration.

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References and Notes

1. This ephemeris, not yet described in the literature, is a numerical integration fit to both optical and laser data. It was developed by J. D. Mulholland and P. L. Bender (JILA) as a part of the Apollo Lunar-Laser Ranging Experiment.
2. C. G. Lehr, M. R. Pearlman, J. A. Monjes, W. F. Hagen, Appl. Opt. 11, 300 (1972).
3. C. G. Lehr, J. P. Ouellette, P. W. Sozanski, J. T. Williams, S. J. Criswell, and M. Mattei, Appl. Opt., Letter to the Editor, in preparation.

The authors acknowledge with appreciation and thanks the cooperation and efforts of the following persons: L. DiPalma, J. T. Williams, and J. Wohn (Smithsonian Astrophysical Observatory); W. Liller and M. Mattei (Harvard College Observatory); D. H. Eckhardt (Air Force Cambridge Research Laboratory); J. G. Williams (Jet Propulsion Laboratory); E. C. Silverberg (McDonald Observatory); and C. O. Alley (University of Maryland).