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Lunar Laser Ranging Experiment: Current Results and Future Plans

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Several hundred range determinations have been made of the point to point distance between the McDonald Observatory in West Texas and the Laser Ranging Retro-Reflector left at the Tranquility Base by the Apollo 11 astronauts. Measurements are being made routinely on a regular and frequent schedule averaging about twelve to fifteen measurement periods per month. The precision of the measurement of the time of flight is about one nanosecond with an accuracy of about two nanoseconds (equivalent to thirty centimeters in the one-way distance).

Significant adjustments to the eccentricity of the moon's orbit and to either its mean distance or to one reflector coordinate appear to be indicated by the preliminary analysis of the data thru January 1970. Analysis of the twenty-four hour period terms in the range residuals indicates rough agreement with presently available geocentric coordinates for the McDonald Observatory. Full application of the laser ranging technique for the establishment of geocentric coordinates requires the measurement of the polar motion which will only be possible when several more stations are operating with comparable precision in well distributed earth locations.

Ground instrumentation has been prepared by groups in France, the USSR, and Japan, and the possibility of participation is being discussed with scientists in a number of other countries. One other group in the United States has developed instrumentation and another is engaged in such development.

The French-made Laser Ranging Retro-Reflector placed on the moon by the Soviet Lunar 17 in the western part of Mare Imbrium emphasizes the international aspect of the lunar ranging program. A second U.S. LR$^3$ will be carried to the Fra Mauro region by Apollo 14 and a third U.S. reflector having three times the number of corner reflectors as the Apollo 11 and 14 LR$^3$'s is planned for the Apollo 15 landing in the area near Hadley Rille. These additional reflector sites on the moon will allow the direct measurement by laser ranging of all the rotational motions associated with the physical librations. The larger LR$^3$ will also allow a larger number of observatories to participate in the lunar laser ranging program.

Recent developments in lasers, timing techniques, and in the knowledge of atmospheric corrections indicate that an accuracy of better than three centimeters can be achieved in lunar laser ranging.