THE UNIVERSITY OF TEXAS AT AUSTIN

DEPARTMENT OF ASTRONOMY

and

McDONALD OBSERVATORY

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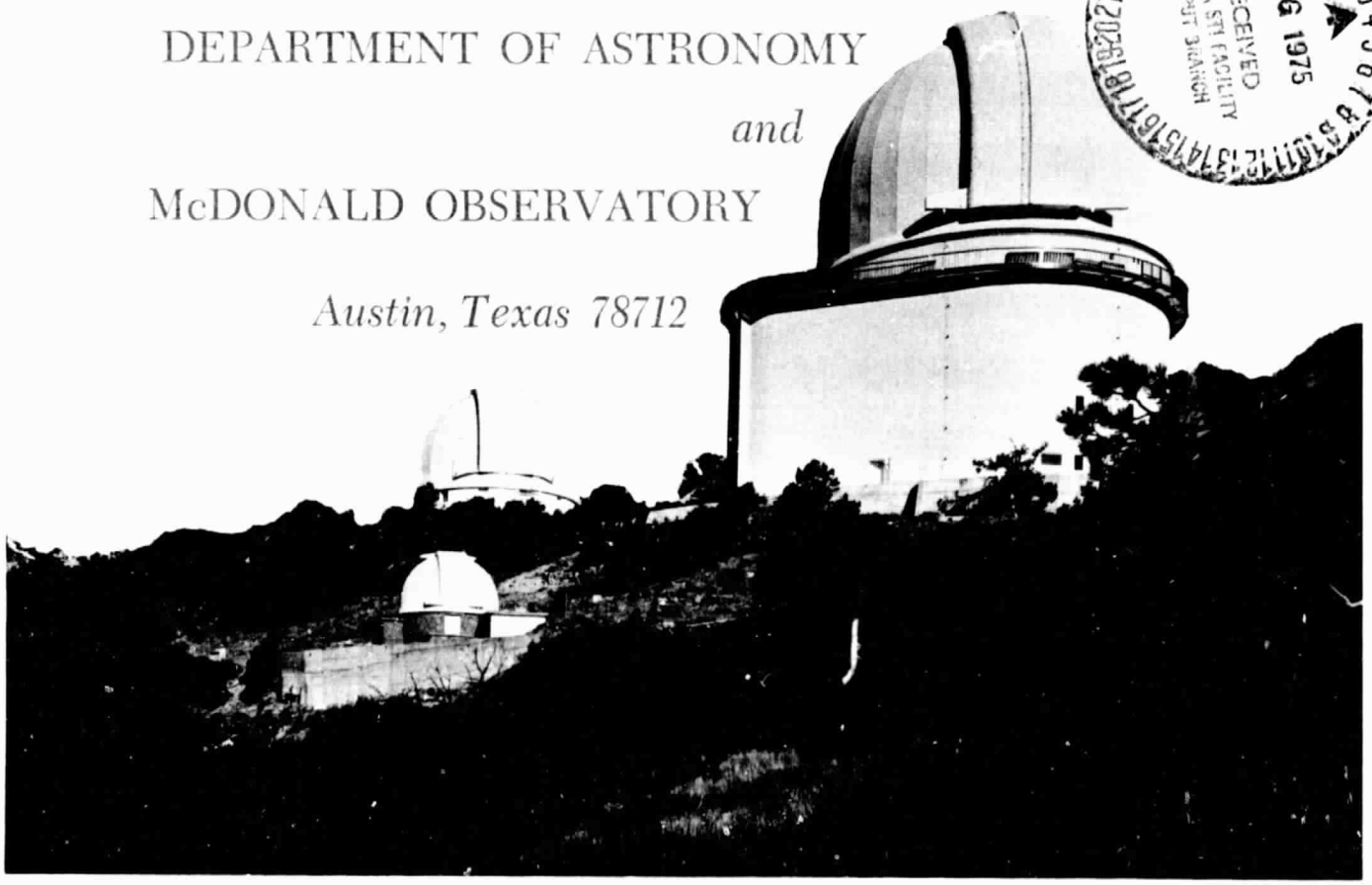

Semi-Annual Status Report

NASA Grant NGR 44-012-219

(Lunar Motion Analysis)

for the period 1975 January 1 - June 30

University of Texas at Austin

Department of Astronomy

Austin, Texas 78712

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Data Management

The processing of raw data tapes from McDonald Observatory continued throughout the report period. The results were as follows:

TAPE ID	LUNATION	PHOTONS	OBSERVATIONS	%
MCD73	1974L11	1819	178	9.8
74	1974L12	252	31	12.3
75	1975L1	1310	103	7.9
76	1975L2	2822	220	7.8
77	1975L3	2109	212	10.1
78	1975L4	1954	404	20.7
79	1975L5	2385	338	14.2

Machine readable observations and residuals for McDonald observations for the period 1974 August 30 through 1975 March 31 were distributed to those requesting them and residual listings for the same period were provided to all LURE team members. Note that the distribution of observations from McDonald tapes MCD70, MCD71 and MCD72 covering the period 1974 August 30 through 1974 November 30 had been delayed until Silverberg's analysis of electronic calibration problems during that period was completed. Also the distribution of McDonald observations for the period 1974 December - 1975 January was delayed because of "firing epoch" problems during that period. Beginning with the data distribution for 1974 December, residuals are now computed with respect to LURE-2 parameters. See Table II.

Three lunations worth of data was transmitted to Austin by the LURE observatory on Mt. Haleakala, Maui, covering a data span 2442463-2442561. Soft-ware was prepared at Austin to process this data, which was written in temporary format. Our data filtering systems did not reveal any obvious lunar returns, although one group of observations

TABLE II

LURE-2 MODEL

McDonald Telescope coordinates:

r = 6374.66466 km

λ (2440400.5) = 255.°9780125E

φ = 30.°5032425

Principal axis reflector coordinates:

	0	2	3	4
r	1735.48452	1736.34715	1735.50073	1734.66115
λ	23.411748	-17.538819	3.567223	30.865756
φ	0.69453	-3.624102	26.155946	25.851806

Ephemeris: LURE-2

Librations: JPL Lunar Libration Tape 5 (extended)

$\beta = 631.26 \times 10^{-6}$ $\quad C_{30} = -10.44 \times 10^{-6}$

$\gamma = 227.37 \times 10^{-6}$ $\quad C_{31} = 28.6 \times 10^{-6}$ $\quad S_{31} = 8.8 \times 10^{-6}$

$C_{32} = 4.82 \times 10^{-6}$ $\quad S_{32} = 1.71 \times 10^{-6}$

$C_{33} = 2.7 \times 10^{-6}$ $\quad S_{33} = -1.14 \times 10^{-6}$

$\tau_o = 1.2451723 \times 10^{-3}$ $\quad \dot{\tau}_o = -2.6562663 \times 10^{-5}$

$\rho_o = -7.0228562 \times 10^{-5}$ $\quad \dot{\rho}_o = -1.94824645 \times 10^{-5}$

$(I\sigma)_o = 1.703917 \times 10^{-4}$ $\quad \dot{(I\sigma)}_o = -1.65123951 \times 10^{-5}$

Other relevant parameters:

c = 299792.458 km/sec

$M_\odot / M_\oplus$ = 81.3007

AUKM = 149597870.95869 km/A.U.

proved to be statistically significant. The spread of these suspected returns and the size of their residuals lend very little weight to their being accepted as true signal returns.

With the multiple pulsing which has been produced by the McDonald laser during early 1975 and with the desire to obtain greater accuracy with the McDonald observations it appears to be quite appropriate to directly use laser pulse shape information in the filtering of return photon data. A first generation cross-correlation analysis routine has been written and debugged. The initial application of this technique to the McDonald data has been favorable when the number of returns are sufficient for proper statistical analysis. Since this technique is still in the check-out stage, until further notice all data distributions will be made using our original filtering system, not the new cross-correlation routines. It is anticipated that these new filtering routines will result in greater accuracy for earlier McDonald data since more accurate electronic calibration results should be obtainable.

As would be expected, most of the activity related to data management and distribution was directed toward the processing of the Hawaiian data tapes. All data so far received have been written in temporary format. The correction of this formatting problem was the primary reason for Shelus' trip to Maui in May. The following items were discussed:

It was agreed that the present formatting of shot records (which provide shot by shot start and stop times, reflector identifications, and range gate and ephemeris prediction information) should remain intact.

It was agreed that extensive revision of the environment record was necessary for several reasons:

1) many archive parameters were lacking. Among these were:
   a) clock epoch offset
   b) atmospheric seeing
   c) electronic calibration accuracy code
   d) laser energy
   e) laser frequency
   f) pulse width
   g) shot-by-shot resolution
   h) dark count
   i) site count
   j) star count
   k) star identifier
   l) spectral filter width
   m) spatial diaphram width
   n) no. of shots fired
   o) uncertainty estimate
   p) electronic delay
   q) clock frequency offset

2) Due to a desire to keep all data numerical we agreed that the largest negative number which could be written would be used for a "no information" indicator on transmitted records.

3) At the present time environmental and calibration data are only written once at the beginning of a day's observations and then once again at the end of that day's observations, regardless of how much time might have intervened. This would require unrealistic linear interpolation over as much as 8-10 hours resulting in faulty information, especially during the central portion of an observing period. An informal definition of an observing "run" was agreed upon in an attempt to overcome this difficulty. It is hoped that this will also provide the means of subdividing a long run of observations into logical sub-units which can be realistically formed into "normal points."

4) Wong will supply us with a list of identification numbers to be used with bright stars which are used to obtain photo-cell readings. Again, this is an attempt to eliminate all BDC or ASCII types of representations.

5) Still to be decided is the manner in which clock epoch and clock frequency offset information is to be transmitted to Austin. At the present time McDonald Observatory reduces its own LORAN-C information to provide us with epoch and frequency offsets for each set of observations directly. Carter wishes only to transmit LORAN-C information and have epoch and frequency offsets be computed therefrom in Austin. Arguments were presented on

both sides with no agreement reached. Since many similar stations are planned throughout the world, it was decided to seek advice from the LURE team as to the most cost-effective and meaningful manner of transmitting this type of information to Austin. Presently Hawaii is not providing epoch or frequency offsets nor is enough LORAN-C information provided to us in order to compute these quantities in Austin.

6) An observatory identification code must still be obtained for the LURE observatory at Haleakala.

Three Dimensional Lunar Ephemeris

At the end of the last report period an apparent ephemeris had been supplied to USNO covering a portion of the interval for which there are photoelectric occultation observations. Similar information was provided for the rest of the interval early in this report period. Our inability to provide all of this information last December was, after some effort, traced to a logical flaw in one of our programs, which caused no difficulty under ordinary conditions but which would occasionally cause the execution to transfer into an infinite loop. This problem has been overcome.

As it turned out this was not the last of our programming problems, despite the fact that the entire software system for the occultation analysis had been debugged and certified as operating in principle, by means of test cases. As it turned out, however, some of the test cases were unrealistic, and some of the programming was tailored to the test cases rather than to the general problem. The situation is now believed to be well in hand. Solutions on the occultation data were underway at the end of the report period.

Simultaneously with this effort, we have continued to improve the mathematical modelling of the range data and the mechanics of the solution

process. This has included the coding of better orbit partial derivatives, the introduction of a number of additional solution parameters, and refinement of the computation of such small magnitude but significant modelling factors as the Universal time and atmospheric refraction. Current solutions to laser only data, depending on the observations used and the parameters solved for, are on the order of a meter if one uses the numerically integrated librations. We will defer a more detailed discussion at this time, because the drafting of the final report on this task will begin soon, and we expect it to be delivered in final form not more than 30 days following the nominal grant termination date (1975 August 31).

Mobile Station Sensitivity Study

The previous semi-annual status report gave a brief description of this study, which was not a proposed task, but rather one that was requested of us by the project monitor. Some preliminary results were given at that time. Since that time, portions of this work have been used in presentations by the principal investigator, by Dr. Eric Silverberg, (U.T. McDonald Observatory), and by Dr. Gary Latham (U.T. Galveston). This study is now finished, but we omit a discussion of the results here, due to the fact that the final report on this task is already in preparation. It is expected to be delivered by 1975 August 15.

Staff, Publications and Travel

During the report period, the project staff consisted of J. D. Mulholland (P.I. 3 man months), S. Killen (3 1/2 mm), G. Loumos (2 1/2 mm), N. Otto (2 mm) and P. J. Shelus (6 mm). Loumos terminated his connection with the project on May 31, while Killen joined it January 1.

No manuscripts were submitted for publication during the report interval, although three of those submitted during the previous period and noted in the previous status report as accepted for publication have since appeared in the open literature. These are Mulholland, "The Rotation of the Moon," Acad. Roy. Belgique, 5th series LX, 1088, 1974, Shelus, Mulholland and Silverberg "Laser Observations of the Moon: Normal Points for 1972" Astron. J. 80, 174, 1975, and Shelus and Jefferys "A Note on an Attempt at More Efficient Poisson Series Evaluation" Cel. Mech. 11, 75, 1975.

Travel supported under this grant during the report period included attendance by Mulholland and Shelus at the February and June LURE Team meetings in Washington and a trip to the Haleakala Observatory by Shelus to facilitate the solution of the problems discussed in the data management section of this report.