Gravity Increased by Lunar Surface Temperature

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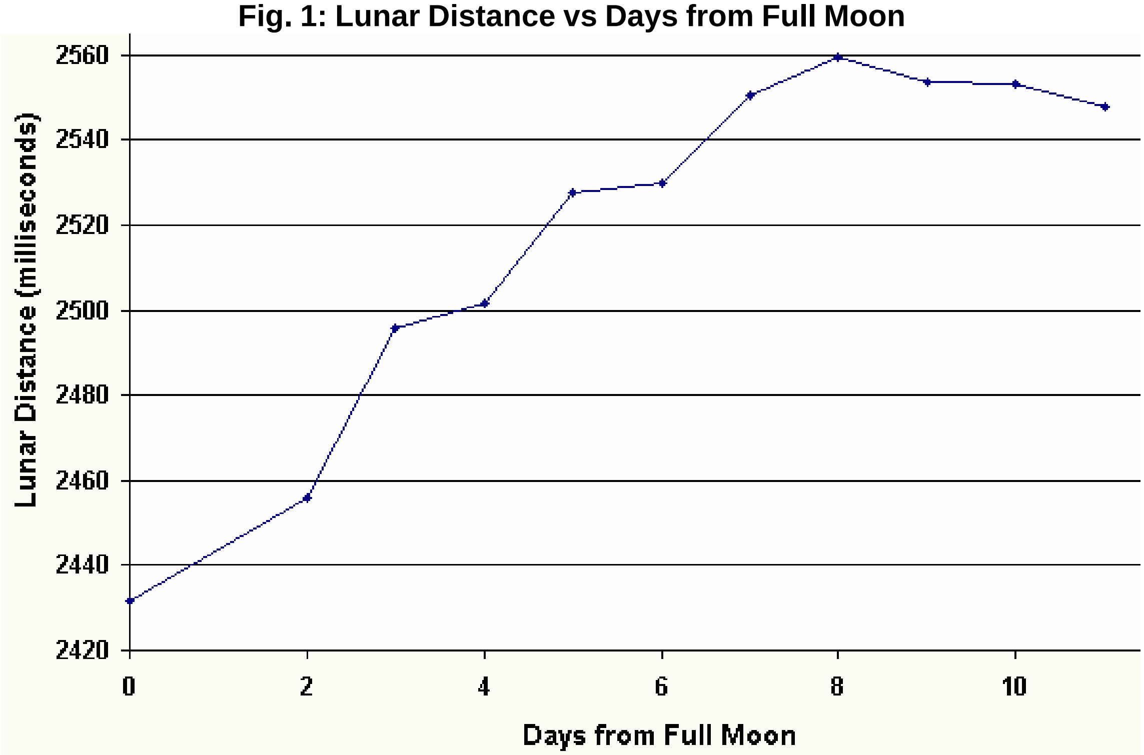
Abstract
Quantitatively large effects of lunar surface temperature on apparent gravitational force measured by lunar laser ranging (LLR) and lunar perigee may challenge widely accepted theories of gravity. LLR data grouped by days from full moon shows the moon is about 5 percent closer to earth at full moon compared to 8 days before or after full moon. In a second, related result, moon perigees were least distant in days closer to full moon. Moon phase was used as proxy independent variable for lunar surface temperature. The results support the prediction by binary mechanics (BM) that gravitational force increases with object surface temperature.

Introduction

Quantitatively large effects of lunar surface temperature on apparent gravitational force measured by lunar laser ranging (LLR) and lunar perigee may challenge widely accepted theories of gravity. LLR data [1] grouped by days from full moon shows the moon is about 5 percent closer to earth at full moon compared to 8 days before or after full moon. In a second, related result, moon perigees were least distant in days closer to full moon. Moon phase was used as proxy independent variable for lunar surface temperature. The results support the prediction by binary mechanics (BM) [2] that gravitational force increases with object surface temperature [3].

Methods and Results

Fig. 1: Lunar Distance vs Days from Full Moon



The entire LLR data set of 8093 measurements from 1987 to 2004 of the l'Observatoire de la Côte d'Azur (OCA) in France [4] was grouped by day from full moon computed with U.S. Naval Oceanography data [5] (Fig. 1, Table 1). These two data sets were synchronized by universal times. Earth-moon distance was expressed in laser round-trip time in milliseconds. This raw data and the source code for the analysis software is available from the author.

Table 1: Lunar Distance in Msec vs Day from Full Moon

Day	N	msec	std error
0	31	2431.88	10.64
2	195	2456.04	6.67
3	936	2495.87	3.47
4	946	2501.72	3.27
5	1182	2527.47	2.73
6	1270	2529.71	2.33
7	1265	2550.60	2.21
8	884	2559.58	2.64
9	620	2553.51	3.25
10	477	2552.91	4.29
11	227	2547.95	6.80

Minimum lunar distance was observed in the 24 hour period of full moon (day 0 in Fig. 1 and Table 1) when lunar surface temperature would be expected to be greatest. As solar illumination of the lunar surface facing earth decreases, lunar distance increased up to a maximum at day 8 before or after full moon, representing about a 5 percent decrease in lunar distance at full moon, where (2559.58 - 2431.88)/2559.58 = 0.0499.

In general, a steady increase in lunar distance over days 0 to 8 was seen. This effect appears to plateau over the 7 to 11 day range.

The 11 sample means in msec were all clearly different according to the 2-sample t test of statistical significance, except differences between day pairs 3 and 4, 5 and 6, 9 and 10 and 10 and 11.

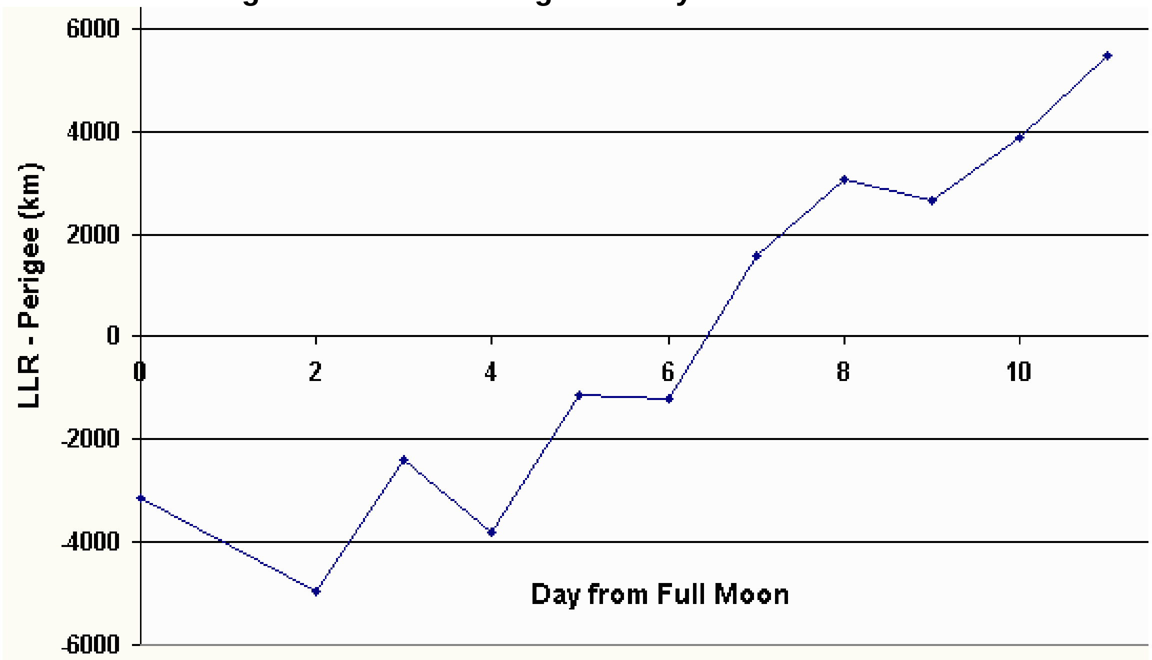
Table 2: Lunar Perigee Distance in km vs Day from Full Moon

Day	N	km	std error
0	17	356890.71	64.66
1	31	358637.19	172.48
2	22	362307.00	205.20
3	17	365739.12	208.10
4	11	368019.36	130.40
5	7	369221.71	210.53
6	4	369613.75	176.81
7	7	369965.86	86.28
8	7	369827.14	134.47
9	8	369307.88	94.73
10	9	367995.44	131.30
11	19	365657.89	196.61

The lunar perigee distance is the shortest distance from earth in each eccentric cycle of the orbit of the moon around earth [6]. Table 2 tabulates these perigees in km by day from full moon for the same Oct, 1987 to Dec, 2004 period of the LLR data shown in Table 1. The product-moment correlation r between day from full moon and perigee distances (Table 2) is 0.716 (N = 12), with $r^2 = 0.513$, which implies that about half of the perigee distance variation may be accounted for by day from full moon.

The calculated perigees (Table 2) were on average some 10788 km less than the distances implied by the LLR measurements, when converted to km (Table 1). Fig. 2 shows the LLR data in km as offsets from the calculated perigee mean values on a per day basis. That is, the Y-axis is the deviation of the LLR-perigee difference from the mean difference of the 11 points.

Fig. 2: LLR minus Perigee vs Days from Full Moon



From days 0 to 6 the shortest distances occurred, while longer values were seen on days 7 to 11 from full moon. Perhaps of special interest is the almost linear upward trend in offsets of LLR distance from calculated perigee from day 2 to day 11. Indeed, for these days, the product-moment correlation between day and LLR distance minus perigee is $r = 0.97$ ($N = 10$). That is, for days 2 to 11 from full moon, time from full moon accounted for 94 percent of the variance of LLR distance minus calculated perigee values.

Discussion

The present study aimed to test the hypothesis predicted by BM [3] that observed gravitational force increases with increased object surface temperature.

First, moon phase was used as an indication of the independent variable -- lunar surface temperature, with highest temperature associated with full moon. LLR data was used to operationally define the dependent variable -- earth-moon gravitational force, assumed to be inversely correlated with lunar distance (Table 1). In short, greater lunar surface temperature in the direction of earth was associated with motion reducing lunar distance.

Second, moon perigees were least distant in days closer to full moon. The orbit of the moon around earth has an approximate 5 percent eccentricity [6]. At lunar perigee, the moon is about 5 percent closer to earth, compared with lunar apogee. Further, the actual lunar distance at perigee also varies substantially. The present study may explain one half (51%) of perigee distance variation in terms of days to full moon in the 0 to 11 day interval (Table 2). That is, the presumed effect of surface temperature on apparent gravitational effects may account for most of the variability in perigee distance.

The approximate plateau from days 7 to 11 is not entirely consistent with the present hypothesis, since solar illumination of the lunar surface facing earth continues to decrease in the day 8 to 11 period, suggesting decreased lunar surface temperatures over that lunar surface area. This issue might be resolved by further analysis including the perigee cycles which may explain the present plateau in LLR data as a function of time from full moon in the period studied. Perhaps there is sufficient correlation between the perigee and new moon phases to account for the perigee effect opposing further increases in lunar distance in the reported 8 to 11 day period where lunar surface temperature is thought to continue decreasing.

On the other hand, the LLR distance means may be "corrected" by expressing them as offsets from the calculated perigee means, as shown in Fig. 2. These deviations of mean LLR from mean calculated perigees indicated greater distances over the range from day 2 to 11 as lunar surface temperature presumably decreased, supporting the hypothesis that apparent gravitational force depends on object surface temperature.

Although the results reported exhibit high levels of statistical significance, the OCA data analyzed is only a fraction of available LLR data over longer periods from other observatories.

BM is the only physical theory known to the author predicting the present results. Gravity is not a primary force in BM [7], but rather a result of four postulated bit operations -- unconditional, scalar, vector and strong, which define exact time-development of BM states [8]. In this context, objects tend to move in the direction of greater 1-state bit density. Observed gravitational forces are simply a specific instance of this general principle.

With increased surface temperature, an object will tend to radiate more 1-state bits from its surface. At full moon, these emitted 1-state bits will tend to increase bit density between earth and moon, compared to other directions, causing object motion decreasing lunar distance. A similar mechanism may explain the Pioneer anomaly [9] where it may be no coincidence that the direction of anomalous motion is toward the greatest nearby source of radiated 1-state bits -- the sun.

References

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