EPSC Abstracts
Vol. 7 EPSC2012-274 2012
European Planetary Science Congress 2012

Lunar Orbit Anomaly and GM=tc^3 Cosmology

L. Riofrio
University of Houston Clear Lake, Texas, USA (Sailorstarfightr@yahoo.com)

Abstract

Studies of the Moon, with thanks to NASA and Johnson Space Center, have quantified a large anomaly in lunar orbital evolution. The Lunar Laser Ranging Experiment (LLRE) has reported the Moon's semimajor axis increasing at *3.82±.07cm/yr*, anomalously high. Tidal data indicates a rate of only *2.9±0.6 cm/yr*. Historical eclipse observations indicate *2.82±.08cm/yr*. Numerical simulation predicts *2.91cm/yr*. LLRE's laser light differs by up to 12σ. A cosmology where speed of light c is related to time t by $GM=tc^3$ predicts that LLRE will differ by *0.935cm/yr*, precisely predicting the anomaly. Observations from the Moon may shed light on "dark" mysteries of Physics.

1. Lunar Orbit Anomaly

The Moon has long been known to be slowly drifting farther from Earth due to tidal forces. As the Moon raises tides on Earth, tidal bulges travel ahead of the Moon due to Earth's 24-hour rotation. A tidal bulge pulls the Moon slightly ahead in its orbit, and causes Earth's rotation rate to slow. In this way angular momentum is transferred from Earth's rotation to the Moon, causing the Moon's orbital semimajor axis to increase.

1.1 Lunar Laser Ranging Experiment

Apollo's Lunar Laser Ranging Experiment bounces Laser light off corner reflectors left on the Moon by astronauts. Previously LLRE has been used to investigate geophysics of the Earth-Moon system and test Relativity. Accuracy is considered fine enough to constrain changes in the gravitational constant G. LLRE has measured the Moon's semimajor axis at a = 384,402*km*. Repeated measurements appear to indicate that distance increasing *3.82 ± .07 cm/yr*, anomalously high. If the Moon were gaining angular momentum at this rate, it would have coincided with Earth *1.5 Gyr* ago. [1] Our studies of lunar samples convincingly show that the Moon has existed separately from Earth over 4.5 Gyr.

1.2 Tidal Rhythmites

Geology and paleontology can also tell how the Moon's distance has changed. Tidal rhythmites, in particular, carry a record of lunar-induced tides. Thicknesses of sedimentary layers vary with the height of local tides. Rhythmites can be used to determine lunar distance over many millions of years. Starting with today's LLRE measurement, we may compile estimates of lunar orbital distance based on rhythmites. [2]

Table 1: Lunar Orbital Distance

Sediment	Age (10^3 yr)	a (10^3 km)
Present	0	384.4
Mansfield	310±5	375.3±1.9
Elatina	620±100	370.9±0.1

The Mansfield sediment of Indiana, the most recent, places the *Moon 375,300 ± 1,900 km* away 310 Myr ago, a recession rate of *2.9±0.6cm/yr*. Study of the older Elatina and Reynella tidal rhythmites also indicates a lower recession rate. [3]

1.3 Eclipse Records

Corroborating data has come from historical astronomers. If the narrow track of an eclipse has been recorded over an observatory, it provides an accurate measure of Earth's slowing rotation rate. As Earth and Moon form a closed system, this tells how much angular momentum has been transferred. Lunar recession rate varies linearly with change in Earth Length of Day (LOD). LLRE's reported rate of *3.82±.07cm/yr* corresponds to a change in Earth Length of Day *2.30msec/cyr*. Observations spanning *2700 yrs* show change in LOD of *1.70±.05msec/cyr*[4], corresponding to lunar recession rate of *2.82±.08cm/yr*. LLRE's laser light differs by over 12σ. This enormous discrepancy in lunar orbital evolution has recently been quantified.

1.4 Numerical Simulation

Tidal action between Earth to Moon is subject to many factors. These include height of local tides, ocean depth, location of ocean basins and the movement of continental plates. A comprehensive numerical solution for tidal action incorporates all these factors. The simulation predicts that the Moon is presently receding at *2.91 cm/yr*, agreeing with sedimentary and eclipse data. [5] LLRE disagrees by *0.91±.07cm/yr*.

2. Speed of Light

Anomalies in observations of Mercury and the moons of Jupiter are today known to result from Relativity and the finite speed of light. The lunar orbit anomaly may also have a cosmological origin. A theory suggests that speed of light *c* is related by:

$$GM = tc^3 \tag{1}$$

Where *t* is age of the Universe, *GM* combines its mass and gravitational constant. This model is suggested to precisely predict the nonlinear redshifts of distant Type Ia supernovae. [6]

Solving for *c*, we would have:

$$c(t) = (GM)^{1/3}t^{-1/3} \tag{2}$$

Time for light to return would increase yearly, making the Moon to appear to recede faster as perceived by LLRE.

Discrepancy in lunar orbital evolution would then be proportional to change in c:

$$\frac{\dot{a}}{a} = -\frac{\dot{c}}{c} = \frac{1}{3t} \tag{3}$$

Multiplied by the Moon's semimajor axis of *384,402km* that distance would appear to increase an additional *0.935cm/yr*, precisely predicting the *12σ* anomaly. [7]

3. Discussion

At one time scholars disagreed whether light travelled instantaneously or had a finite speed. Galileo suggested placing lanterns on distant hilltops to time light's passage, but lacked an accurate clock. Today we have laser lanterns and the distant hilltop of the Moon. A tiny change in the *c* may appear in measurements of lunar orbital evolution.

As with Mercury, a lunar orbit anomaly may shed light on a significant problem in Physics. Redshifts of distant Type Ia supernovae increase non-linearly. This appearance of "cosmic acceleration" may in fact be *c* slowing over time. Though present timepieces are not accurate enough to measure *c* change in the laboratory, a more accurate Atomic Clock Ensemble (ACES) will soon be installed by ESA aboard the International Space Station. Future observations from the lunar surface may solve other problems in cosmology.

Acknowledgements

Great thanks are due to colleagues in the ARES directorate at NASA Johnson Space Center. A generous grant from the American Astronomical Society has allowed presentation of this paper.

References

[1] Dickey J.O. et al.: Lunar Laser Ranging: A Continuing Legacy of the Apollo Program, Science, Vol. 265, pp. 482-490, 1994.

[2] Bills, A.B and Ray, C.D.: Lunar Orbital Evolution: A Synthesis of Recent Results, Geophysical Research Letters, Vol. 26, pp. 3045-3048, 1999.

[3] Williams, G.E.: Geophysical Constraints on the Precambrian History of Earth's Rotation and the Moon's Orbit, Reviews of Geophysics, Vol. 38, pp. 37-59, 2000.

[4] Stephenson, F.R. and Morrison, L.V.: Long-Term Fluctuations in the Earth's Rotation 700 BC to AD 1900, Philosophical Transactions of the Royal Society, Vol. 351, pp. 165-202, 1995.

[5] Poliakow, E.: Numerical modeling of the paleotidal evolution of the Earth-Moon System, IAU Colloquium 197, 31 August-4 September 2001, Belgrade, Serbia, 2005.

[6] Riofrio, L.: $GM=tc^3$ Explanation of Supernova Data, Observing Dark Energy, 18-20 March 2004, Tucson, USA, 2005.

[7] Riofrio, L.: Calculation of lunar orbit anomaly, Planetary Science, Vol. 1, 2012.

Extra page