AN ACES SEARCH FOR ANISOTROPIES IN FUNDAMENTAL CONSTANTS

LOUISE RIOFRIO

ACES WORKSHOP

OCTOBER 29, 2019

International Lunar Observatory Association

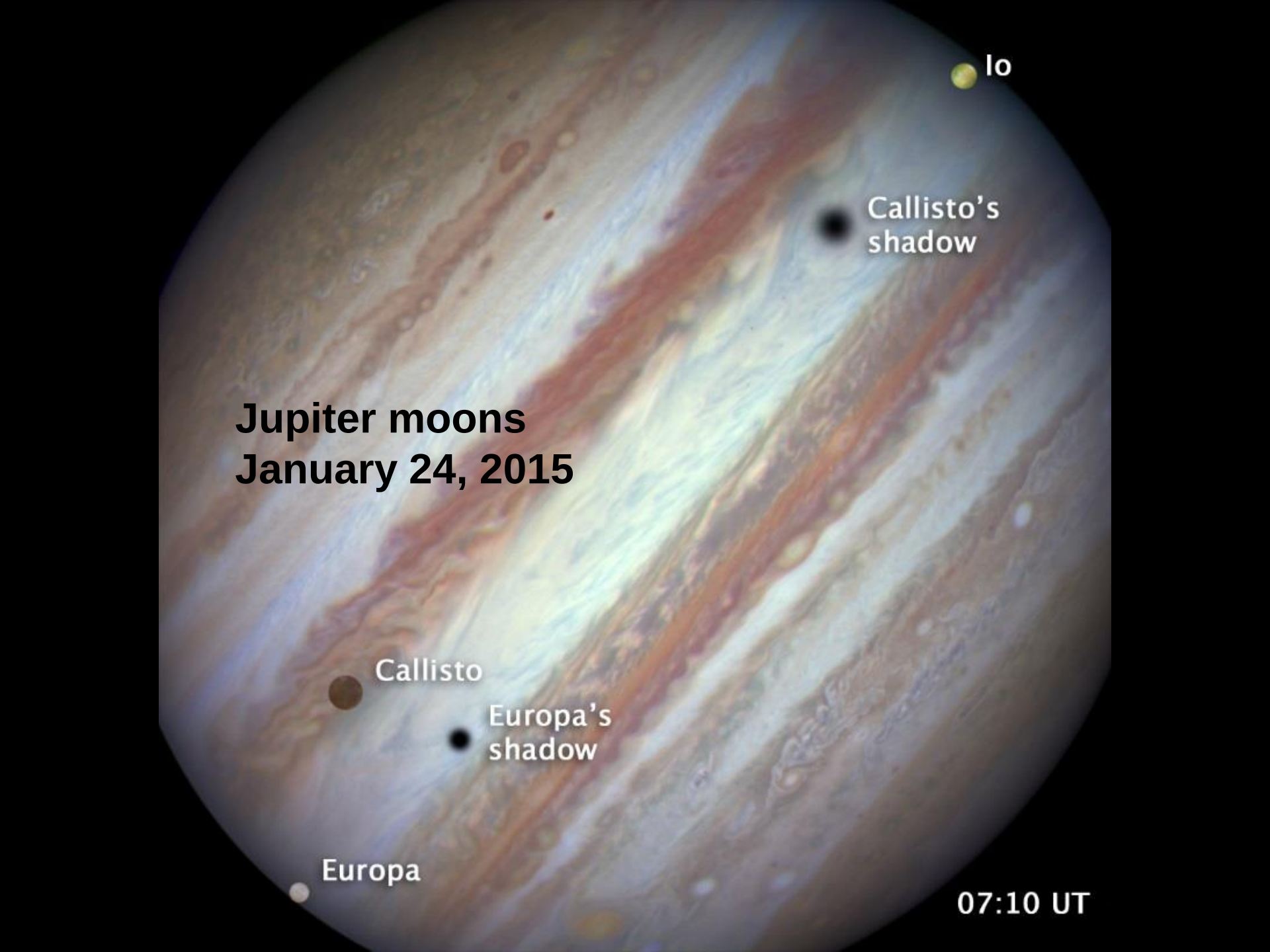
To expand human understanding of the Cosmos through observation from our Moon – with Aloha

- Hawaii non-profit since 2007
- Multi-Function ILO
  - Galaxy astronomy, communications
  - Lunar base build-out
- Astronomy from the Moon: A First Light Industry

JOHNSON SPACE CENTER

The Galileo Experiment

With this conviction, Galileo did try to set up an experiment to measure the speed of light in 1638. Galileo and his assistant each took a shuttered lantern, and positioned themselves on hilltops one mile apart. As soon as the assistant saw Galileo flashing his lantern, he would reply by opening the shutter to his own lantern. Galileo would then mark down how long it took before he saw the light from the other lantern. Dividing the return trip of two miles with the time, he would obtain the speed of light in just the same way of measuring the speed of any moving daily object.


Io
Callisto's shadow
Jupiter moons
January 24, 2015
Callisto
Europa's shadow
Europa
07:10 UT

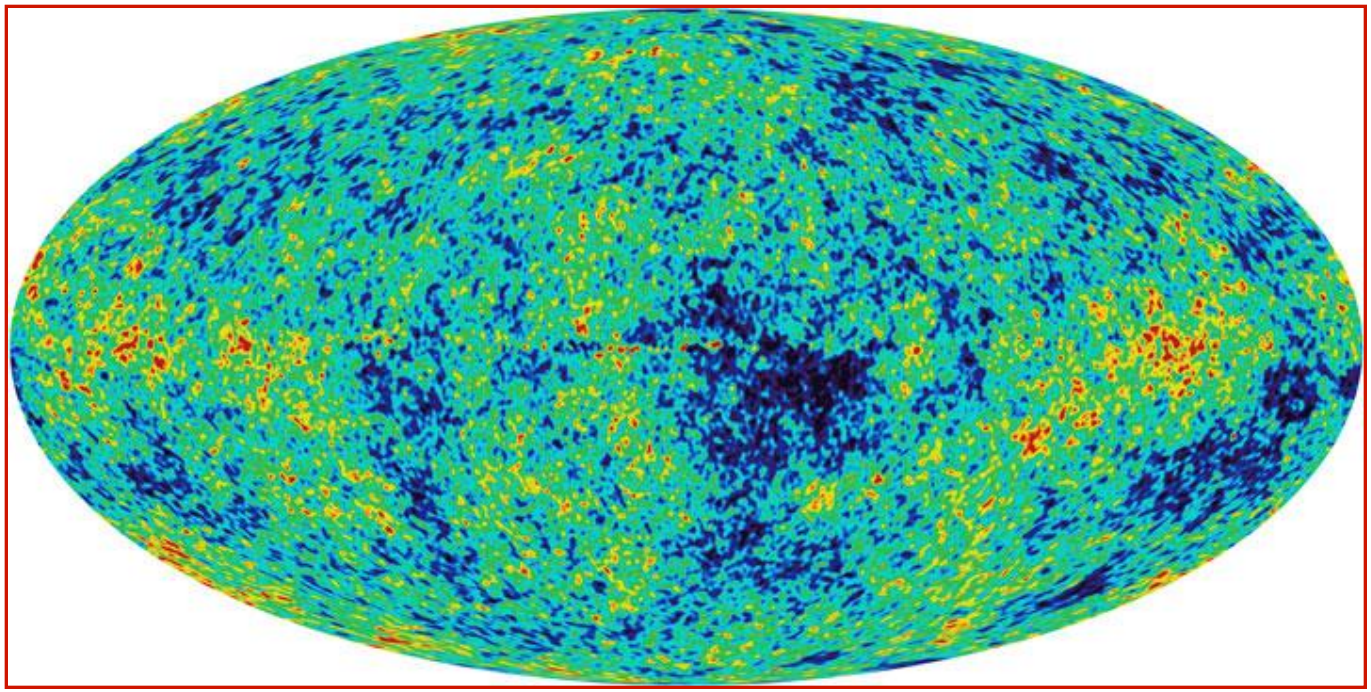
DECEMBER 8, 2016


“When forced to summarise the General Theory of Relativity in one sentence, Time and Space and Gravity have no separate existence from Matter”
--Albert Einstein
GM=tc3
M

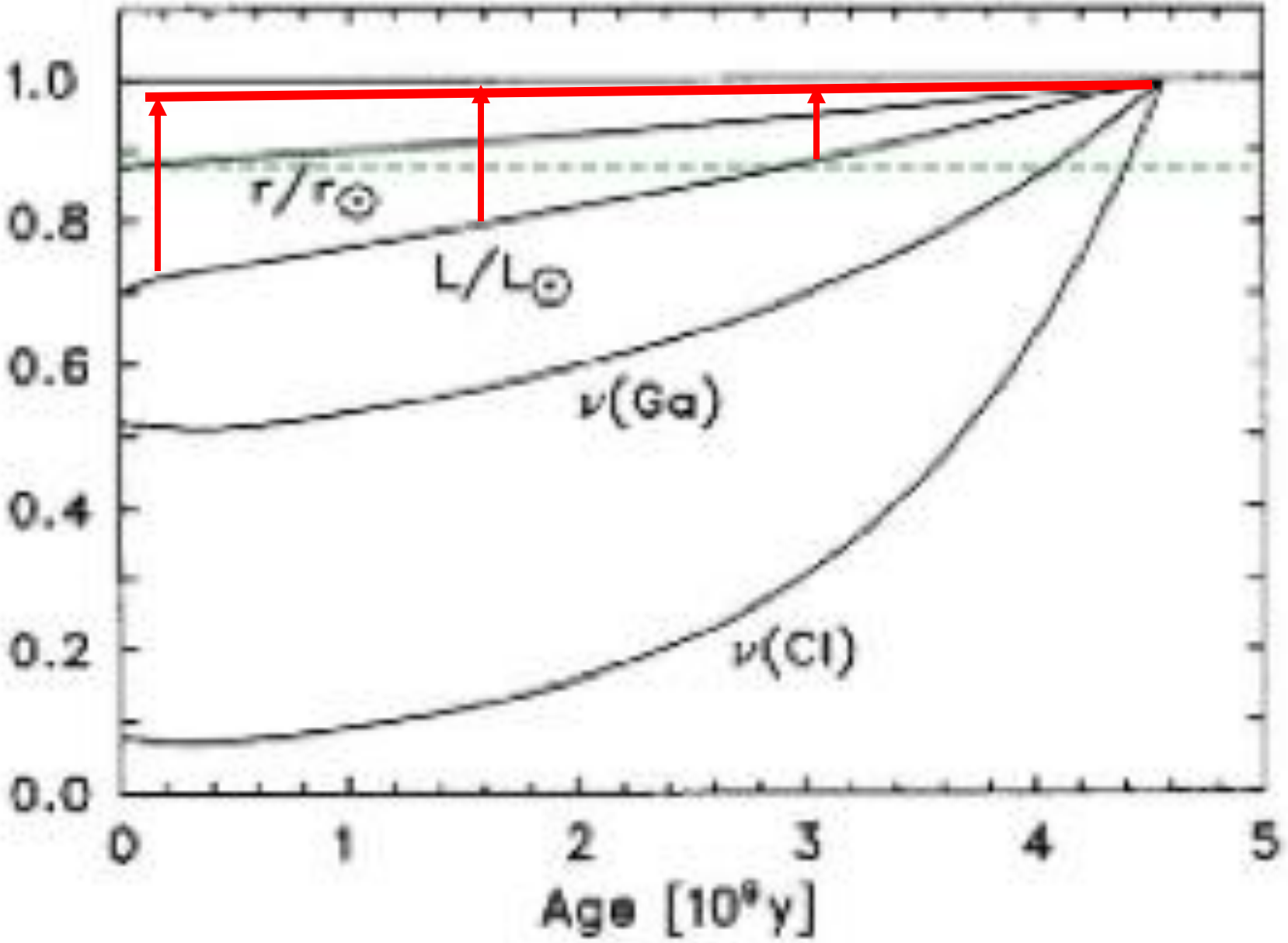
Testing the Big Bang model

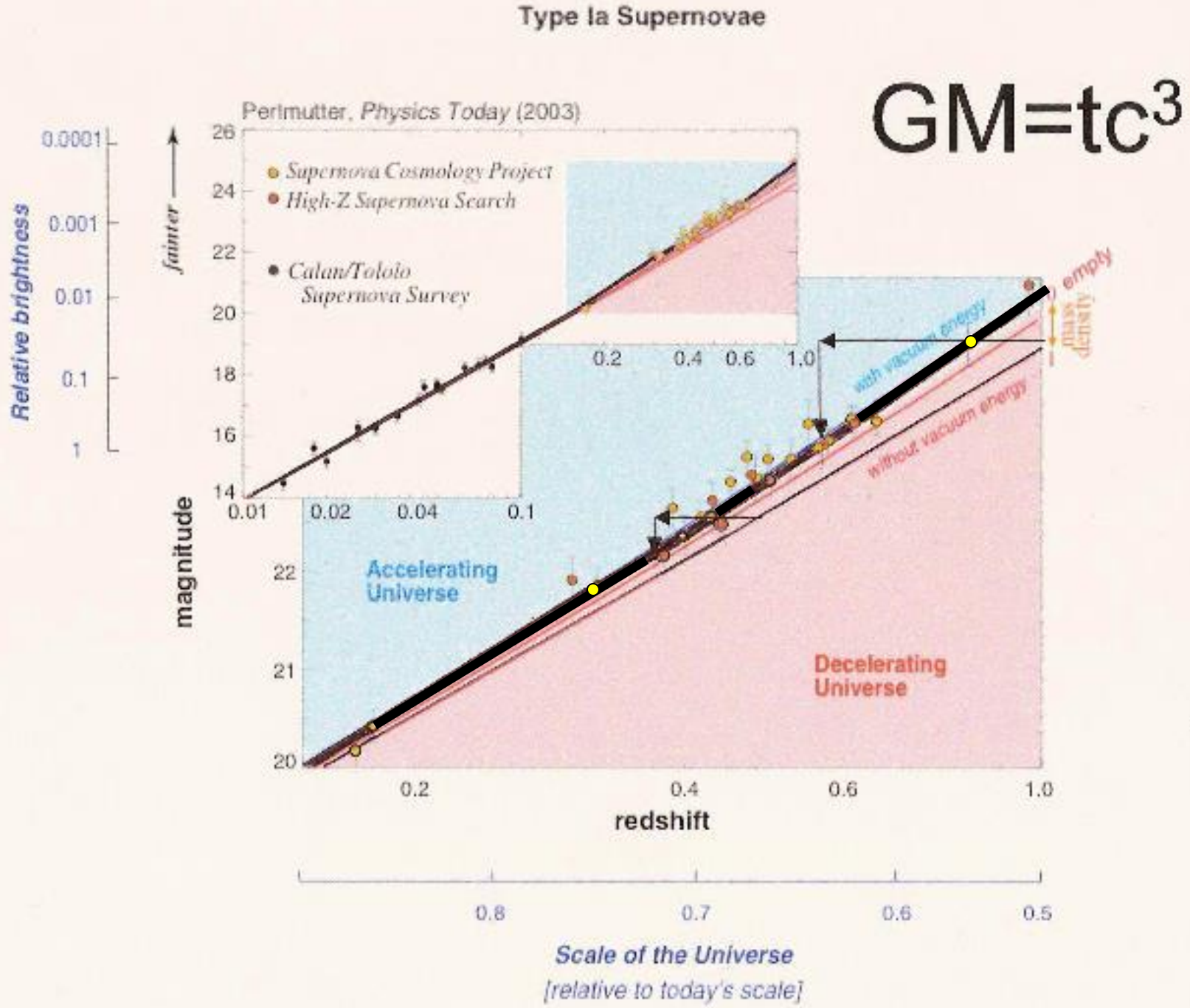
Prediction: If the universe was denser, hotter, in past, we should see evidence of left-over heat from early universe.

Observation: Left-over heat from the early universe. (Penzias and Wilson, 1965)



$GM=tc^3$




Type Ia Supernovae
GM=tc3
Perlmutter, Physics Today (2003)
Supernova Cosmology Project
High-Z Supernova Search
Calan/Tololo Supernova Survey
Relative brightness
0.0001
0.001
0.01
0.1
1
fainter
magnitude
redshift
Accelerating Universe
Decelerating Universe
with vacuum energy
without vacuum energy
empty
mass density
Scale of the Universe
[relative to today's scale]

Lunar Laser Ranging

Apollo 11 LLRE July 20, 1969

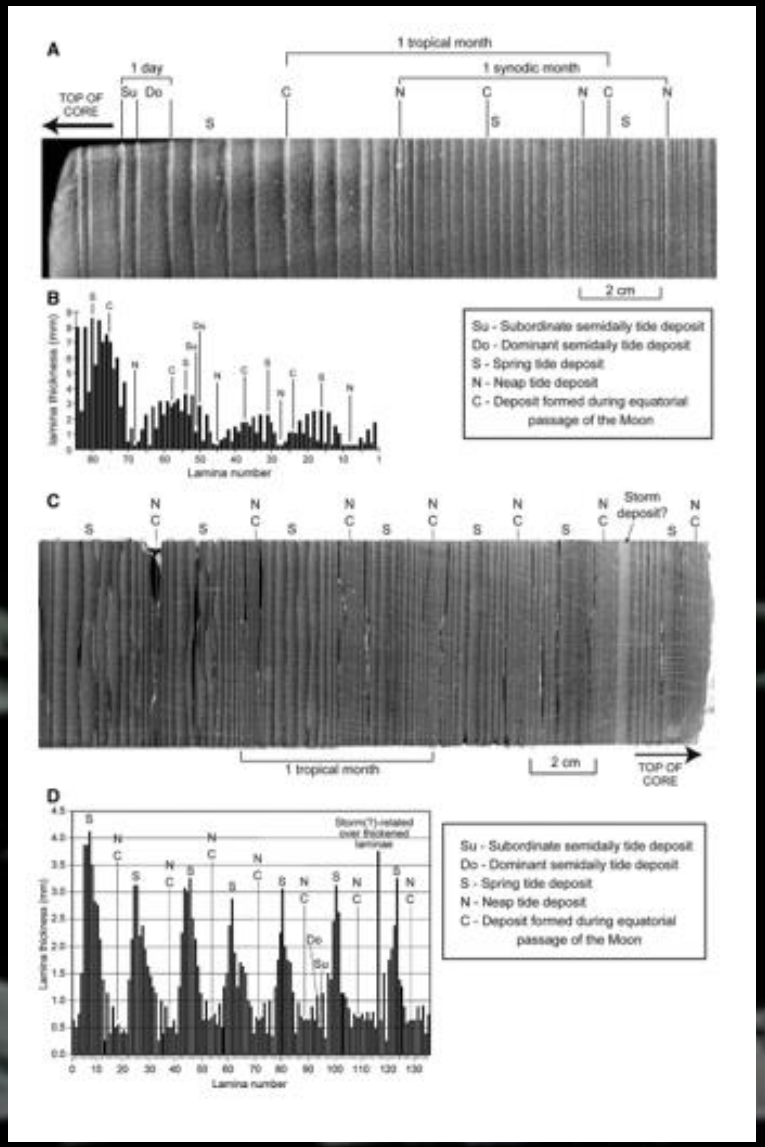
The Moon's distance is known to be slowly increasing due to tidal action transferring angular momentum from Earth's rotation to the Moon.

The Lunar Laser Ranging Experiment (LLRE) from 1969 reports a recession rate of **3.82 ± .07 cm/yr,** anomalously high. The Moon would have coincided with Earth just 1.5 Gyr ago. (Bills, Ray 1999)

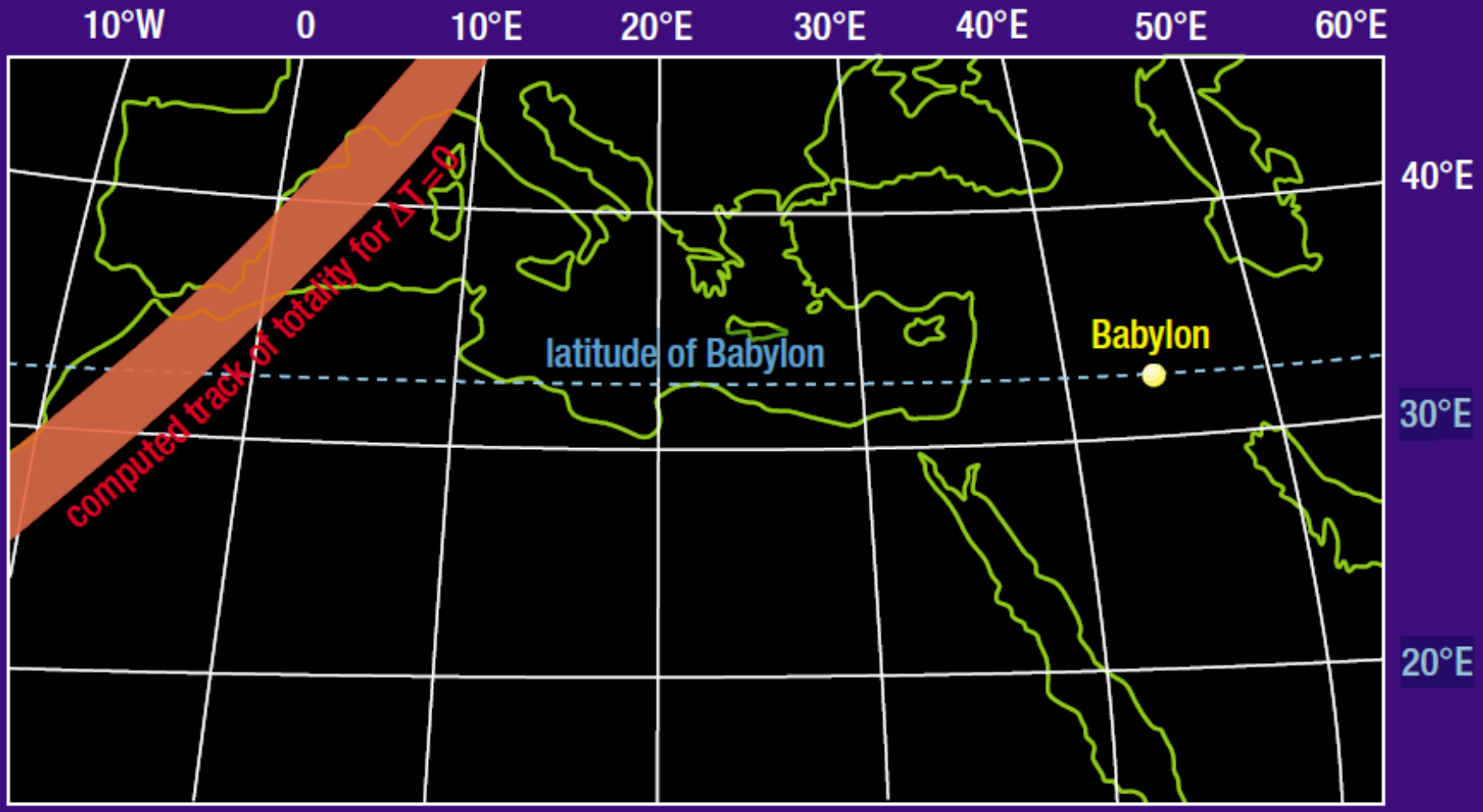
Lunar Anomaly

Sedimentary data indicates 2.9 ± 0.6 cm/yr.
(Bills, Ray 1999)

Sediment Location	Age 10^6 yr	Distance 10^3km
Present	0	384.4
Mansfield	310±5	375.3±1.9
Elatina	620±100	357.1±0.1
Cottonwood	900±100	350.9±4.6



Stephenson et al., in *Proceedings of the Royal Society*
December 7, 2016 corresponds to 2.91 ± .05 cm/yr



4: Computed track of totality for the eclipse of 15 April in 136 BC, assuming a fixed length of day ($\Delta T = 0$). This track lies more than 50° to the west of Babylon, where totality was actually observed.

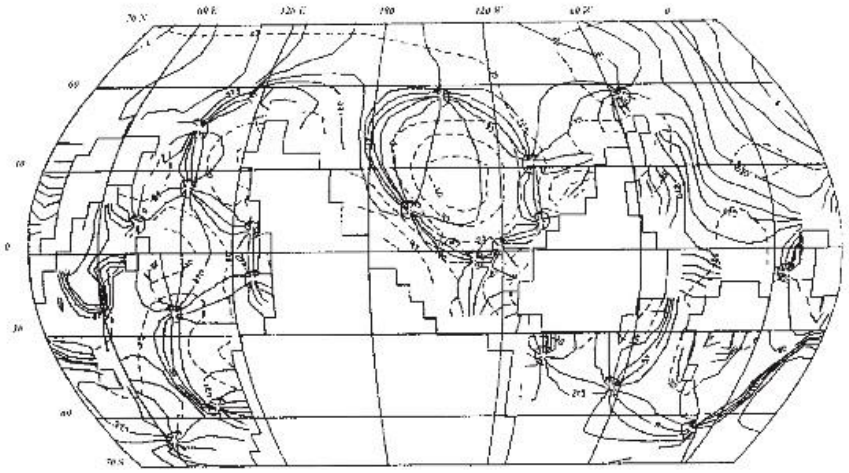


Figure 4. Tidal map. M_2 wave. 570 Myr ago.

Main characteristics of tidal evolution of the Earth–Moon system. M_2 wave

T, 10^6 yr	Ω, 10^{-5} s^{-1}	ω, 10^{-6} $s{-}1$	σ, 10^{-4} s^{-1}	$A+$, cm	L, 10^{16} $n \cdot m$	δ, deg	Q	$\dot{R}$, cm/yr	$\dot{\omega}$, "/cent^2	$\dot{\tau}$, s/cent
0	7.292	2.662	1.405	24.23	3.42	5.18	11.0	2.91	19.7	1.59
10	7.306	2.665	1.408	24.28	3.14	4.75	12.0	2.68	18.4	1.46
50	7.349	2.675	1.416	24.46	2.17	3.27	17.5	1.83	12.4	0.98
100	7.382	2.682	1.423	24.60	0.94	1.43	40.0	0.81	5.6	0.43
200	7.407	2.688	1.428	24.71	0.40	0.61	93.9	0.34	2.3	0.18
300	7.423	2.691	1.431	24.77	0.53	0.81	70.7	0.46	3.2	0.24
350	7.439	2.695	1.434	24.85	0.93	1.41	40.6	0.80	5.5	0.42
400	7.452	2.698	1.436	24.89	0.66	1.01	56.7	0.57	3.9	0.30
450	7.476	2.703	1.441	24.99	1.80	2.70	21.2	1.54	10.7	0.80
500	7.527	2.715	1.451	25.21	2.95	4.48	12.8	2.53	17.7	1.31
570	7.617	2.736	1.469	25.60	2.54	3.82	15.0	2.19	15.5	1.11

Lunar Anomaly Solved?

Sedimentary data: 2.9 ± 0.6 cm/yr
Eclipse records: 2.91 ± .05 cm/yr
Simulation: 2.91 cm/yr
Average: 2.9 cm/yr
LLRE's laser light: 3.82 ± .07 cm/yr
ANOMALY: 0.92 ± .07 cm/yr

GM = tc^3 predicts an apparent increase of 0.926 cm/yr, matching the 12-sigma anomaly within a fraction of a standard deviation.

ACES

Atomic Clock Ensemble in Space (ACES)
can measure $\dot{c}/c < 10^{-10}$ or 3.0 cm/sec
Theory predicts 0.72 cm/sec per year

OPPORTUNITY FOR COOPERATION

ACES

Does the speed of light change with time? ×

room.eu.com/article/does-the-speed-of-light-change-with-time

Issue #2(20) 2019

Does the speed of light change with time?

SPACE

Atomic Clock In Space To Test Changing Speed Of Light

BY: LOUISE RIOFRIO | FEBRUARY 21, 2019

how a single candle can both defy and define the darkness – Anne Frank

McGill Institute of Air and Space Law

26 April 2019

As mystery of the Universe's expansion rate widens, a simple solution is offered

NASA scientist claims time travel is POSSIBLE because 'speed of light is changing'

A FORMER NASA scientist has claimed time travel is possible because the "speed of light is changing".

SHARE

By Simon Green Video News Editor

1905 - 2005

INSIDE EINSTEIN'S UNIVERSE

Summary:

In Galileo's time epicycles were hypothesised to explain a fixed Earth as centre of the universe.

The first evidence for a finite speed of light came from Jupiter's Galilean satellites

A simple equation may solve many problems of cosmology

Evidence for a changing c may come from distant supernovae and laser reflectors on the Moon

The Atomic Clock Ensemble in Space (ACES) aboard ISS will test the prediction of a "c change".

http://www.universeforum.org/einstein/

1905 - 2005

INSIDE EINSTEIN'S UNIVERSE

Bibliography:

Riofrio, L., "Calculation of lunar orbit anomaly," *Planetary Science,* Vol. 1, 1, 2012

Riofrio, L., "$GM=tc^3$ Explanation of Supernova Data," *Beyond Einstein,* Stanford University, 2004

Perlmutter et al., *Astrophysical Journal*, 1999

Riess et al., *Astronomical Journal,* 1998

Bills and Ray, *Geophysical Research Letters*, 1999

Stephenson and Morrison, *Phil. Trans. R. Soc.,* 1995

Poliakow, E., *IAU Proceedings* 2004: 445

http://www.universeforum.org/einstein/

“When forced to summarise the General Theory of Relativity in one sentence,Time and Space and Gravity have no separate existence from Matter”
--Albert Einstein

$R=ct$ $GM=tc^3$