A Simple 28 Year Moon Phase Time Series with some Surprizing Results

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Initial Goal

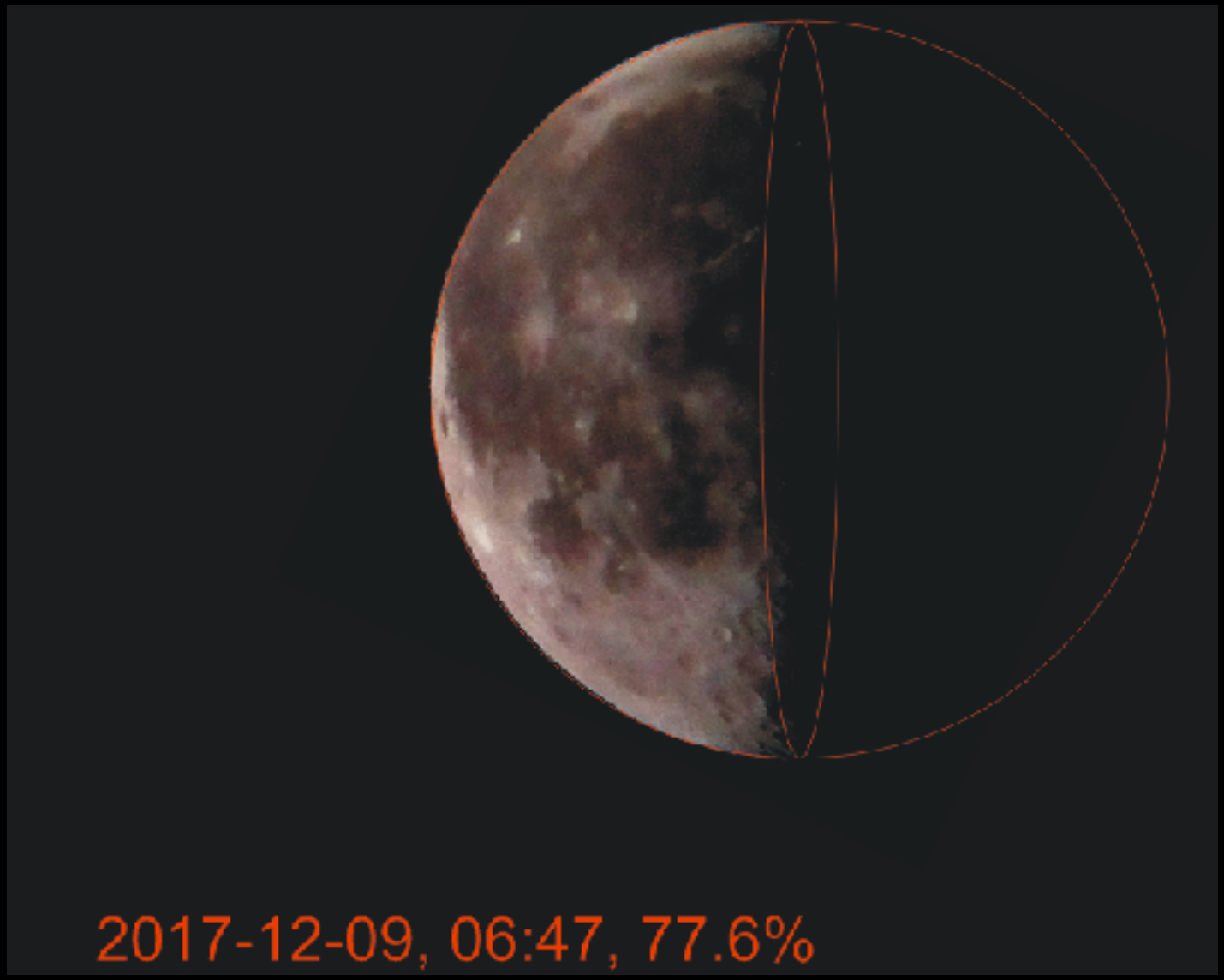
- Determine the duration of the lunar month using simple observations.

Motivation

- An experiment in extracting signal from noise.

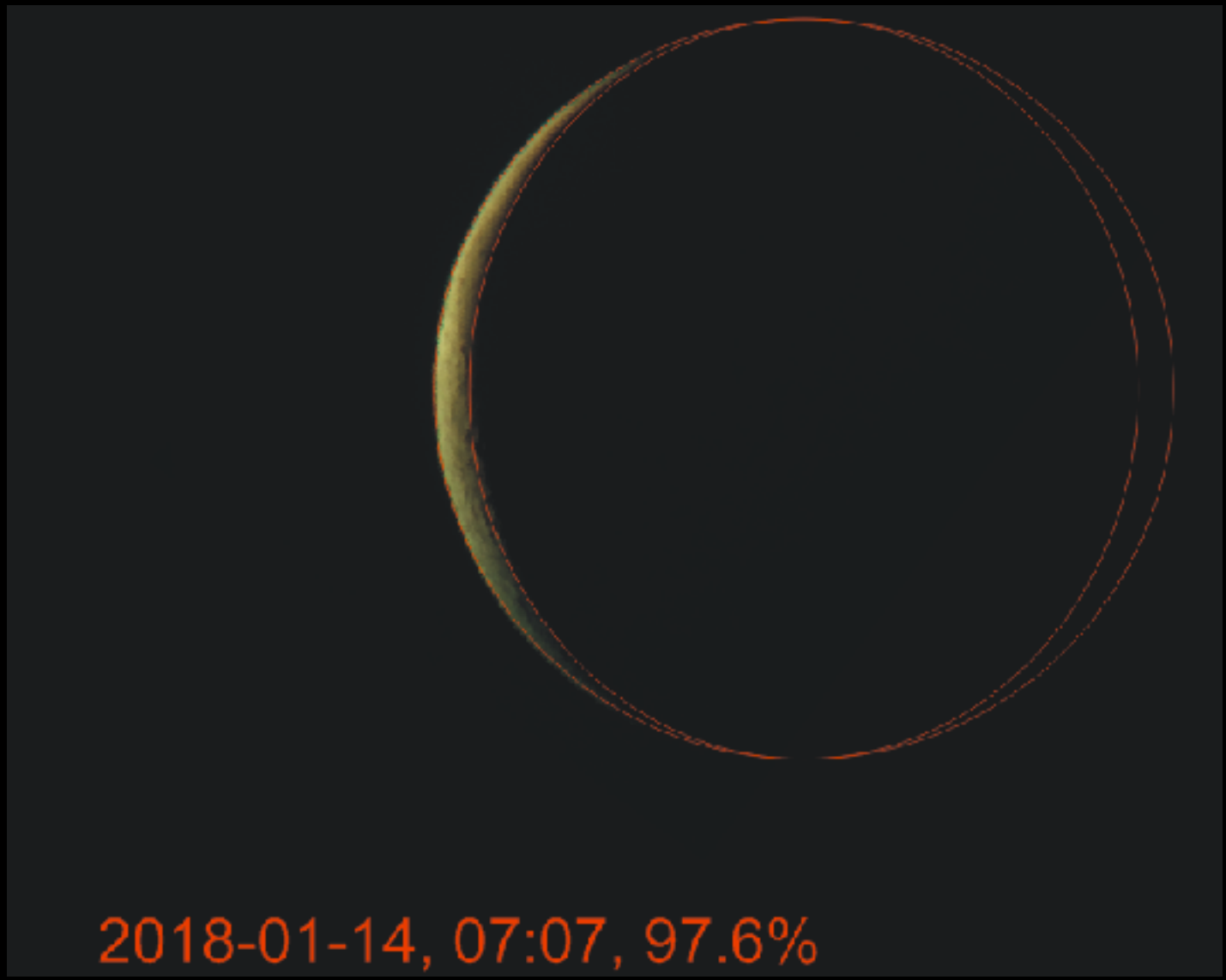
Method

- Whenever the moon is visible, record the percentage illuminated.
- Add 100% every subsequent lunation.
- Plot lunation+phase% against date.


2017-12-09, 06:47, 77.6%


2017-12-23, 17:06, 13.5%

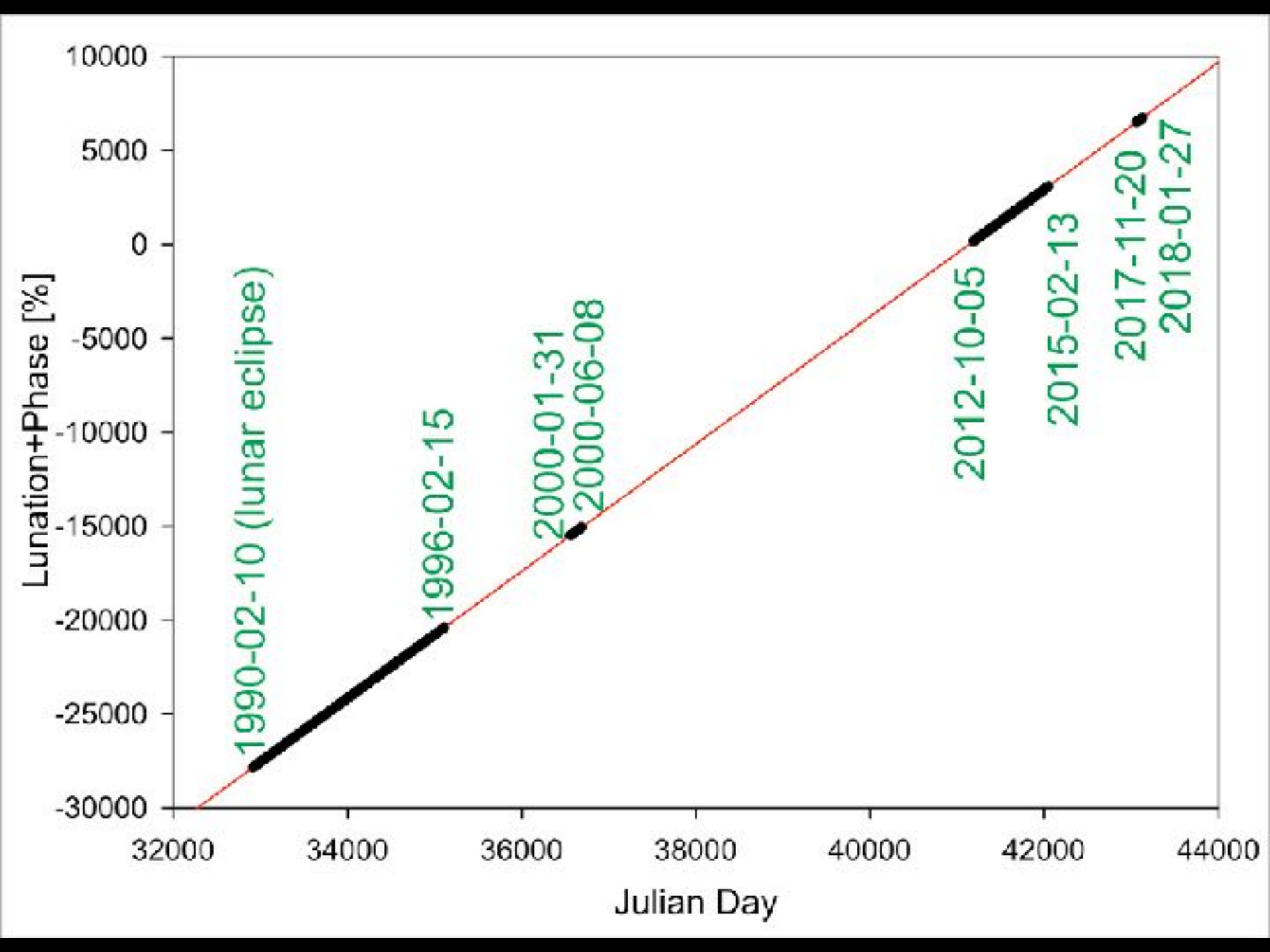

2018-01-02, 21:50, 51.8%

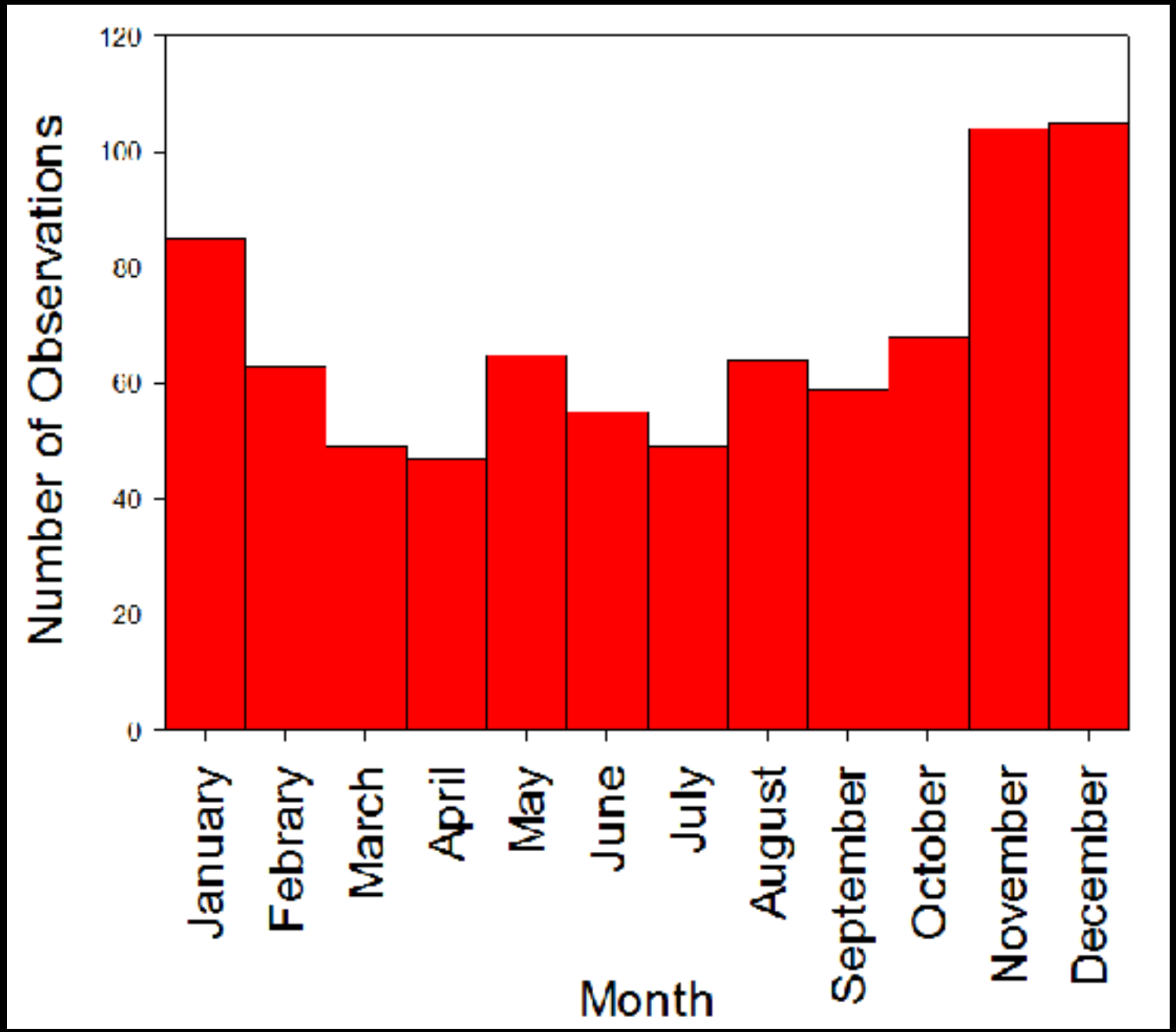

2018-01-14, 07:07, 97.6%

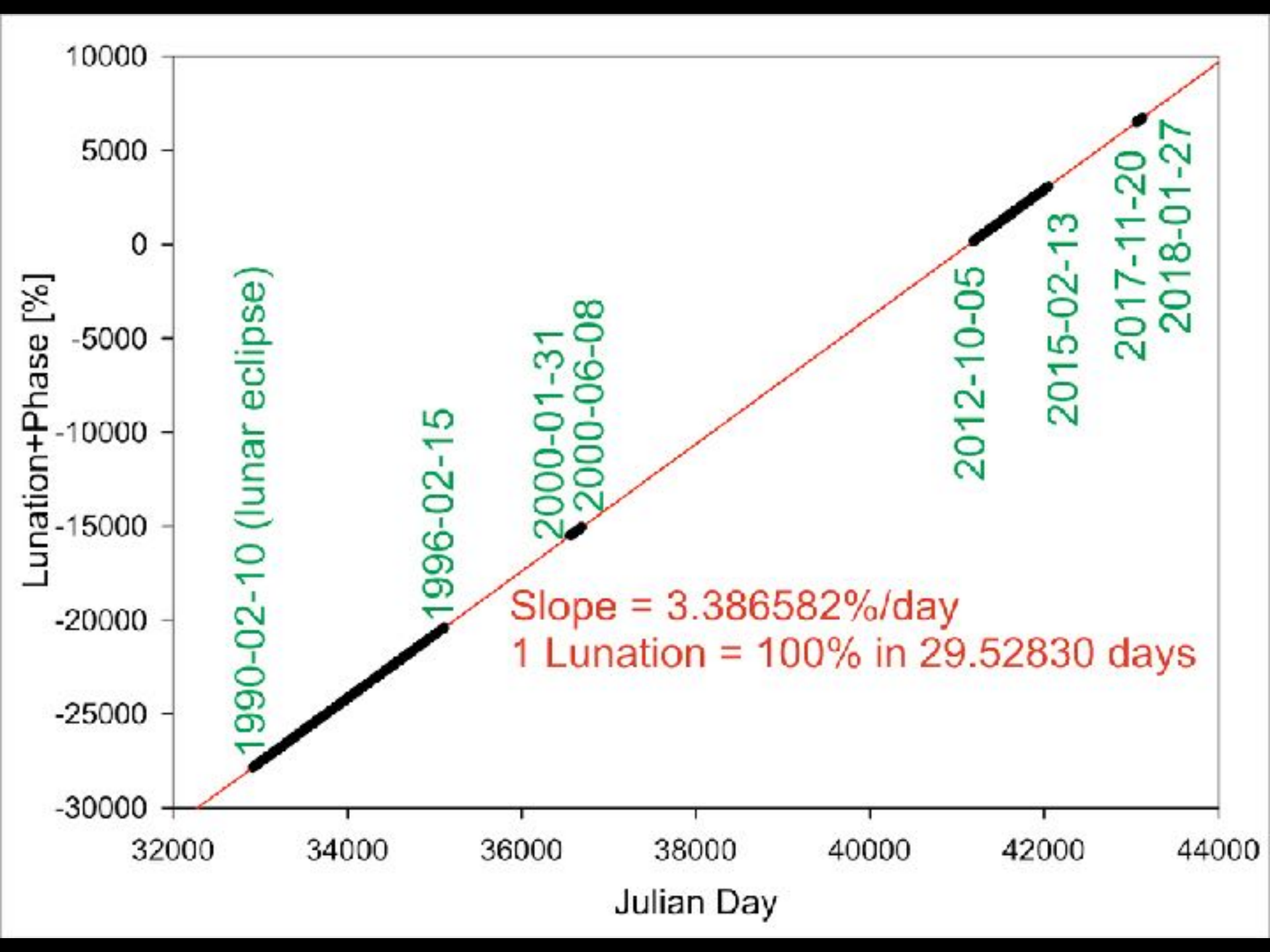
Moon

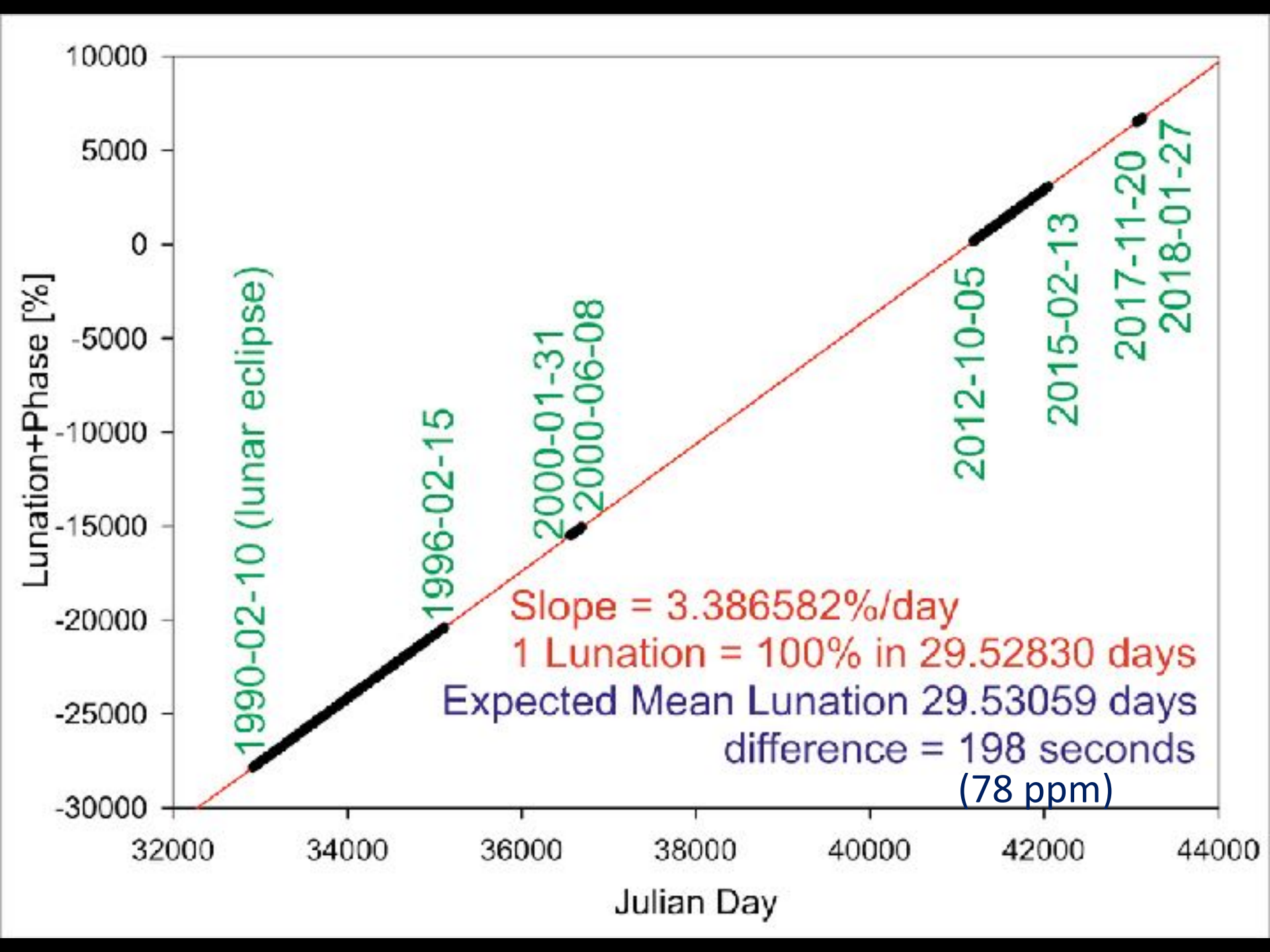
2017-11-20	03
21	04
22	10
23	14
26	26
28	33
29	37
30	42
1	44
Dec 2	49
3	57
5	60
6	64
7	66
9am	73
10am	76
11am	84
20	3
22	10
23	16
27	30
30	40
Jan 4	53
5	58
9am	79
10am	80
21	13

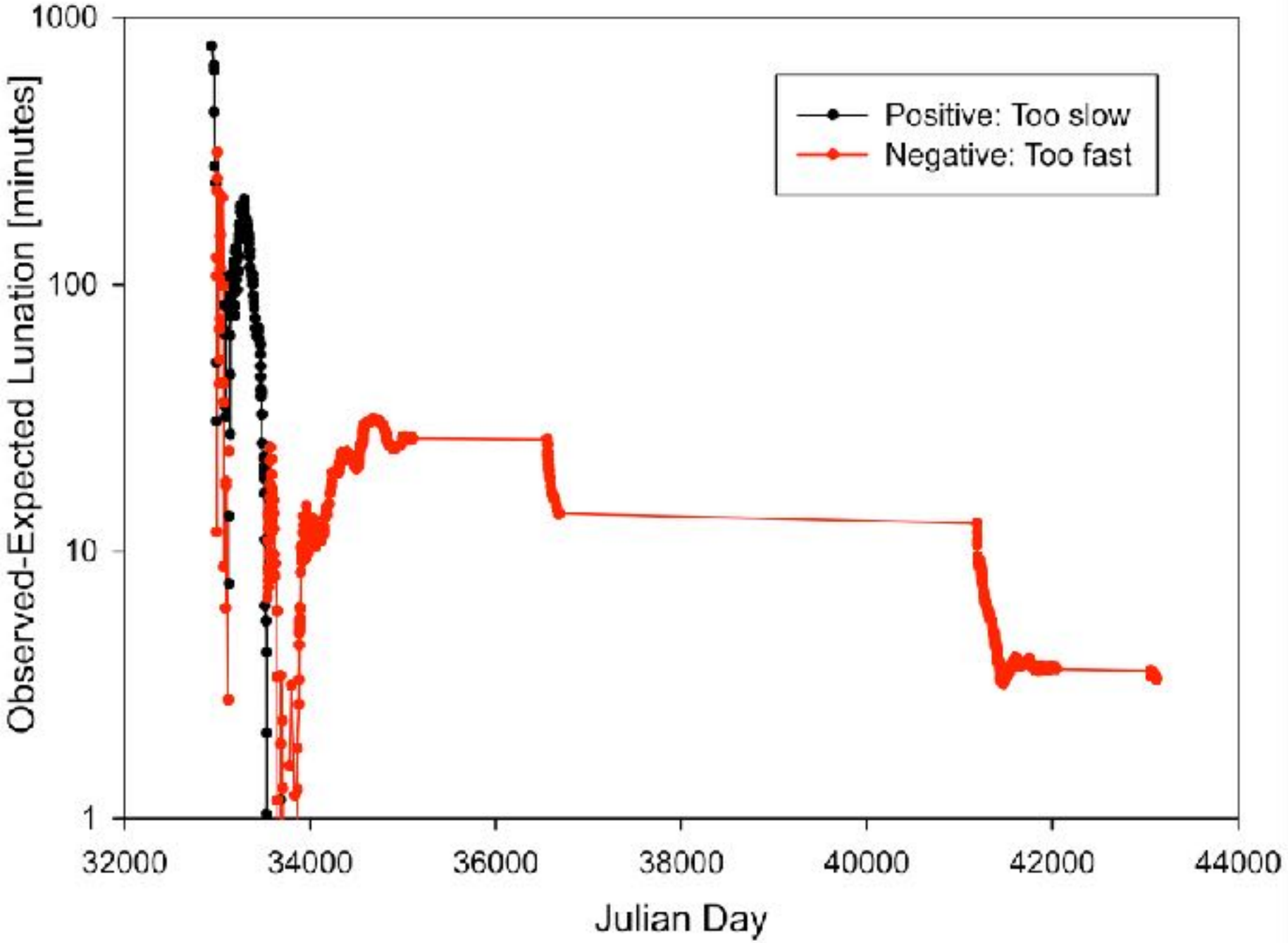
22	17
24	24
25	28
27	37

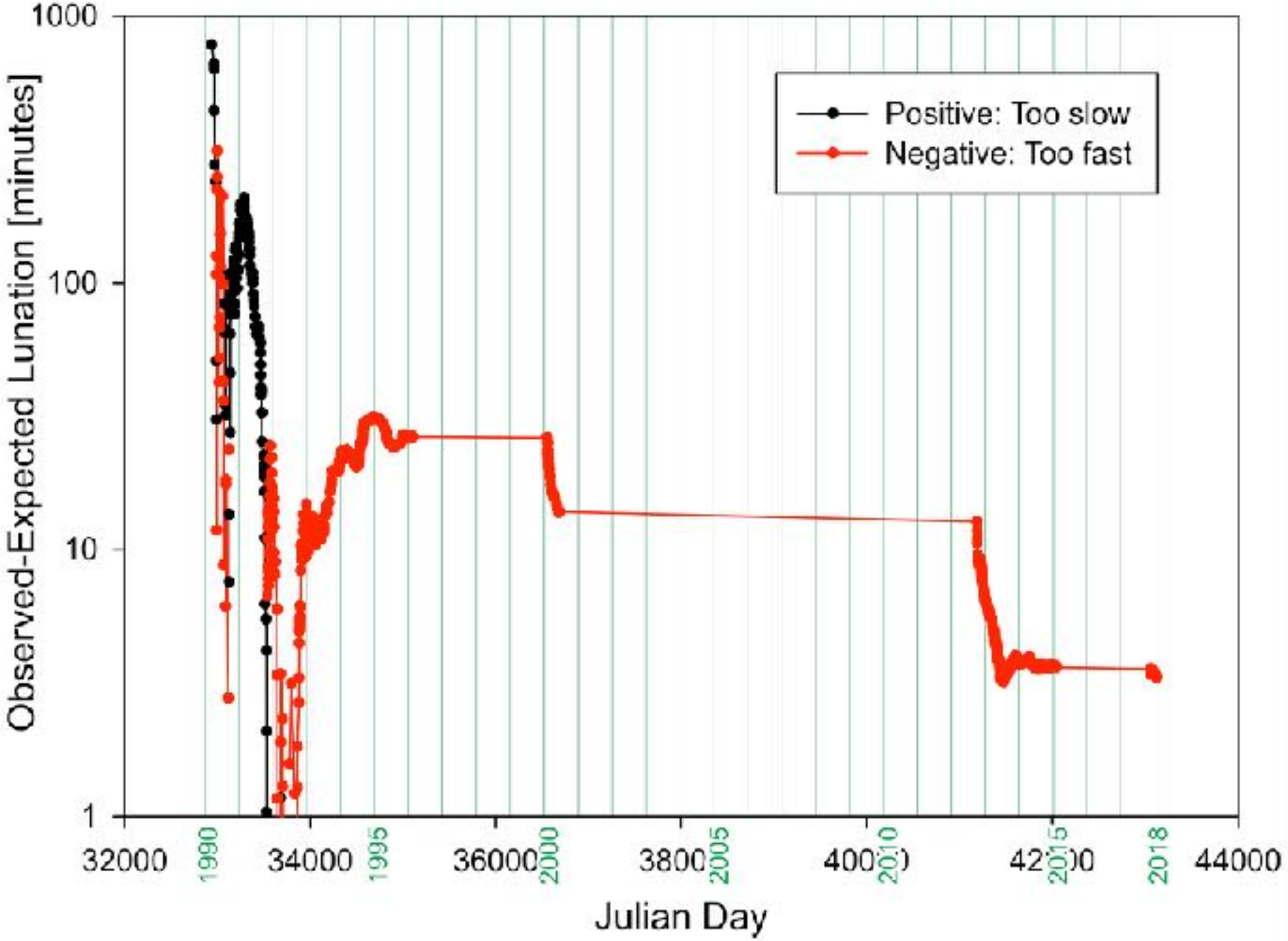

10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
Lunation+Phase [%]
32000
34000
36000
38000
40000
42000
44000
Julian Day
1990-02-10 (lunar eclipse)
1996-02-15
2000-01-31
2000-06-08
2012-10-05
2015-02-13
2017-11-20
2018-01-27

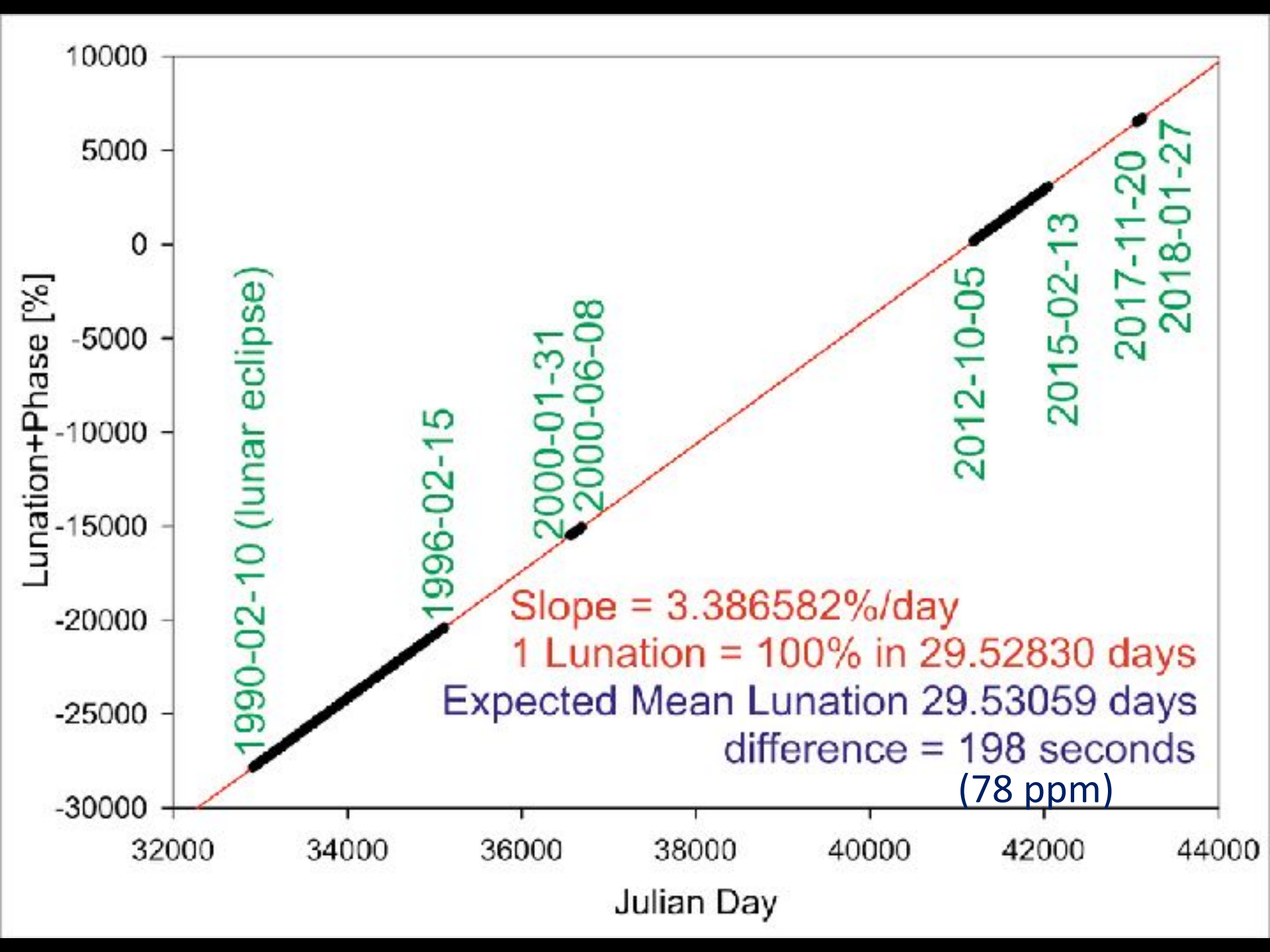

Number of Observations
120
100
80
60
40
20
0
January
Febrary
March
April
May
June
July
August
September
October
November
December
Month


10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
Lunation+Phase [%]
32000
34000
36000
38000
40000
42000
44000
Julian Day
1990-02-10 (lunar eclipse)
1996-02-15
2000-01-31
2000-06-08
2012-10-05
2015-02-13
2017-11-20
2018-01-27
Slope = 3.386582%/day
1 Lunation = 100% in 29.52830 days

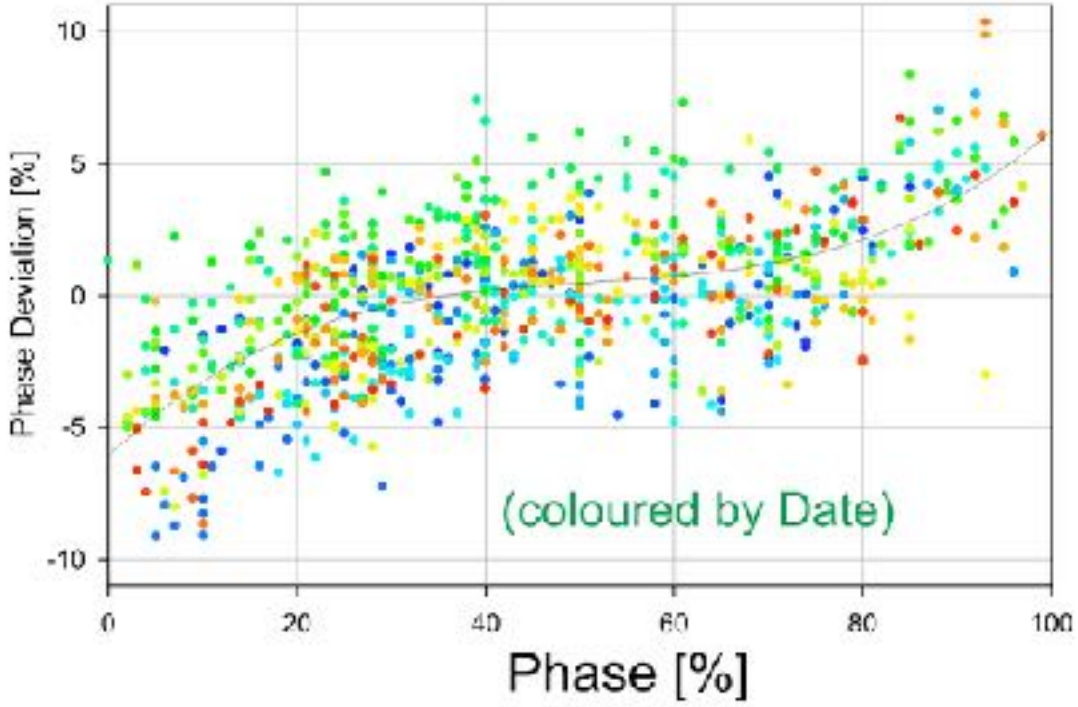

10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
Lunation+Phase [%]
32000
34000
36000
38000
40000
42000
44000
Julian Day
1990-02-10 (lunar eclipse)
1996-02-15
2000-01-31
2000-06-08
2012-10-05
2015-02-13
2017-11-20
2018-01-27
Slope = 3.386582%/day
1 Lunation = 100% in 29.52830 days
Expected Mean Lunation 29.53059 days
difference = 198 seconds
(78 ppm)

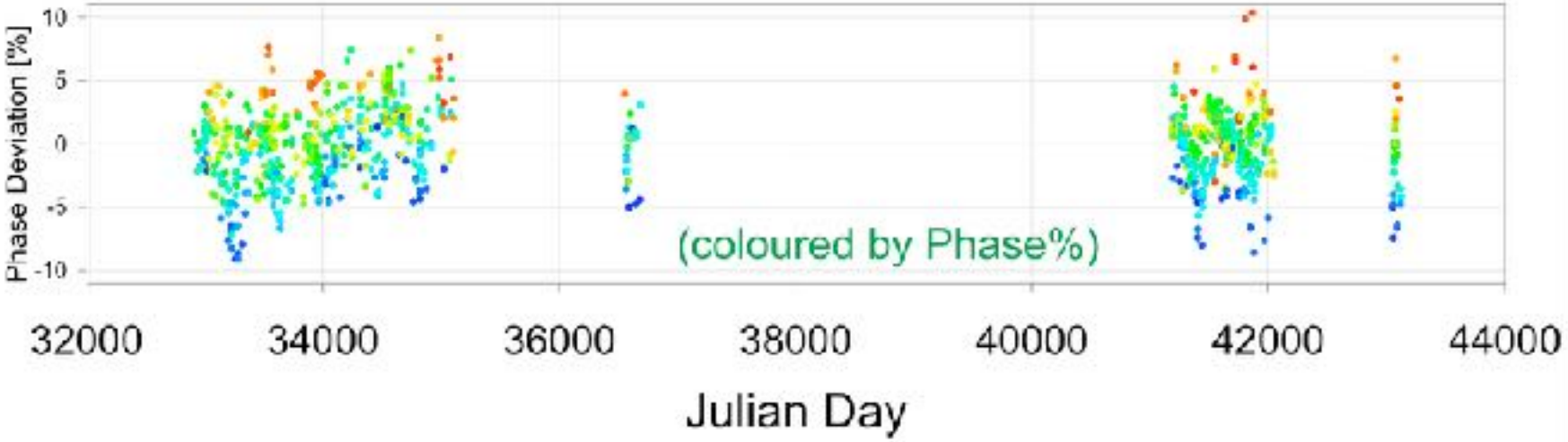

1000
100
10
1
Observed-Expected Lunation [minutes]
Positive: Too slow
Negative: Too fast
32000
34000
36000
38000
40000
42000
44000
Julian Day

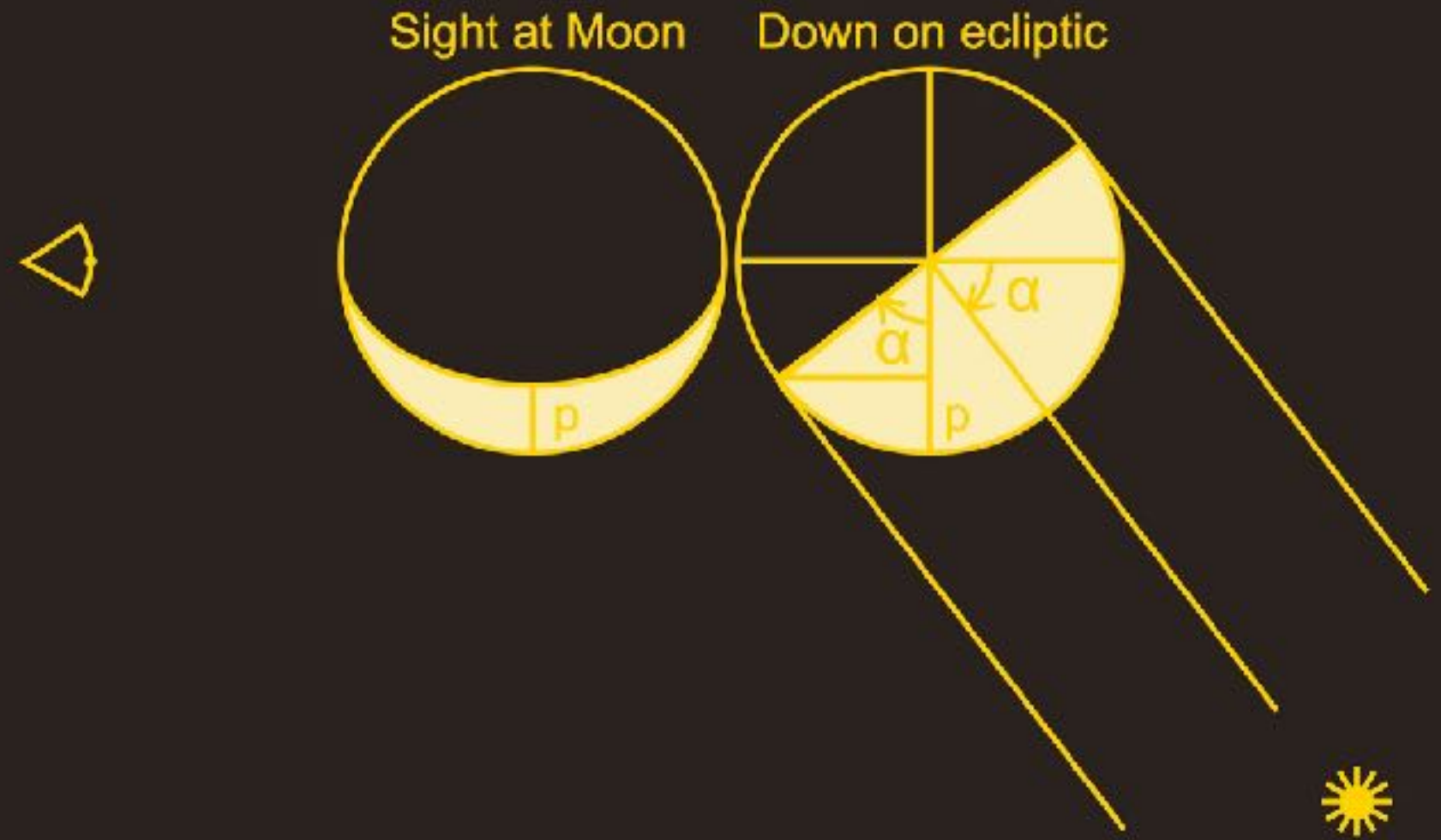

1000
100
10
1
Observed-Expected Lunation [minutes]
Positive: Too slow
Negative: Too fast
32000
1990
34000
1995
36000
2000
3800
2005
400
2010
42
2015
2018
44000
Julian Day

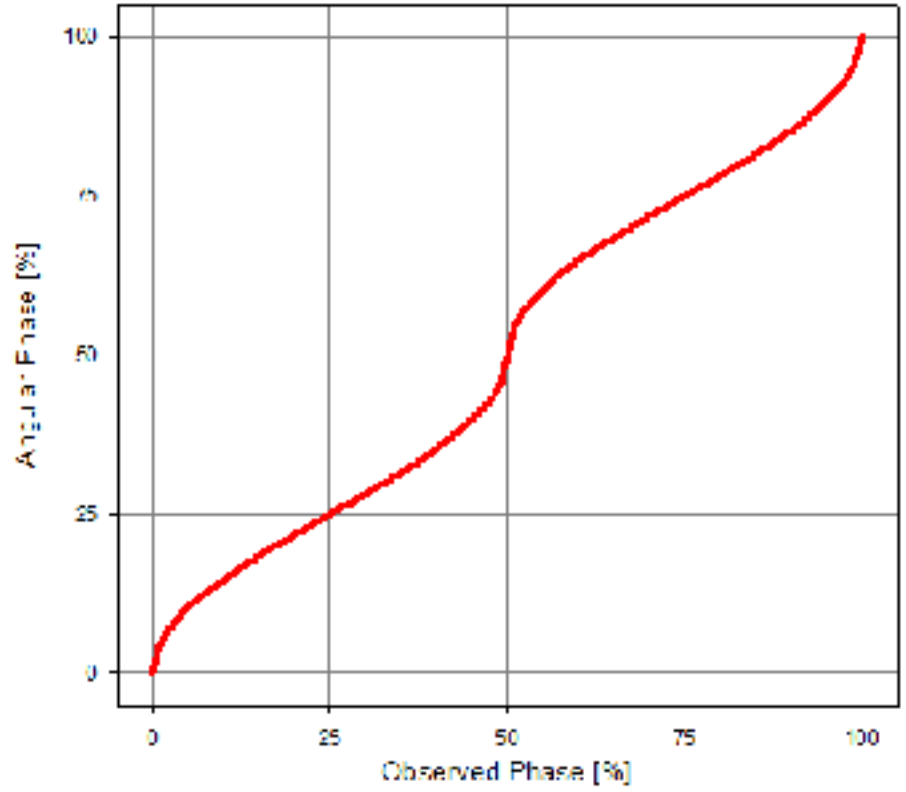

10000
5000
0
-5000
-10000
-15000
-20000
-25000
-30000
Lunation+Phase [%]
32000
34000
36000
38000
40000
42000
44000
Julian Day
1990-02-10 (lunar eclipse)
1996-02-15
2000-01-31
2000-06-08
2012-10-05
2015-02-13
2017-11-20
2018-01-27
Slope = 3.386582%/day
1 Lunation = 100% in 29.52830 days
Expected Mean Lunation 29.53059 days
difference = 198 seconds
(78 ppm)

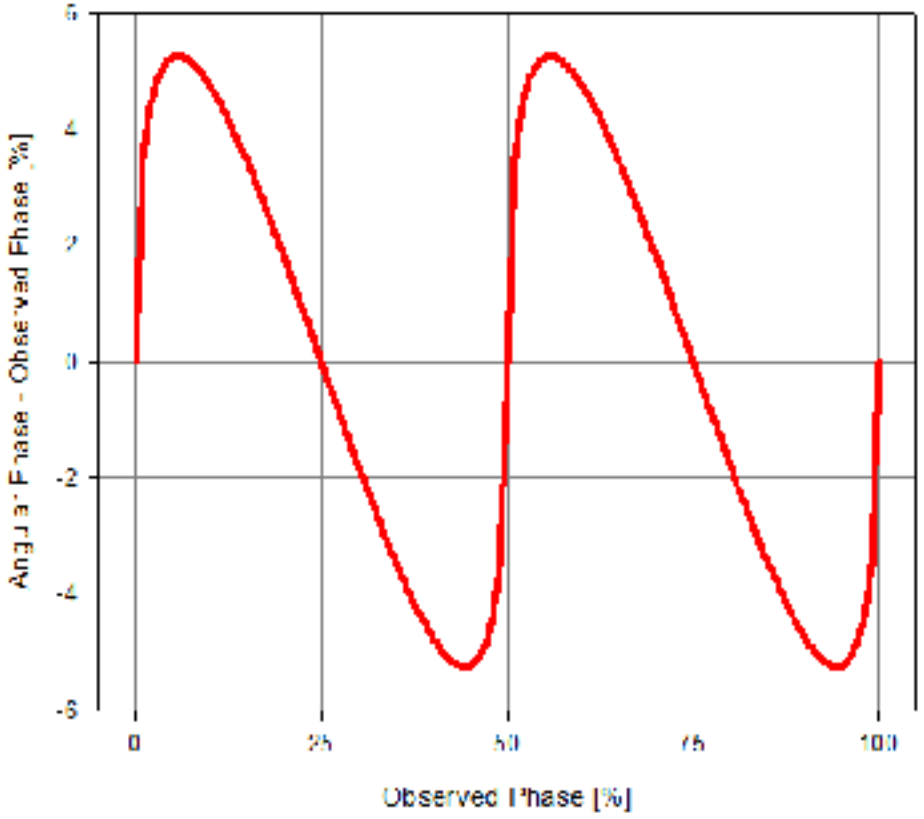
The deviations from the straight line fit are even more interesting!

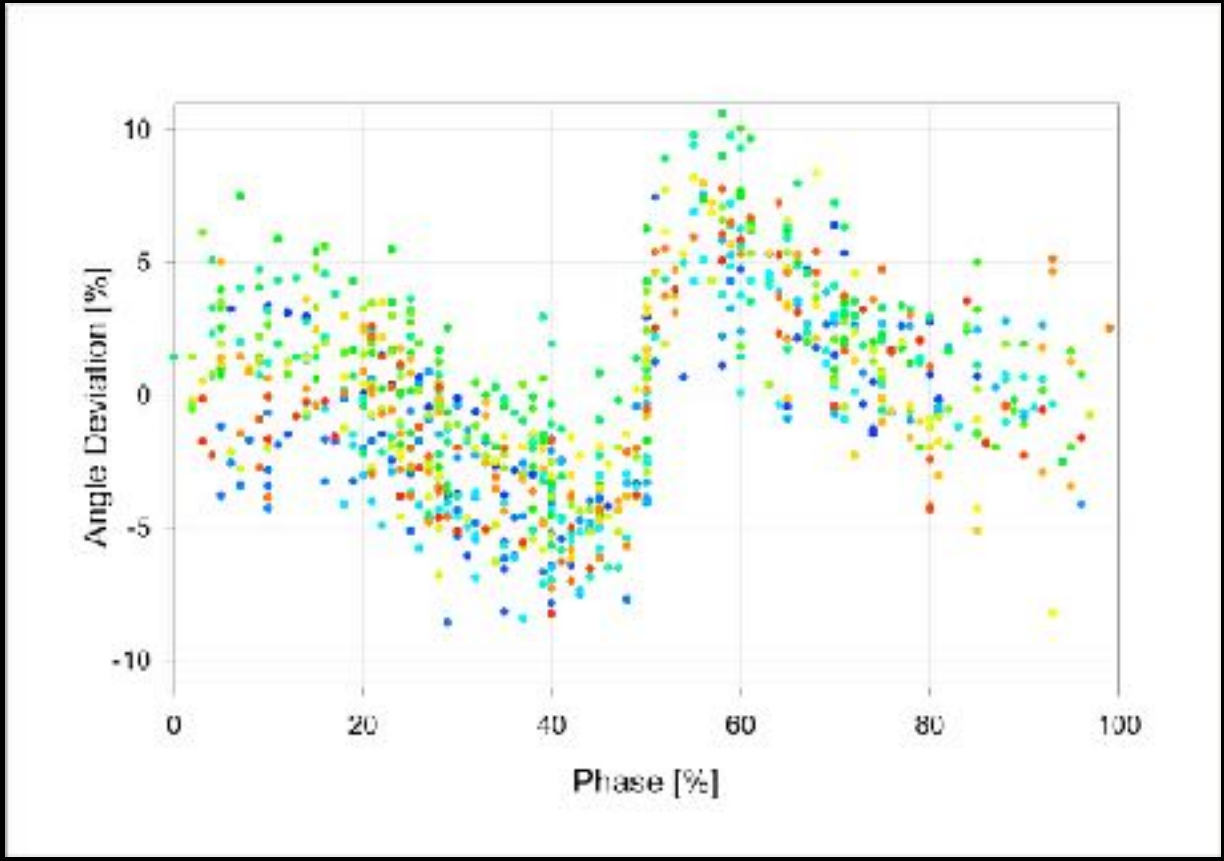




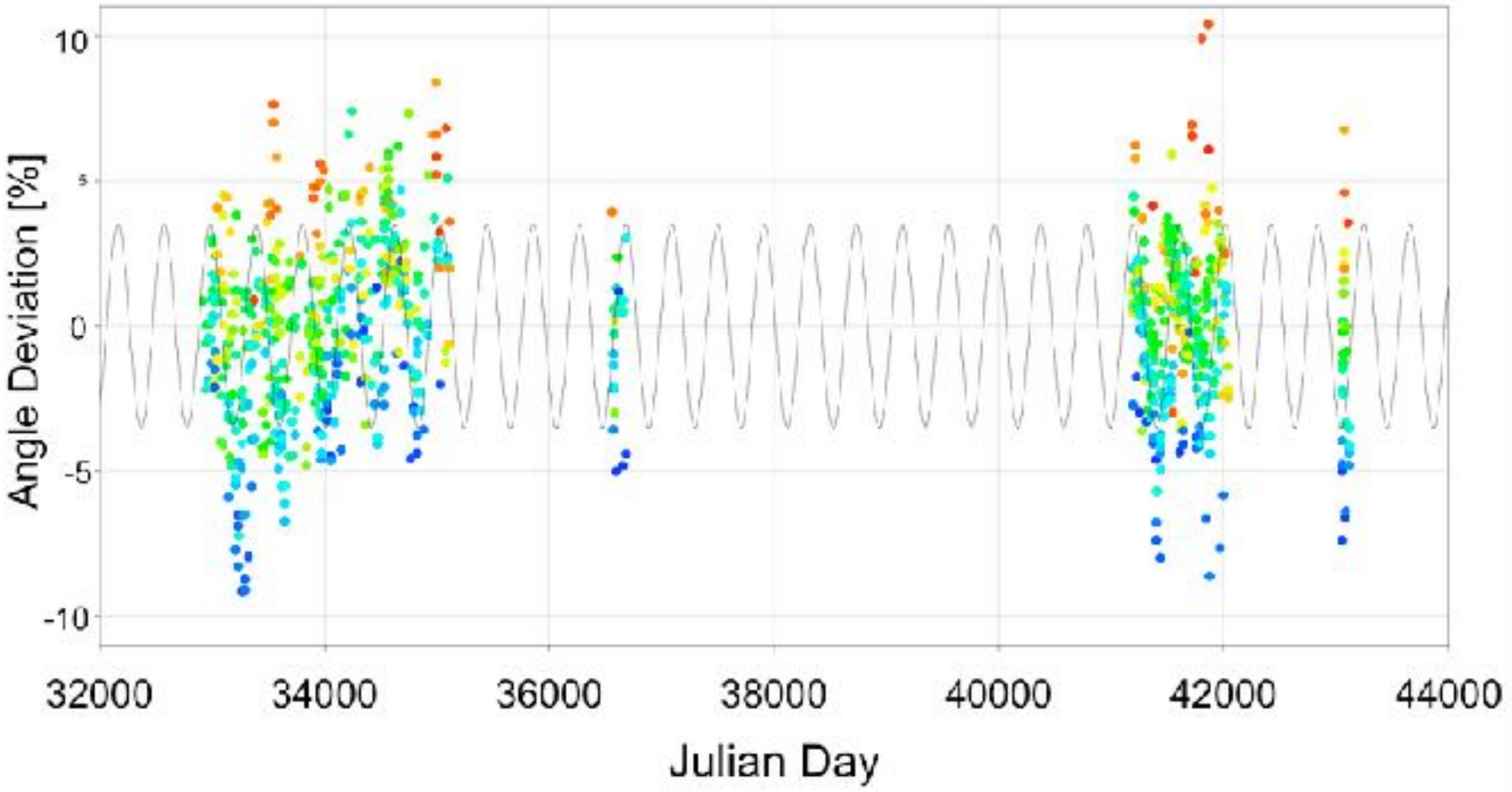

Sight at Moon
Down on ecliptic
p
α
α
p


100
50
25
0
0
25
50
75
100
Observed Phase [%]


4
2
0
-2
-4
-6
0
25
50
75
100
Observed Phase [%]



Clearly, the geometric manipulation does not explain the monthly variation


10
5
0
-5
-10
Angle Deviation [%]
32000
34000
36000
38000
40000
42000
44000
Julian Day

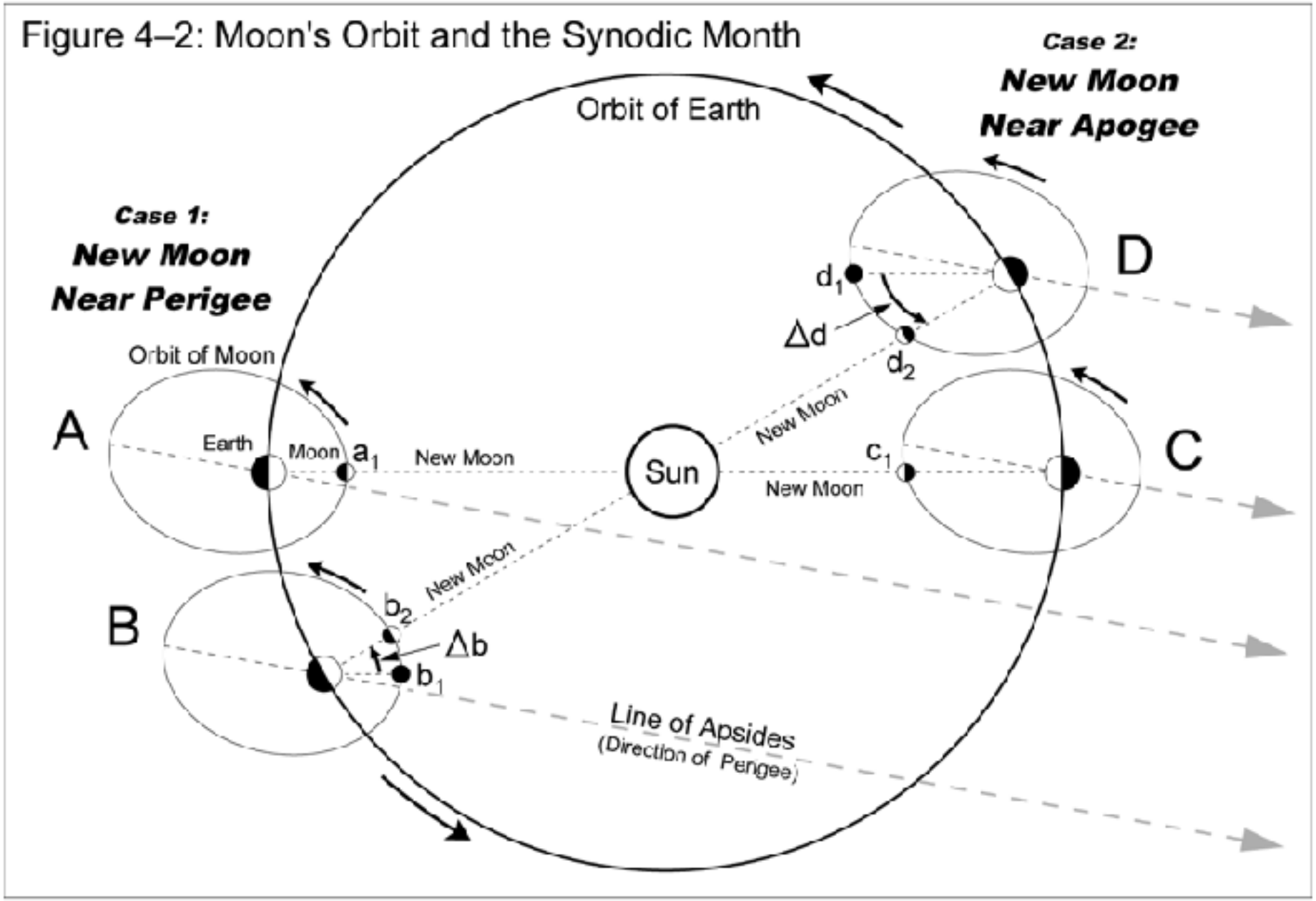
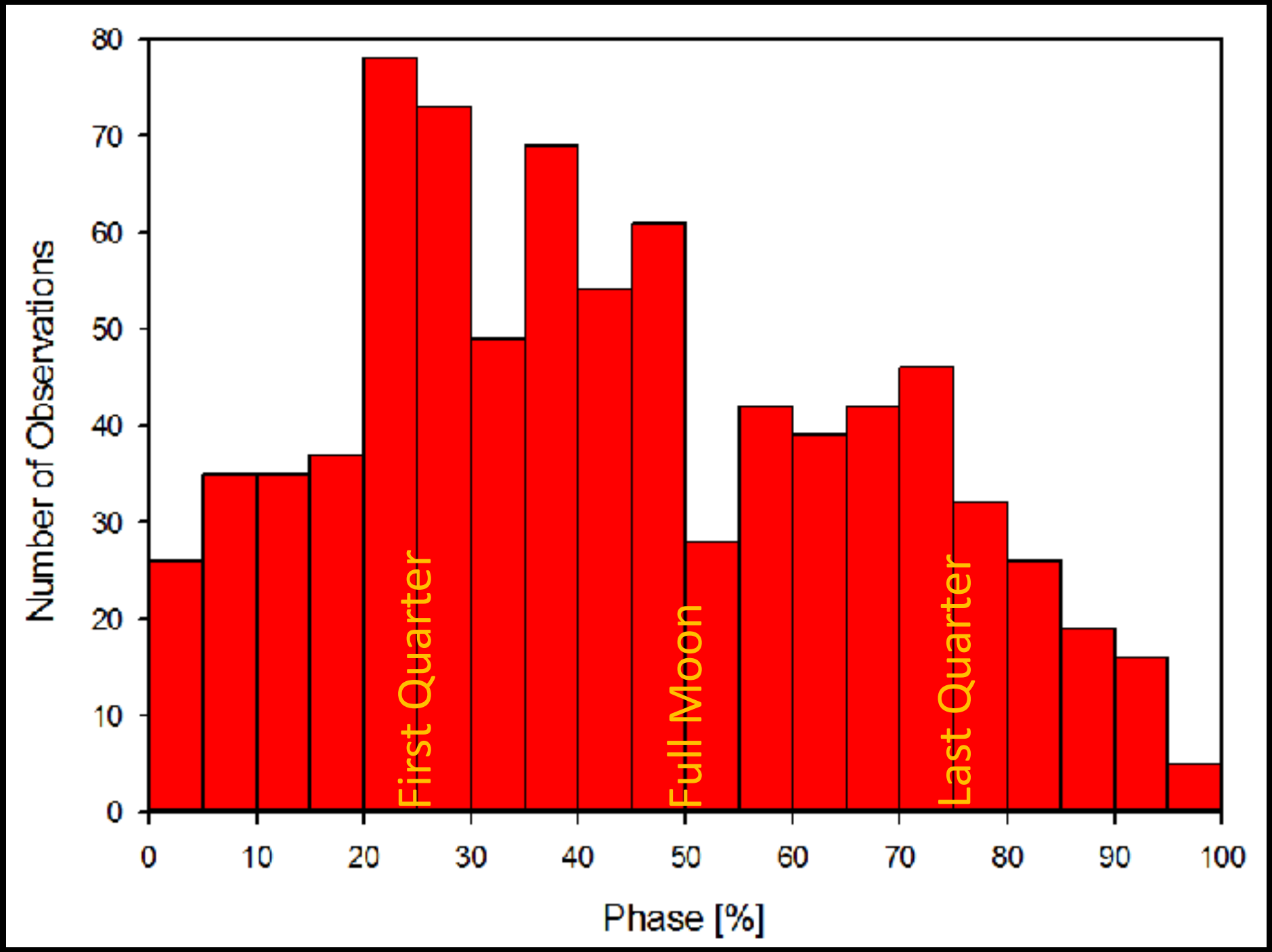


Figure 4–2: Moon's Orbit and the Synodic Month
Case 2:
New Moon
Near Apogee
Orbit of Earth
Case 1:
New Moon
Near Perigee
D
d1
Δd
d2
Orbit of Moon
A
Earth
Moon
a1
New Moon
Sun
New Moon
c1
New Moon
C
New Moon
B
b2
Δb
b1
Line of Apsides
(Direction of Perigee)


Number of Observations
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
80
90
100
Phase [%]
First Quarter
Full Moon
Last Quarter

First Quarter
Last Quarter

MonthPhase1st = -139532.7880 + 3.3863231972 juldate

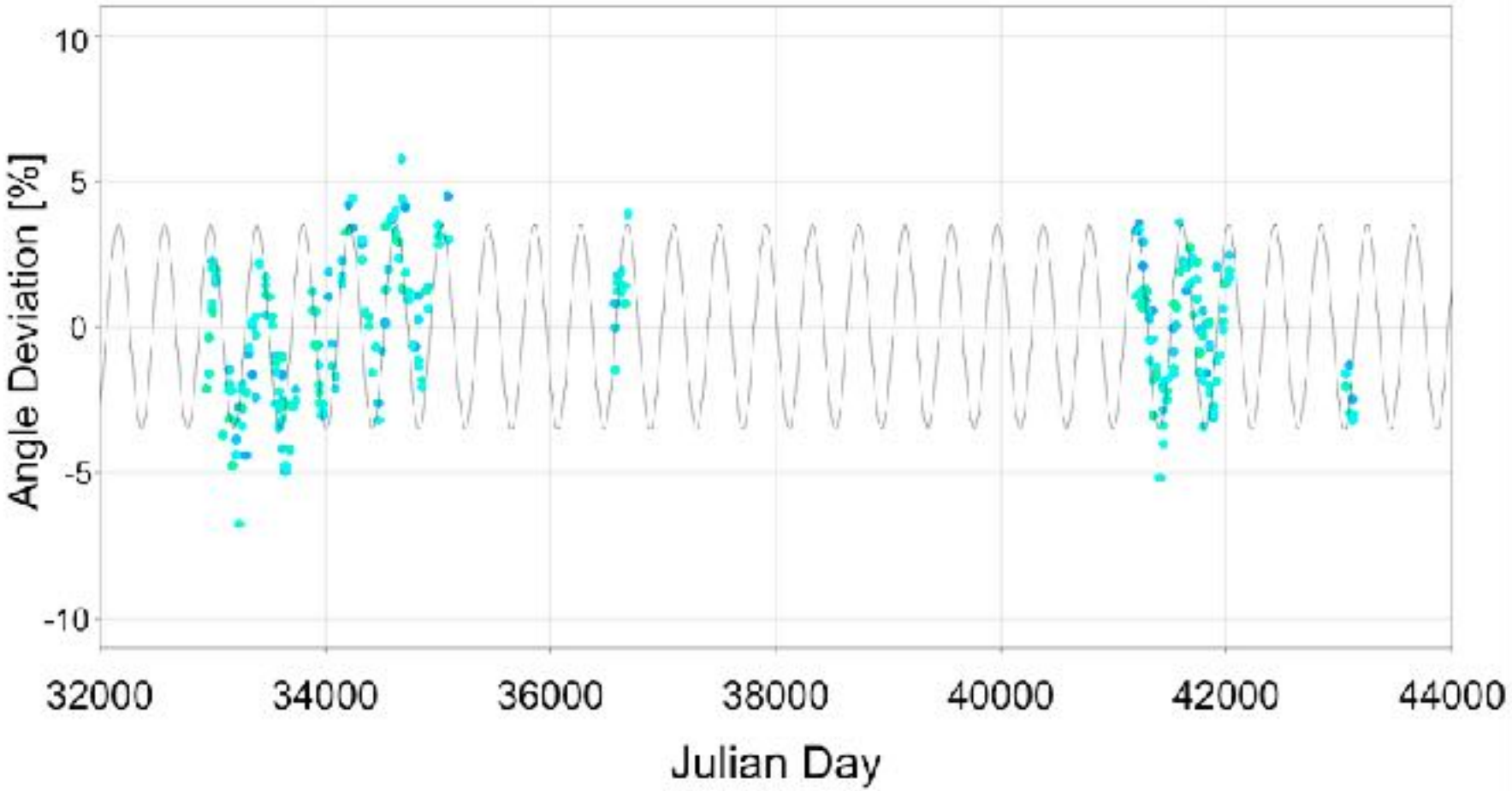
MonthPhaseLast = -139582.8064 + 3.3863230150 juldate

Lunation+Phase%

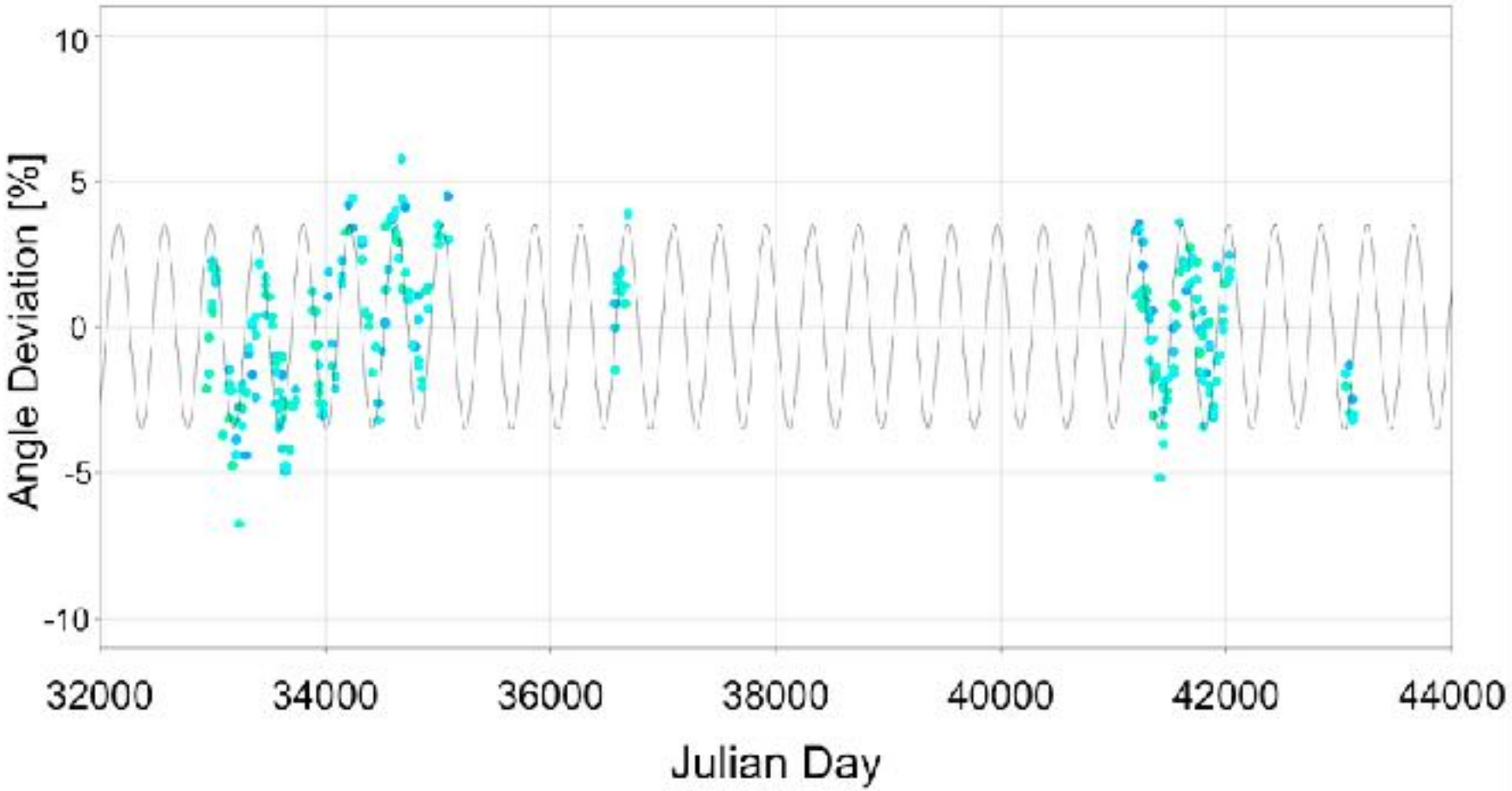
Deviation Phase from Linear Fit[%]

Julian Date

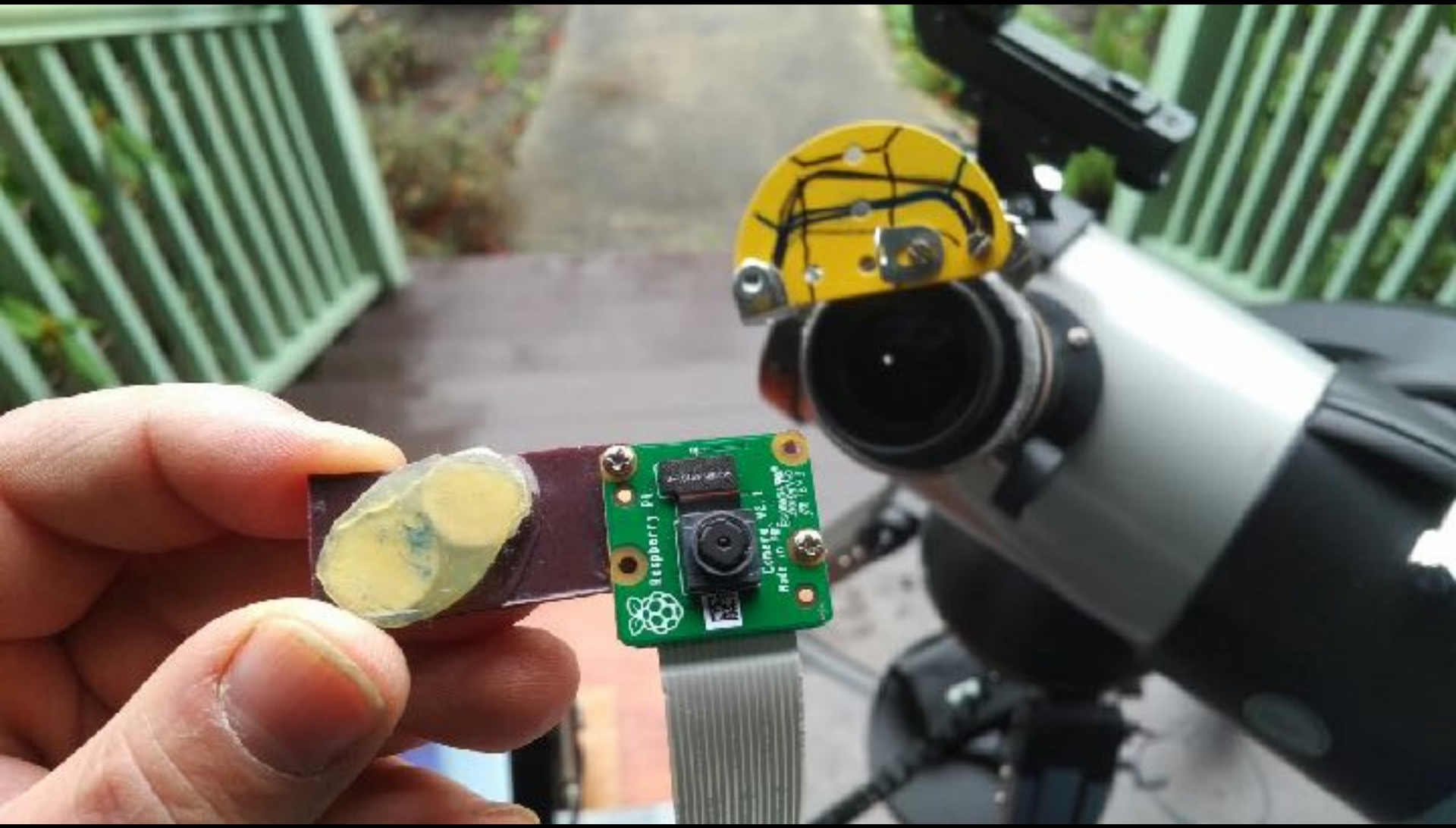
- The best data come from around the 1st Quarter
- 15% to 35%
- Best Fit Period: 411 days
- Eastward advance of the lunar orbital perigee:



- The best data come from around the 1st Quarter
- 15% to 35%
- Best Fit Period: 411 days
- Eastward advance of the lunar orbital perigee: **412 days**!



Telescope Measurements


Raspberry Pi
Camera V2.1


2017-11-23, 18:36, 12.5%


2017-11-28, 20:42, 38.2%

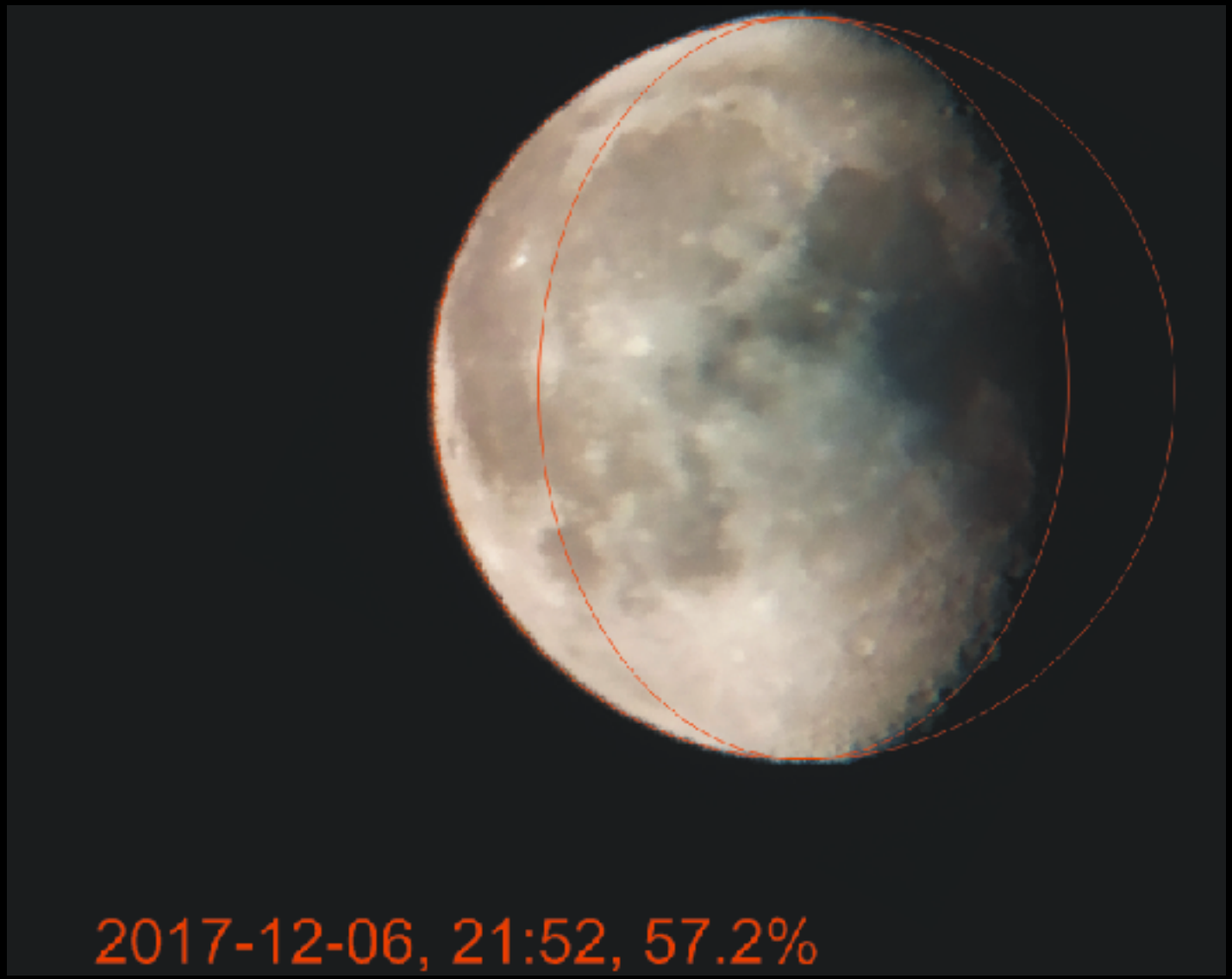

2017-11-30, 19:57, 45.2%

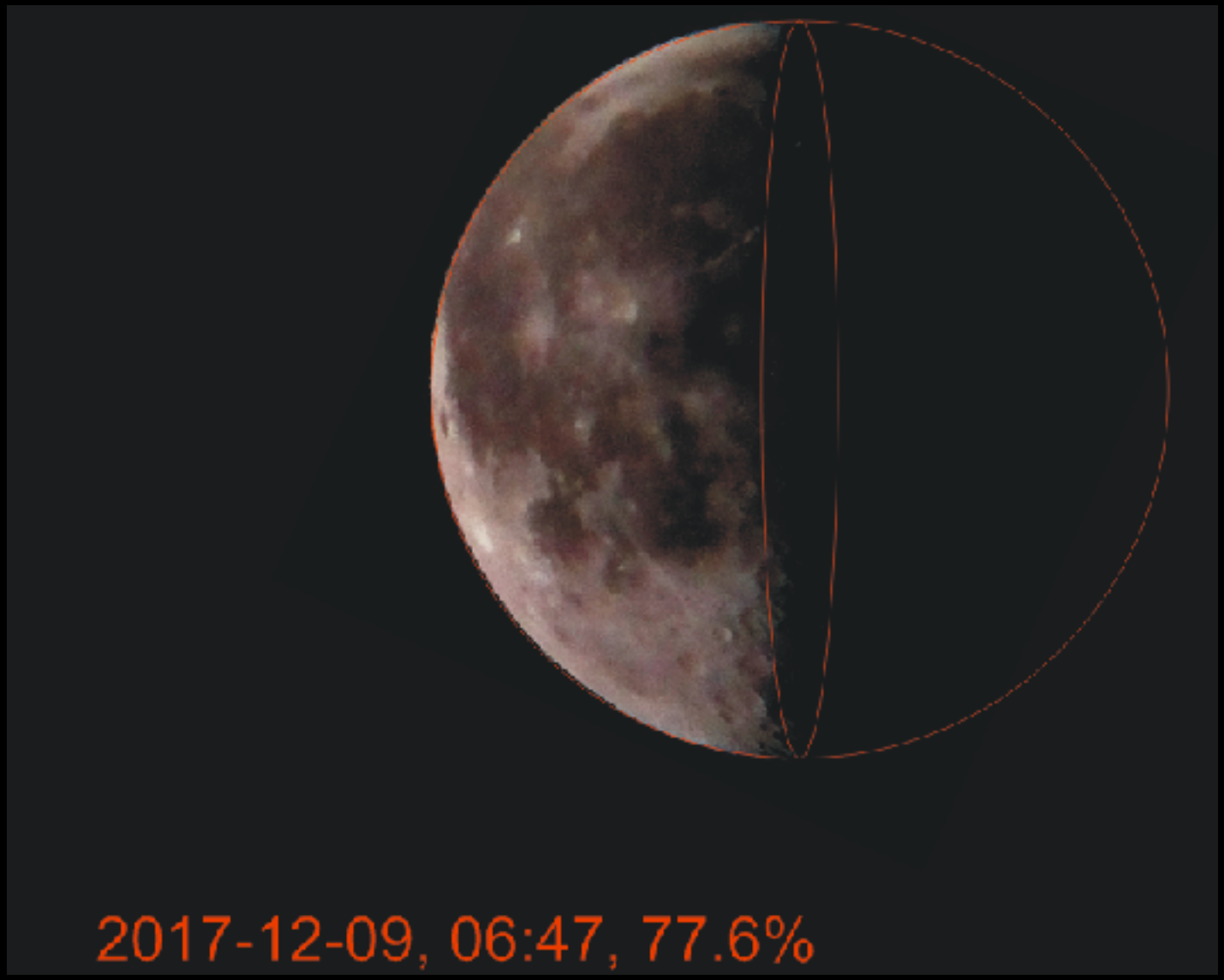

2017-12-02, 23:59, 49.7%


2017-12-03, 19:29, 51.0%


2017-12-04, 20:21, 52.3%


2017-12-05, 20:40, 54.6%


2017-12-06, 21:52, 57.2%


2017-12-09, 06:47, 77.6%

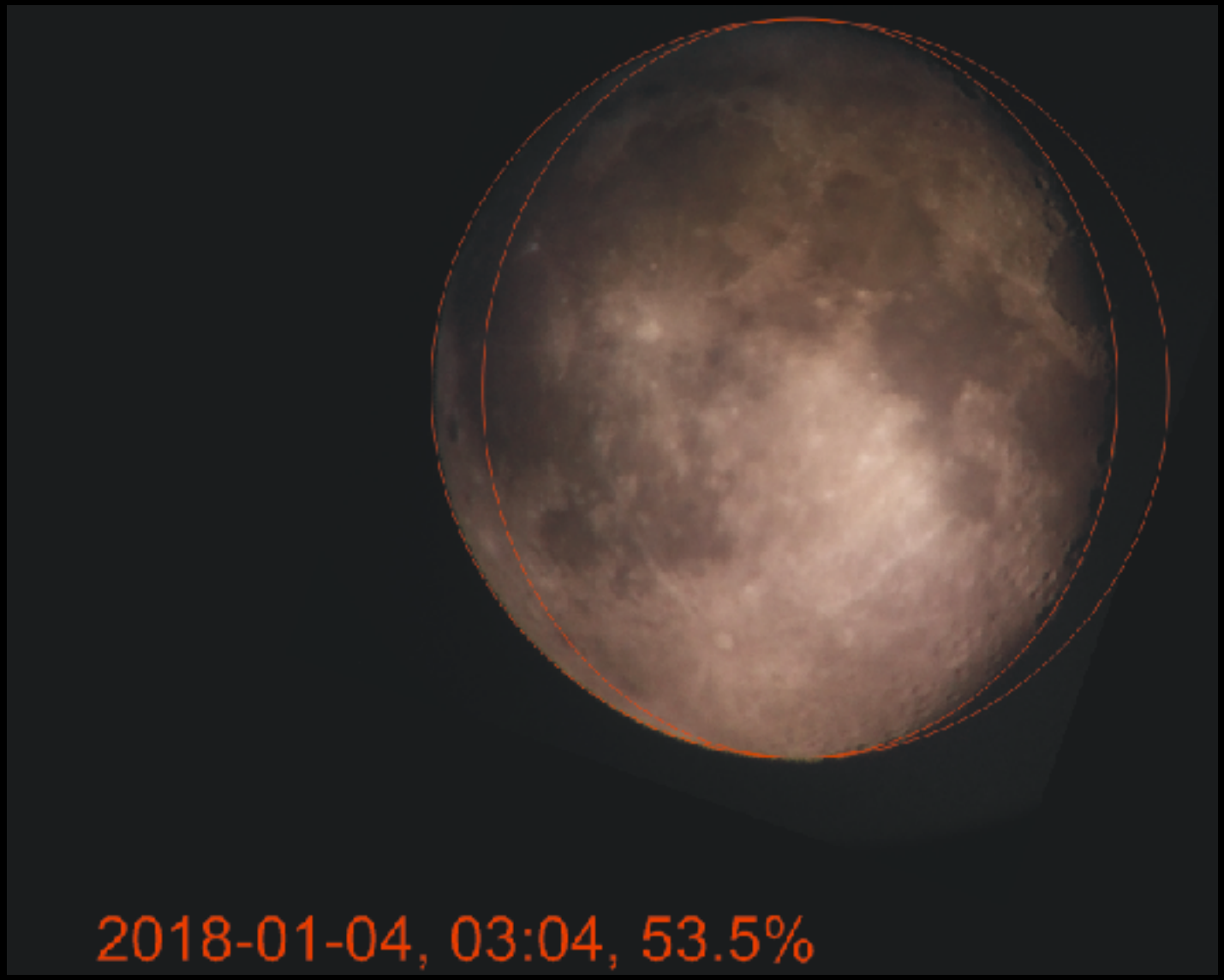

2017-12-11, 06:46, 84.9%

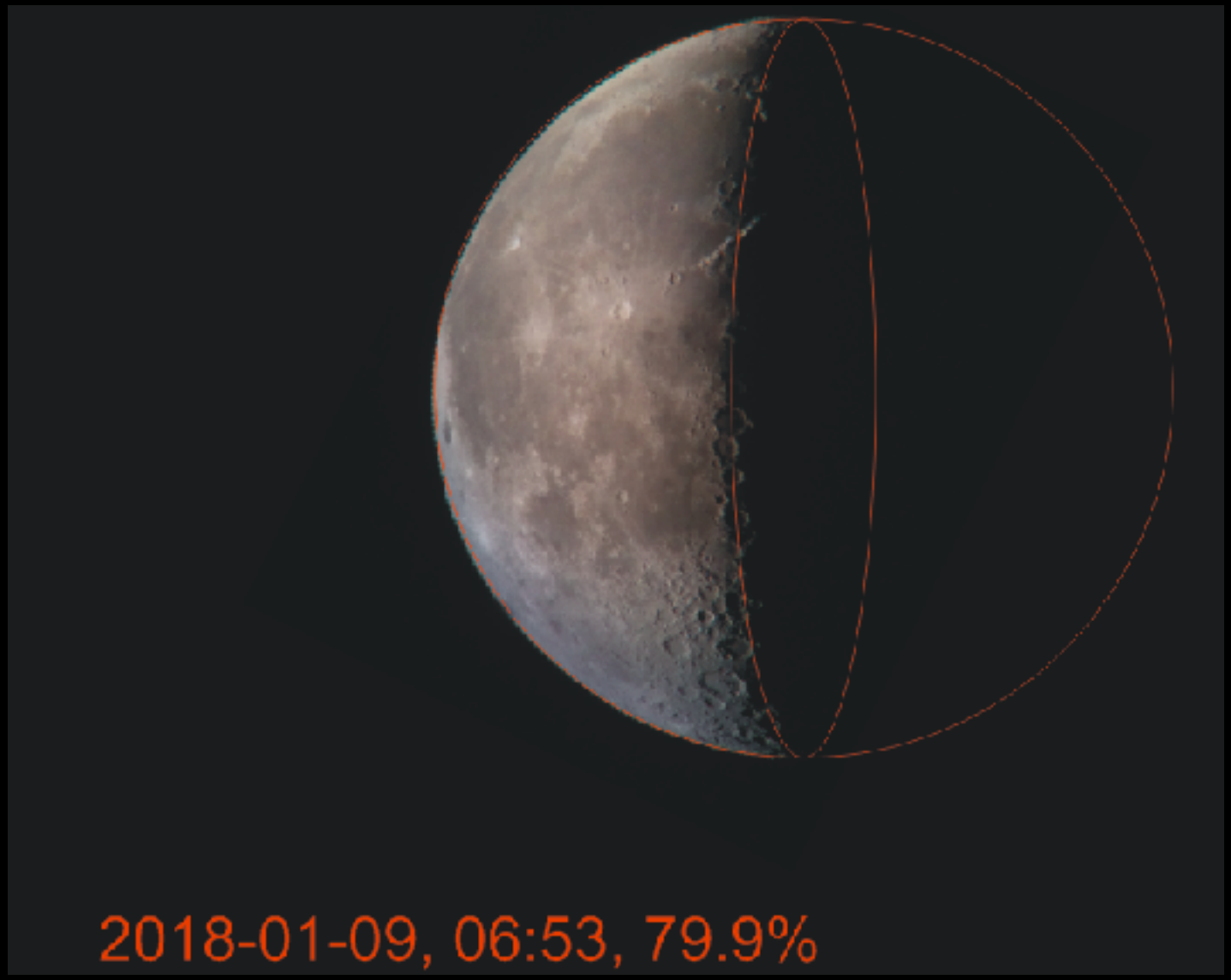

2017-12-13, 06:55, 92.1%

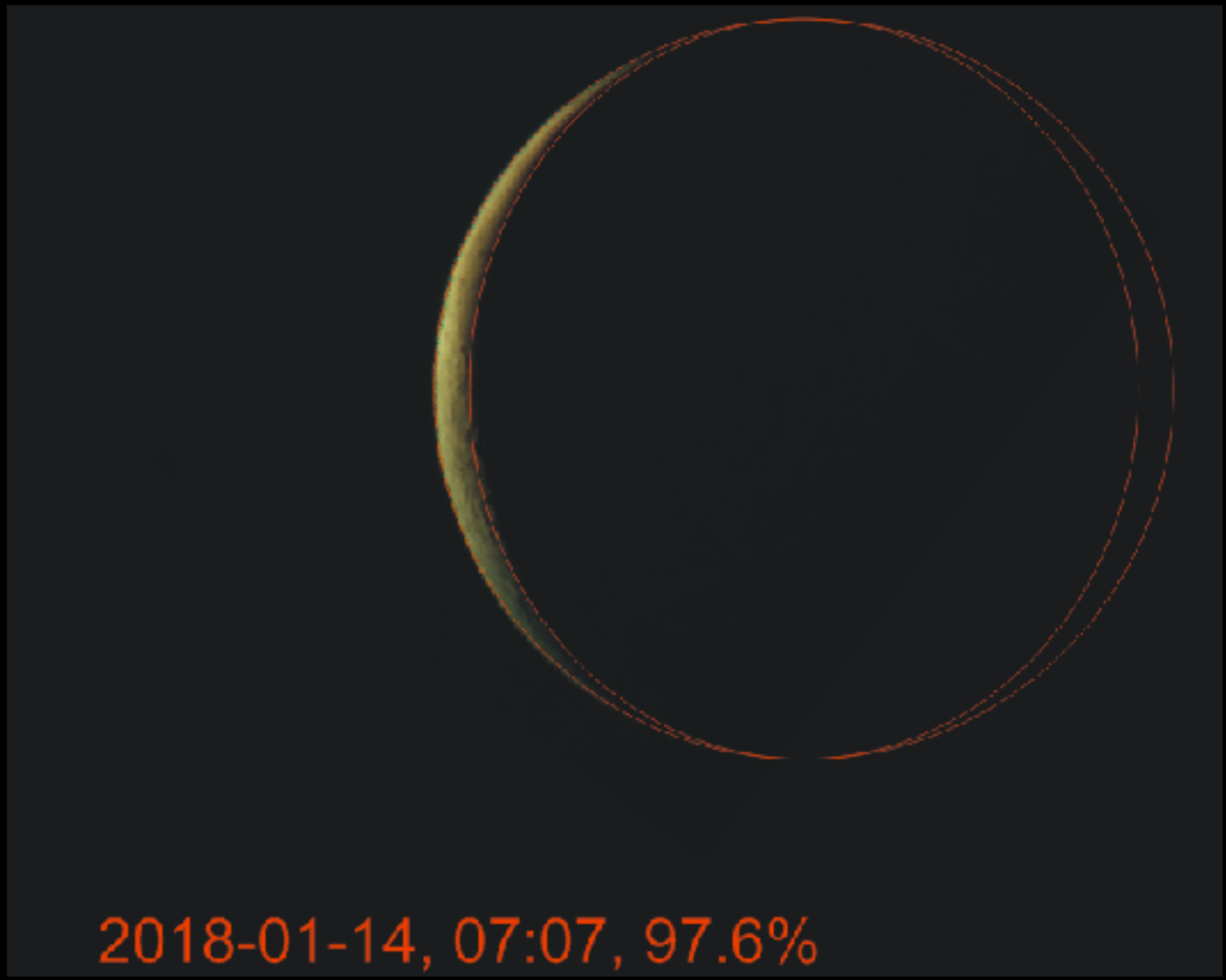

2017-12-23, 17:06, 13.5%

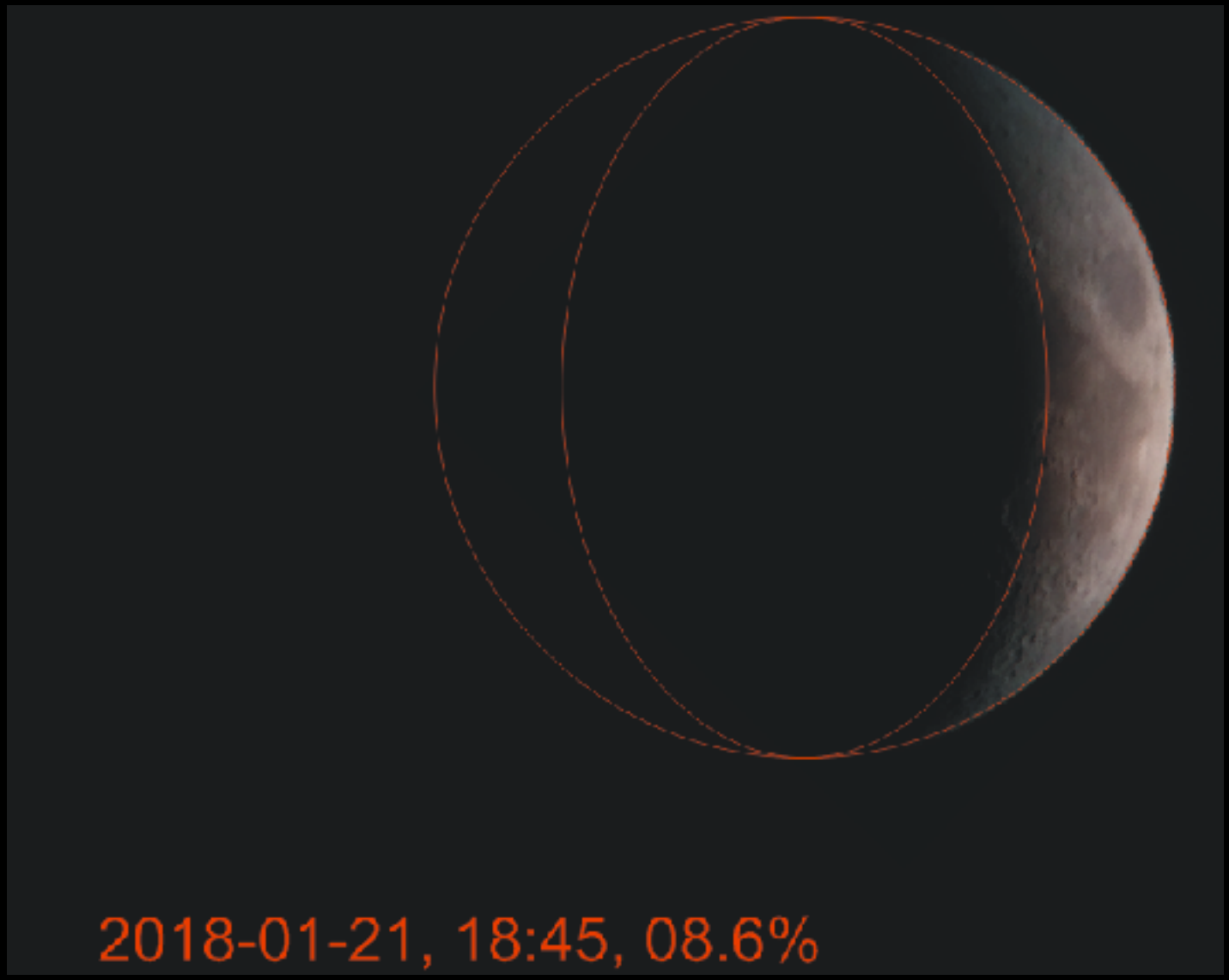

2017-12-31, 21:26, 49.2%

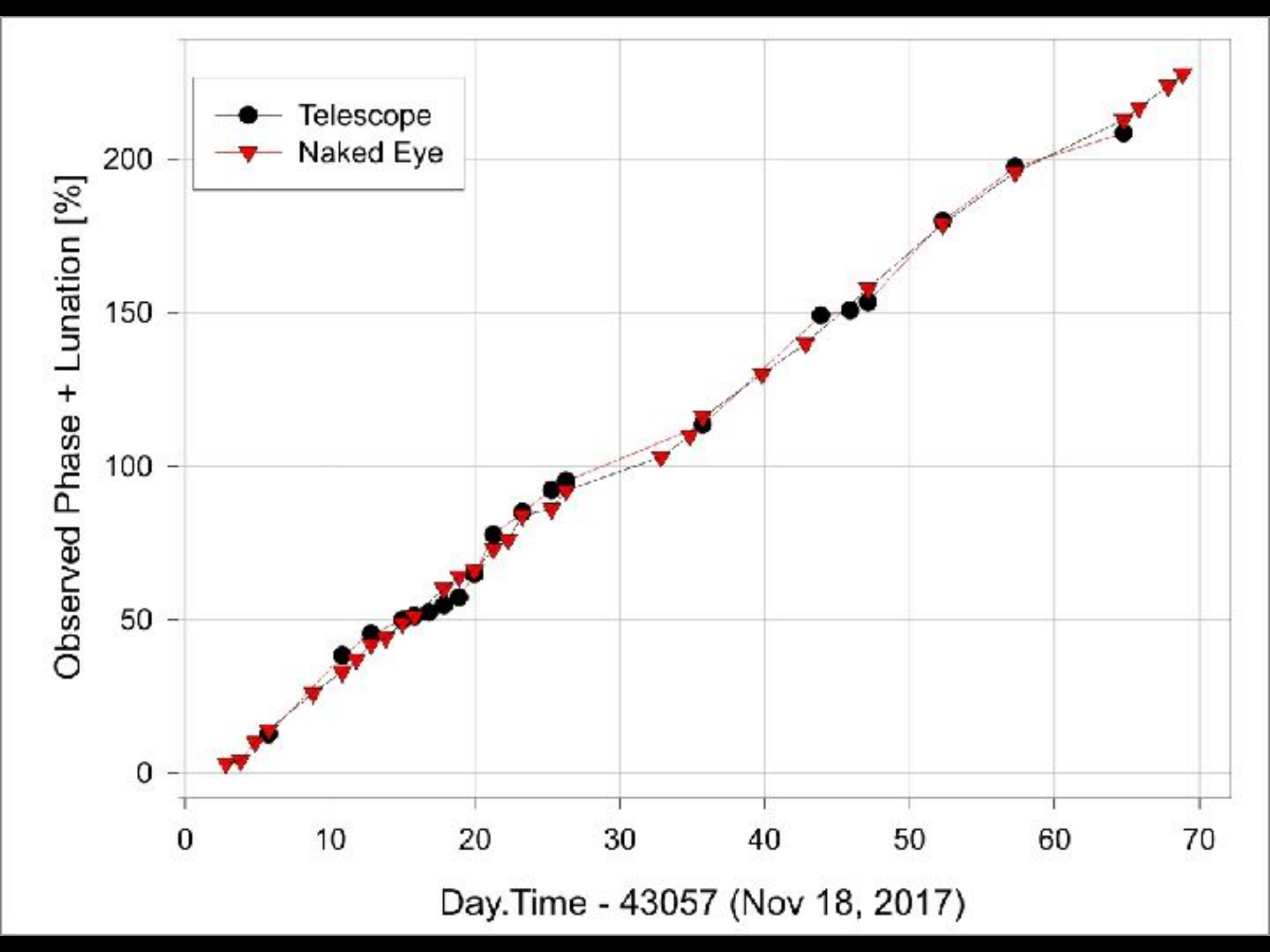

2018-01-02, 21:50, 51.8%


2018-01-04, 03:04, 53.5%

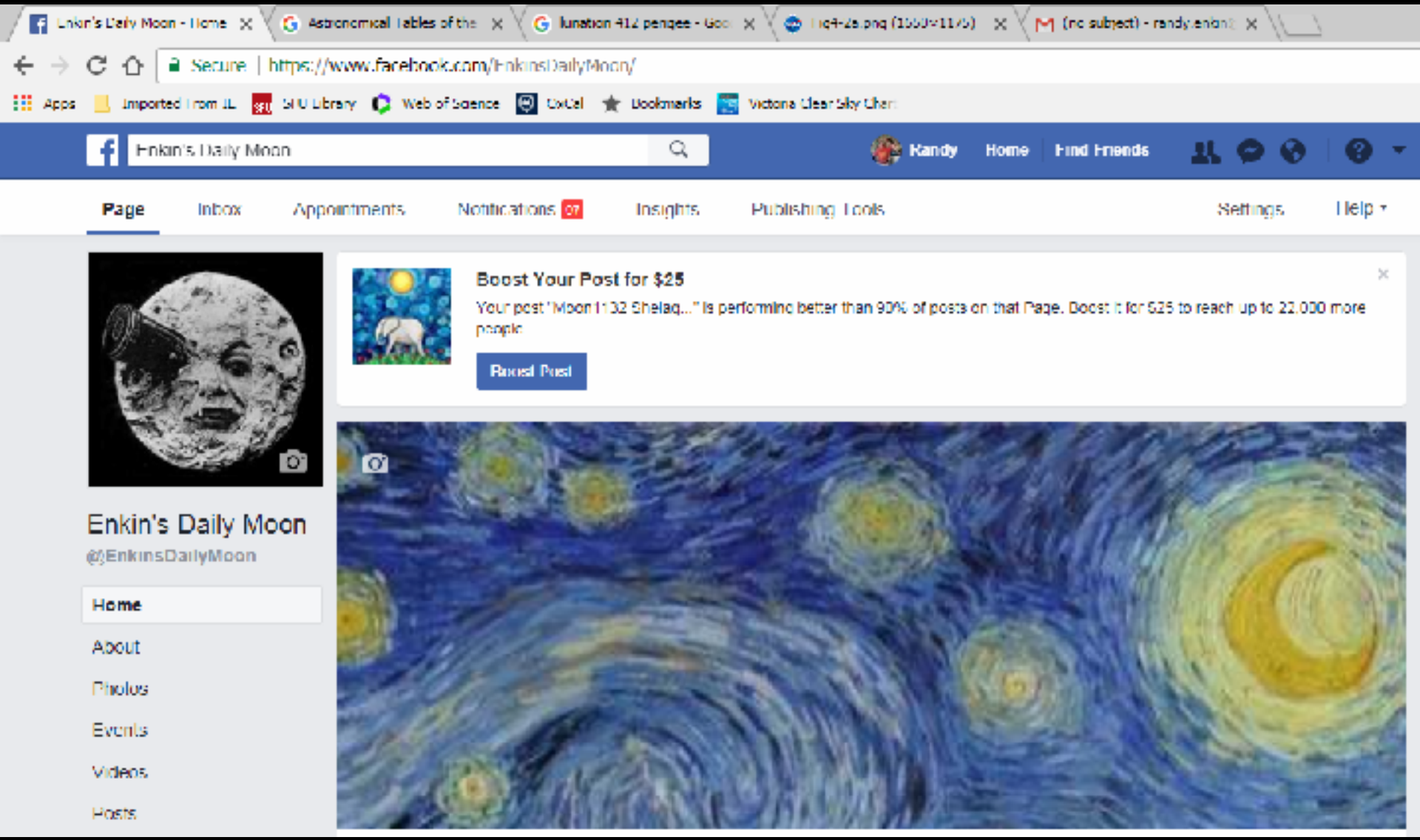

2018-01-09, 06:53, 79.9%


2018-01-14, 07:07, 97.6%


2018-01-21, 18:45, 08.6%


Telescope
Naked Eye
Observed Phase + Lunation [%]
0
50
100
150
200
0
10
20
30
40
50
60
70
Day.Time - 43057 (Nov 18, 2017)

https://www.facebook.com/EnkinsDailyMoon/



"The moon represents the passage of time, illumination, the feminine, and world unity. I have been posting a daily moon since August 2014."

https://www.facebook.com/EnkinsDailyMoon/

Video - The Phases of the Moon

Thank-You and Clear Skies

randy.enkin@gmail.com

https://www.facebook.com/EnkinsDailyMoon