Data Analysis Bootcamp
Final Project

by Laura Russell

Problem Statement

My main aim was to to visualise the light curve that our Sun would produce from the perspective of TRAPPIST-1 Solar system; where we discovered exoplanets similar to our own.

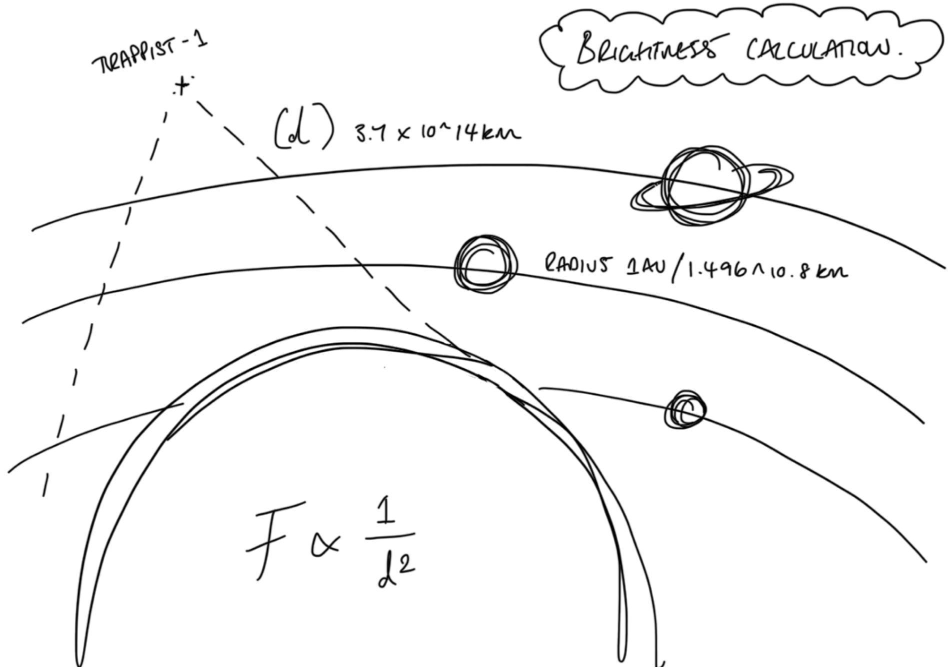
Asking hypothetically if they had a NASA, what their data would show about us?

A light curve, is a model that measures how bright a star appears over time;

Part of the reason we discovered exoplanets aound TRAPPIST-1 was down to us noticing variation in it’s brightness, caused by those planets passing in front and therefore dimming the light.

So I would need to track when planets crossed in between our Sun and TRAPPIST-1 system. This meant locating TRAPPIST-1 in our sky,

in the constellation of **Aquarius**

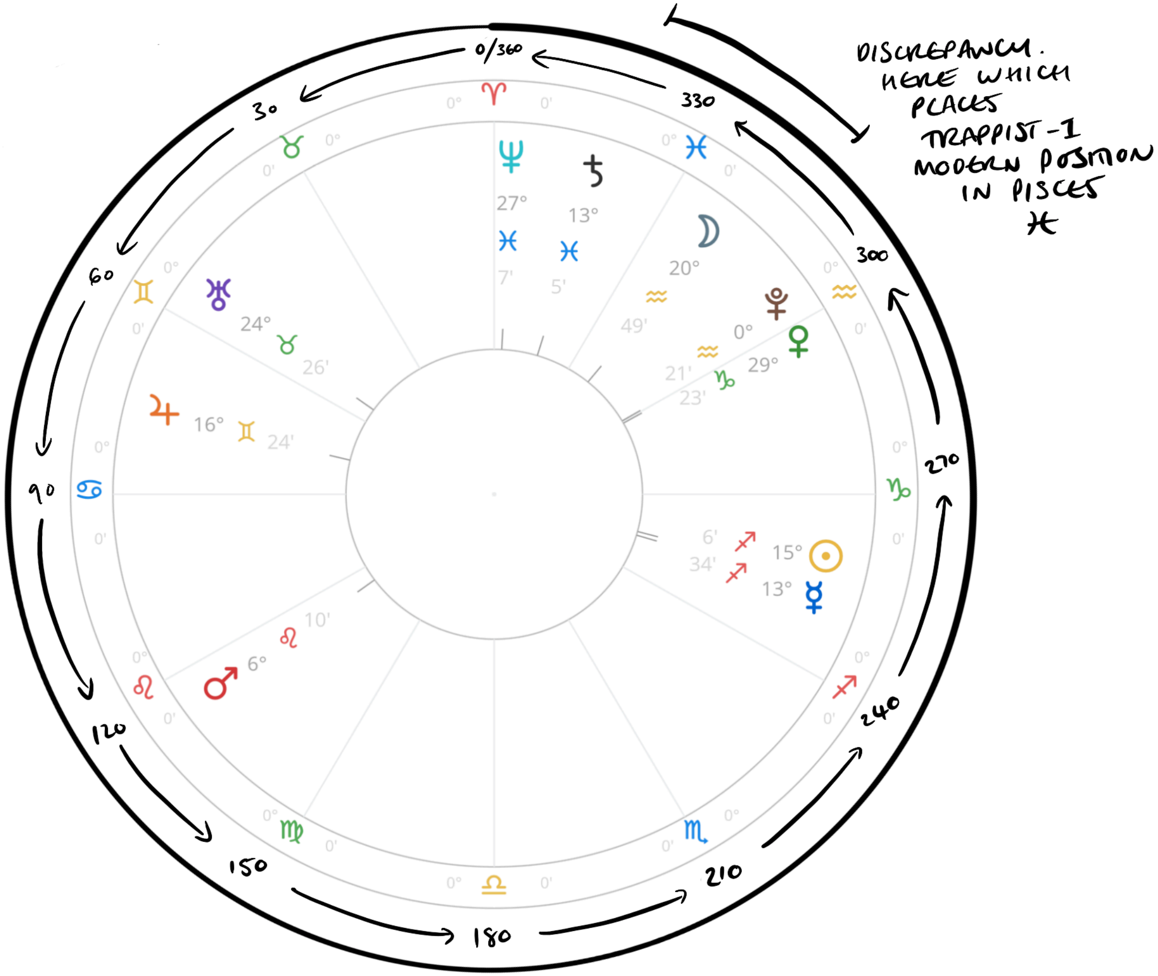


To find this position I initially worked from an Astrological Ephemeris;
A dataset that logs the positions of the planets each day

Ancient astrologers took the 360° ecliptic band around the earth and split it into 12, 30 degree segments, to divide the sky roughly by constellations.

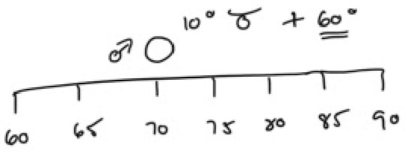
These positions are given as:

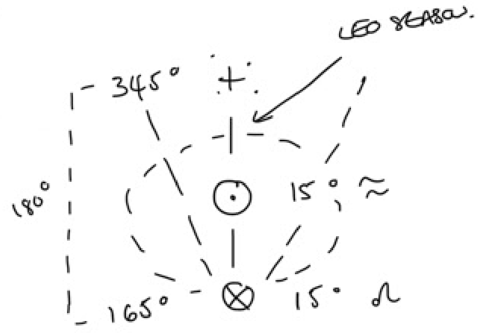
Mars at 6°10’ degrees/seconds of Leo



(VERNAL EQUINOX 0°)

ARIES	30°
TAURUS	60°
GEMINI	90°
CANCER	120°
LEO	150°
VIRGO	180°
LIBRA	210°
SCORPIO	240°
SAGITTARIUS	270°
CAPRICORN	300°
AQUARIUS	330°
PISCES	360°





flux 0.0 → 1.0%

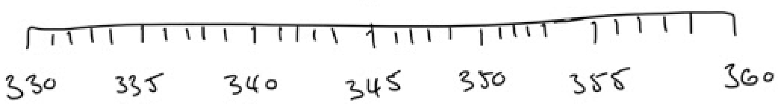
(365 / 2 = 182)

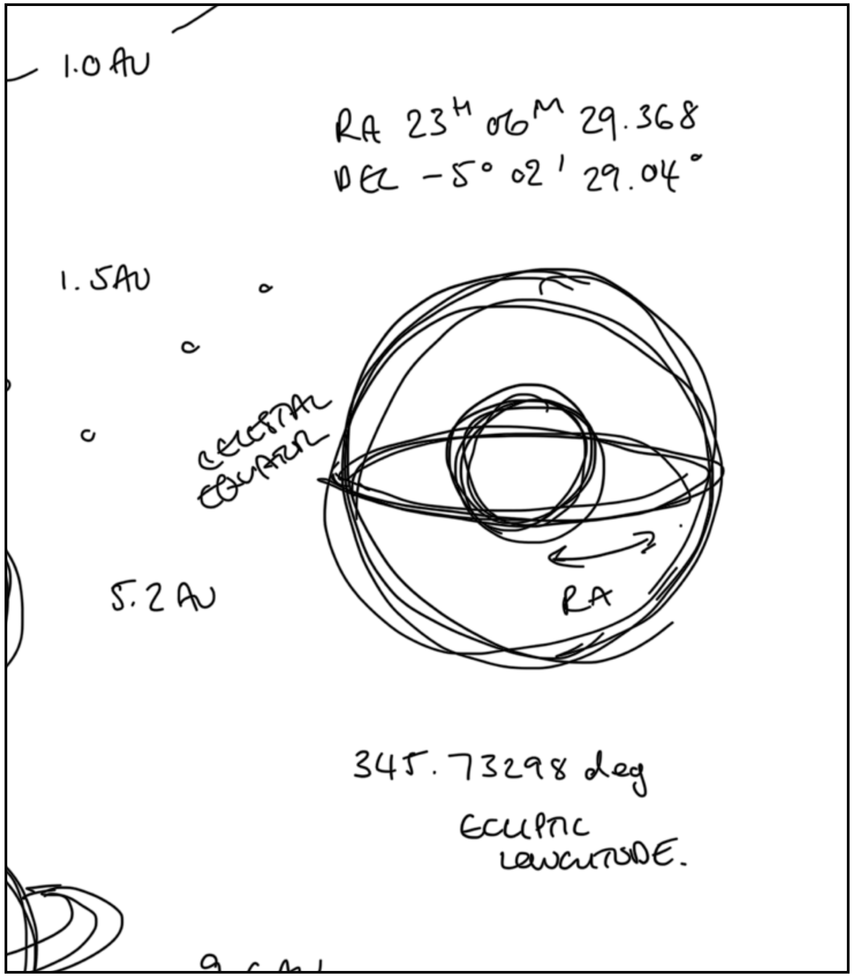
+ 182 DAYS.

☉ 15° ≈ 3/2/2025
[345°]
0.0

☉ 12° ♌ 4/8/2025
[165°]
1.0

TRAPPIST-1 15° ≈





NASA Exoplanet Archive
https://exoplanetarchive.ipac.caltech.edu › overview

TRAPPIST-1 Overview

Ecliptic Latitude .62982 deg. Ecliptic Longitude: 345.73298 deg. Galactic Latitude: -56.64891 deg. **Galactic Longitude: 69.71519 deg.** Total Proper Motion ...

A1 | fx 01/09/2024

	A	B	C	D	E	F	G	H	I	J	K
1	September 2024	SUN	MOON	MERCURY	VENUS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
2	Su 01 22:42:36	09VI03	15LE54	22LE05	02LI59	27GE40	19GE01	16PI35	27TA15	29PI04	00AQ01
3	Mo 02 22:46:33	10VI01	28LE04	22LE35	04LI13	28GE17	19GE08	16PI30	27TA15	29PI02	29CP60
4	Tu 03 22:50:29	10VI59	10VI06	23LE13	05LI26	28GE54	19GE15	16PI25	27TA15	29PI00	29CP59
5	We 04 22:54:26	11VI58	22VI00	23LE59	06LI40	29GE30	19GE21	16PI21	27TA15	28PI59	29CP58
6	Th 05 22:58:22	12VI56	03LI50	24LE53	07LI53	00CN06	19GE28	16PI16	27TA15	28PI57	29CP57
7	Fr 06 23:02:19	13VI54	15LI36	25LE54	09LI07	00CN43	19GE34	16PI12	27TA15	28PI56	29CP56
8	Sa 07 23:06:16	14VI52	27LI23	27LE02	10LI20	01CN19	19GE40	16PI07	27TA15	28PI54	29CP55
9	Su 08 23:10:12	15VI50	09SC13	28LE16	11LI33	01CN54	19GE46	16PI03	27TA14	28PI53	29CP54
10	Mo 09 23:14:09	16VI49	21SC11	29LE36	12LI47	02CN30	19GE52	15PI58	27TA14	28PI51	29CP53
11	Tu 10 23:18:05	17VI47	03SG21	01VI02	14LI00	03CN06	19GE57	15PI53	27TA14	28PI49	29CP52
12	We 11 23:22:02	18VI45	15SG47	02VI32	15LI13	03CN41	20GE03	15PI49	27TA13	28PI48	29CP52
13	Th 12 23:25:58	19VI44	28SG34	04VI07	16LI27	04CN16	20GE08	15PI44	27TA13	28PI46	29CP51
14	Fr 13 23:29:55	20VI42	11CP46	05VI45	17LI40	04CN51	20GE13	15PI40	27TA12	28PI44	29CP50
15	Sa 14 23:33:51	21VI40	25CP24	07VI27	18LI53	05CN26	20GE18	15PI35			
16	Su 15 23:37:48	22VI39	09AQ30	09VI11	20LI07	06CN01	20GE23	15PI30			

C2 | fx

```
=VALUE(LEFT(B2, 2)) + VLOOKUP(MID(B2, 3, 2), Lookup!$A$2:$B$13, 2, FALSE) & "." & RIGHT(B2, 2)
```

	A	B	C	D	E	F	G	H	I			
1	September 2024	SUN	SUN	MOON	MOON	MERCURY	MERCURY	VENUS	VENUS			
2	Su 01 22:42:36	09VI03	**159.03**	15LE54	**135.54**	22LE05	**142.05**	02LI59	**182.59**			
3	Mo 02 22:46:33	10VI01	**160.01**	28LE04	**148.04**	22LE35	**142.35**	04LI13	**184.13**			
4	Tu 03 22:50:29	10VI59	**160.59**	10VI06	**160.06**	23LE13	**143.13**	05LI26	**185.26**			
5	We 04 22:54:26	11VI58	**161.58**	22VI00	**172.00**	23LE59	**143.59**	06LI40	**186.40**			
6	Th 05 22:58:22	12VI56	**162.56**	03LI50	**183.50**	24LE53	**144.53**	07LI53	**187.53**			
7	Fr 06 23:02:19	13VI54	**163.54**	15LI36	**195.36**	25LE54	**145.54**	09LI07	**189.07**			
8	Sa 07 23:06:16	14VI52	**164.52**	27LI23	**207.23**	27LE02	**147.02**	10LI20	**190.20**			
9	Su 08 23:10:12	15VI50	**165.50**	09SC13	**219.13**	28LE16	**148.16**	11LI33	**191.33**			
10	Mo 09 23:14:09	16VI49	**166.49**	21SC11	**231.11**	29LE36	**149.36**	12LI47	**192.47**			
11	Tu 10 23:18:05	17VI47	**167.47**	03SG21	**243.21**	01VI02	**151.02**	14LI00	**194.00**			
12	We 11 23:22:02	18VI45	**168.45**	15SG47	**255.47**	02VI32	**152.32**	15LI13	**195.13**			
13	Th 12 23:25:58	19VI44	**169.44**	28SG34	**268.34**	04VI07	**154.07**	16LI27	**196.27**	04CN16	**94.16**	20GE08
14	Fr 13 23:29:55	20VI42	**170.42**	11CP46	**281.46**	05VI45	**155.45**	17LI40	**197.40**	04CN51	**94.51**	20GE13
15	Sa 14 23:33:51	21VI40	**171.40**	25CP24	**295.24**	07VI27	**157.27**	18LI53	**198.53**	05CN26	**95.26**	20GE18
16	Su 15 23:37:48	22VI39	**172.39**	09AQ30	**309.30**	09VI11	**159.11**	20LI07	**200.07**	06CN01	**96.01**	20GE23

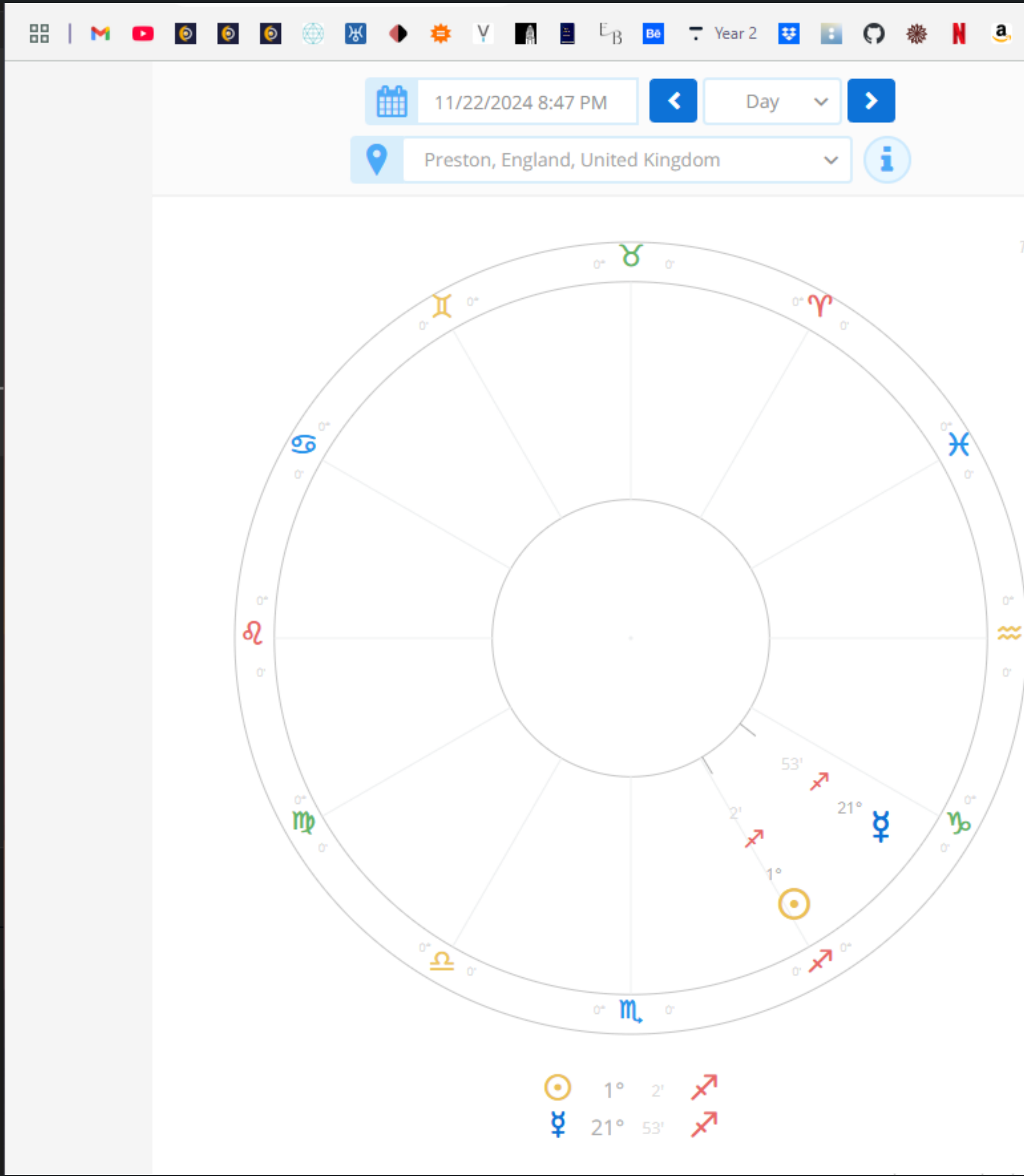
	A	B
1	Signs	Degrees
2	AR	
3	TA	30
4	GE	60
5	CN	90
6	LE	120
7	VI	150
8	LI	180
9	SC	210
10	SG	240
11	CP	270
12	AQ	300
13	PI	330
14		

experiment.py > ...

```python
from skyfield import api
from skyfield.api import load, Star, wgs84, load_file
from skyfield.framelib import ecliptic_frame
from skyfield.data import hipparcos
from skyfield.framelib import ecliptic_frame

planets = load('de421.bsp')
sun, earth, mercury, mars, venus = planets['sun'], planets['earth'], planets['

ts = load.timescale()
t = ts.now()
position = planets['earth'].at(t).observe(planets['sun'])
pos2 = planets['earth'].at(t).observe(planets['mercury'])

x, y, z = position.frame_xyz(ecliptic_frame).au
x2, y2, z2 = pos2.frame_xyz(ecliptic_frame).au

lat, lon, distance = position.frame_latlon(ecliptic_frame)
lat2, lon2, distance2 = pos2.frame_latlon(ecliptic_frame)

print('Spherical ecliptic coordinates:')
print('Sun {:.4f} longitude'.format(lon.degrees))
print('Mercury {:.4f} longitude'.format(lon2.degrees))
```

TERMINAL PORTS PROBLEMS OUTPUT DEBUG CONSOLE

```
PS F:\Documents\data_vis\projects> & C:/Users/EnglishMuffin/AppData/Local/Programs/Python/Python312/python.exe f:/Documents/data_vis/projects/experiment.py
Spherical ecliptic coordinates:
Sun 241.0528 longitude
Mercury 261.8953 longitude
PS F:\Documents\data_vis\projects>
```



Initially I used Skyfield to calculate the eciptic positions of the planets from earth and they did line up with the degree markers of the astrolgical signs.

experiment.py > ...

```python
from skyfield.framelib import ecliptic_frame
from skyfield.data import hipparcos
from skyfield.framelib import ecliptic_frame

planets = load('de421.bsp')
sun, earth, moon, mercury, mars, venus = planets['sun'], planets['earth'], pla
# jupiter, saturn, uranus, neptune, pluto
# planets['jupiter barycenter'], planets['saturn barycenter'], planets['uranus

ts = load.timescale()
# t = ts.now()
t = ts.utc(2024, 11, 23, 3, 18, 1.0)


# ts = load.timescale()
# t = ts.utc(2024, 12, 6, 2, 18, 1.0)

position = planets['earth'].at(t).observe(planets['sun'])
pos1 = planets['earth'].at(t).observe(planets['moon'])
pos2 = planets['earth'].at(t).observe(planets['mercury'])
pos3 = planets['earth'].at(t).observe(planets['venus'])
pos4 = planets['earth'].at(t).observe(planets['mars'])
# pos5 = planets['earth'].at(t).observe(planets['jupiter'])
# pos6 = planets['earth'].at(t).observe(planets['saturn'])

x, y, z = position.frame_xyz(ecliptic_frame).au
x1, y1, z1 = pos2.frame_xyz(ecliptic_frame).au
x2, y2, z2 = pos2.frame_xyz(ecliptic_frame).au
```

TERMINAL PORTS PROBLEMS OUTPUT DEBUG CONSOLE

```
Mercury 262.01 longitude
Venus 283.50 longitude
Mars 124.95 longitude
PS F:\Documents\data_vis\projects> & C:/Users/EnglishMuffin/AppData/Local/Programs/Python/Python312/python.exe f:/Documents/data_vis/projects/experiment.py
Spherical ecliptic coordinates:
Sun 241.33 longitude
Moon 152.17 longitude
Mercury 262.01 longitude
Venus 283.50 longitude
Mars 124.95 longitude
PS F:\Documents\data_vis\projects>
```

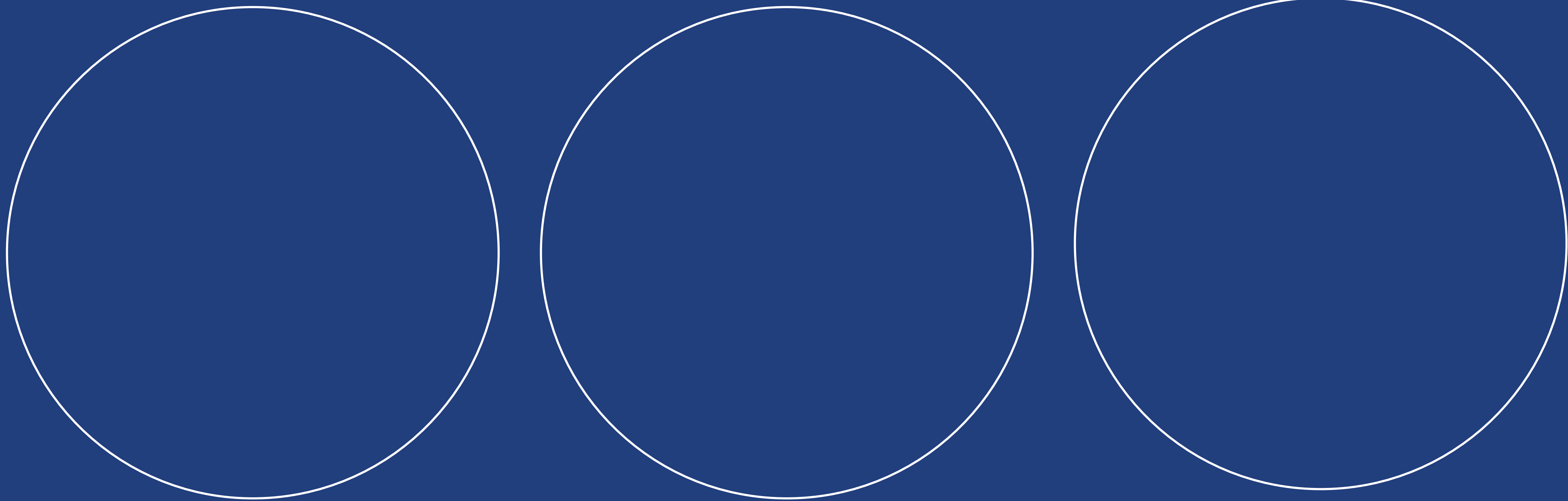
Eph Data

File Home Insert Share Page Layout Formulas Data Review View Help Draw

C88 =VALUE(LEFT(B88, 2)) + VLOOKUP(MID(B88, 3, 2), Table1, 2, FALSE) & "." &

	A	B	C	D	E	F	G	H	I
64									
65	November 2024								
66	Fr 01 02:43:06	09SC03	**219.03**	03SC13	**213.13**	27SC28	**237.28**	17SG06	**257.06**
67	Sa 02 02:47:03	10SC03	**220.03**	15SC11	**225.11**	28SC53	**238.53**	18SG18	**258.18**
68	Su 03 02:50:59	11SC03	**221.03**	27SC17	**237.17**	00SG16	**240.16**	19SG30	**259.30**
69	Mo 04 02:54:56	12SC04	**222.04**	09SG32	**249.32**	01SG39	**241.39**	20SG42	**260.42**
70	Tu 05 02:58:52	13SC04	**223.04**	21SG58	**261.58**	03SG01	**243.01**	21SG54	**261.54**
71	We 06 03:02:49	14SC04	**224.04**	04CP36	**274.36**	04SG22	**244.22**	23SG06	**263.06**
72	Th 07 03:06:45	15SC04	**225.04**	17CP27	**287.27**	05SG42	**245.42**	24SG18	**264.18**
73	Fr 08 03:10:42	16SC04	**226.04**	00AQ34	**300.34**	07SG01	**247.01**	25SG30	**265.30**
74	Sa 09 03:14:39	17SC05	**227.05**	13AQ58	**313.58**	08SG19	**248.19**	26SG42	**266.42**
75	Su 10 03:18:35	18SC05	**228.05**	27AQ40	**327.40**	09SG35	**249.35**	27SG53	**267.53**
76	Mo 11 03:22:32	19SC05	**229.05**	11PI43	**341.43**	10SG49	**250.49**	29SG05	**269.05**
77	Tu 12 03:26:28	20SC05	**230.05**	26PI05	**356.05**	12SG02	**252.02**	00CP17	**270.17**
78	We 13 03:30:25	21SC06	**231.06**	10AR45	**10.45**	13SG13	**253.13**	01CP28	**271.28**
79	Th 14 03:34:21	22SC06	**232.06**	25AR38	**25.38**	14SG22	**254.22**	02CP40	**272.40**
80	Fr 15 03:38:18	23SC07	**233.07**	10TA37	**40.37**	15SG28	**255.28**	03CP51	**273.51**
81	Sa 16 03:42:14	24SC07	**234.07**	25TA34	**55.34**	16SG31	**256.31**	05CP02	**275.02**
82	Su 17 03:46:11	25SC07	**235.07**	10GE20	**70.20**	17SG31	**257.31**	06CP14	**276.14**
83	Mo 18 03:50:08	26SC08	**236.08**	24GE46	**84.46**	18SG28	**258.28**	07CP25	**277.25**
84	Tu 19 03:54:04	27SC08	**237.08**	08CN48	**98.48**	19SG20	**259.20**	08CP36	**278.36**
85	We 20 03:58:01	28SC09	**238.09**	22CN22	**112.22**	20SG08	**260.08**	09CP47	**279.47**
86	Th 21 04:01:57	29SC10	**239.10**	05LE29	**125.29**	20SG50	**260.50**	10CP58	**280.58**
87	Fr 22 04:05:54	00SG10	**240.10**	18LE10	**138.10**	21SG27	**261.27**	12CP09	**282.09**
88	Sa 23 04:09:50	01SG11	**241.11**	00VI29	**150.29**	21SG57	**261.57**	13CP20	**283.20**
89	Su 24 04:13:47	02SG11	**242.11**	12VI33	**162.33**	22SG20	**262.20**	14CP30	**284.30**
90	Mo 25 04:17:43	03SG12	**243.12**	24VI25	**174.25**	22SG34	**262.34**	15CP41	**285.41**
91	Tu 26 04:21:40	04SG13	**244.13**	06LI12	**186.12**	22SG40	**262.40**	16CP52	**286.52**
92	We 27 04:25:37	05SG14	**245.14**	17LI59	**197.59**	22SG36	**262.36**	18CP02	**288.02**
93	Th 28 04:29:33	06SG14	**246.14**	29LI49	**209.49**	22SG22	**262.22**	19CP13	**289.13**
94	Fr 29 04:33:30	07SG15	**247.15**	11SC47	**221.47**	21SG57	**261.57**	20CP23	**290.23**
95	Sa 30 04:37:26	08SG16	**248.16**	23SC55	**233.55**	21SG21	**261.21**	21CP33	**291.33**
96									
97	December 2024								
98	Su 01 04:41:23	09SG17	**249.17**	06SG14	**246.14**	20SG35	**260.35**	22CP43	**292.43**
99	Mo 02 04:45:19	10SG18	**250.18**	18SG46	**258.46**	19SG37	**259.37**	23CP53	**293.53**

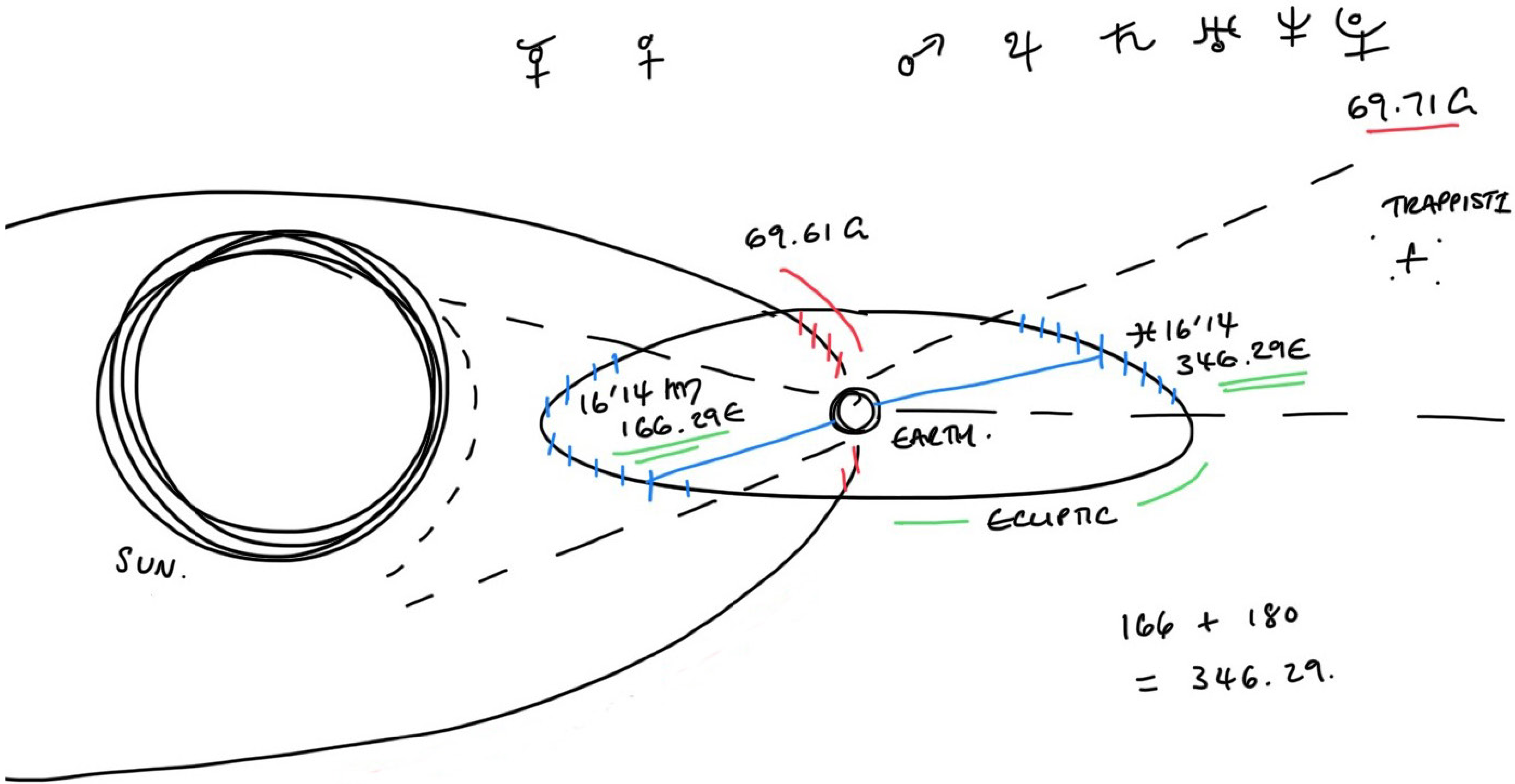
OG Position Mass Test Position Coordinate convert Lookup



Astrological Frame
360 ° Longitude

Ecliptic Frame
360 ° Longitude

Galactic Frame
360 ° Longitude


☿ ♀ ♂ ♃ ♄ ♅ ♆ ♇
69.71 G
TRAPPIST1
69.61 G
♓ 16'14
346.29E
16'14 ♍
166.29E
EARTH.
ECLIPTIC
SUN.
166 + 180
= 346.29.

```python
ts = load.timescale()
# t = ts.now()
t = ts.utc(2025, 9, 8, 10, 55, 1.0)

print('Spherical ecliptic coordinates:')
position = planets['earth'].at(t).observe(planets['sun'])
x, y, z = position.frame_xyz(ecliptic_frame).au
lat, lon, distance = position.frame_latlon(ecliptic_frame)
print('Sun {:.2f} longitude'.format(lon.degrees))

print('Spherical ecliptic coordinates:')
position = planets['sun'].at(t).observe(planets['earth'])
x, y, z = position.frame_xyz(ecliptic_frame).au
lat, lon, distance = position.frame_latlon(ecliptic_frame)
print('Earth {:.2f} longitude'.format(lon.degrees))

print('Spherical galactic coordinates:')
earthpos = planets['sun'].at(t).observe(planets['earth'])
xe, ye, ze = earthpos.frame_xyz(galactic_frame).au
late, lone, distancee = earthpos.frame_latlon(galactic_frame)
print('Earth {:.2f} longitude'.format(lone.degrees))
```

TERMINAL PORTS PROBLEMS OUTPUT DEBUG CONSOLE

```
PS F:\Documents\data_vis\projects> & C:/Users/EnglishMuffin/AppData/Local/Pro
Spherical ecliptic coordinates:
Sun 166.06 longitude
Spherical ecliptic coordinates:
Earth 346.05 longitude
Spherical galactic coordinates:
Earth 69.19 longitude
PS F:\Documents\data_vis\projects>
```

So, we can assume for our purposes that anything that reaches this area of the ecliptic degree based from a heliocentric position, that it will be in line of sight from TRAPPIST-1

```python
# ____________________________________

ts = load.timescale()
# t = ts.now()
t = ts.utc(2024, 9, 8, 10, 55, 1.0)

print('Spherical ecliptic coordinates:')
position = planets['earth'].at(t).observe(planets['sun'])
x, y, z = position.frame_xyz(ecliptic_frame).au
lat, lon, distance = position.frame_latlon(ecliptic_frame)
print('Sun {:.2f} longitude'.format(lon.degrees))

print('Spherical galactic coordinates:')
earthpos = planets['sun'].at(t).observe(planets['earth'])
xe, ye, ze = earthpos.frame_xyz(galactic_frame).au
late, lone, distancee = earthpos.frame_latlon(galactic_frame)
print('Earth {:.2f} longitude'.format(lone.degrees))
```

TERMINAL PORTS PROBLEMS OUTPUT DEBUG CONSOLE Python

```
12/python.exe f:/Documents/data_vis/projects/experiment.py
Spherical ecliptic coordinates:
Sun 165.32 longitude
Spherical galactic coordinates:
Earth 67.97 longitude
PS F:\Documents\data_vis\projects> & C:/Users/EnglishMuffin/AppData/Local/Programs/Python/Python3
12/python.exe f:/Documents/data_vis/projects/experiment.py
Spherical ecliptic coordinates:
Sun 166.29 longitude
Spherical galactic coordinates:
Earth 69.61 longitude
PS F:\Documents\data_vis\projects>
```

└ TRAPPIST-1 h

DISCOVERY DATA

Host	Planet
TRAPPIST-1	TRAPPIST-1 b
TRAPPIST-1	TRAPPIST-1 c
TRAPPIST-1	TRAPPIST-1 d
TRAPPIST-1	TRAPPIST-1 e
TRAPPIST-1	TRAPPIST-1 f
TRAPPIST-1	TRAPPIST-1 g
TRAPPIST-1	TRAPPIST-1 h

Exoplanet Archive Notes (3)

★ TRAPPIST-1 Stellar Parameters (9 S

RA
23h06m30.33s

DEC
-05d02m36.46s

DISTANCE

PARALLAX

ECLIPTIC LATITUDE
.62982 deg

ECLIPTIC LONGITUDE
345.73298 deg

GALACTIC LATITUDE
-56.64891 deg

GALACTIC LONGITUDE
69.71519 deg

If the Sun were 10 parsecs away from Earth, it would have an apparent magnitude of 4.83.

TRAPPIST-1 is 12.1 parsecs away from our star

4.83 / 10 = 0.483 * 12.1 =

5.84 magnitude

helio.py > ...

```python
earthpos = planets['sun'].at(t0).observe(planets['earth'])
late, lone, distancee = earthpos.frame_latlon(ecliptic_frame)
earth_values = lone.degrees

moonpos = planets['sun'].at(t0).observe(planets['moon'])
latm, lonm, distancem = moonpos.frame_latlon(ecliptic_frame)
moon_values = lonm.degrees

mercurypos = planets['sun'].at(t0).observe(planets['mercury'])
latme, lonme, distanceme = mercurypos.frame_latlon(ecliptic_frame)
mercury_values = lonme.degrees

venuspos = planets['sun'].at(t0).observe(planets['venus'])
latv, lonv, distancev = venuspos.frame_latlon(ecliptic_frame)
venus_values = lonv.degrees

marspos = planets['sun'].at(t0).observe(planets['mars'])
latma, lonma, distancema = marspos.frame_latlon(ecliptic_frame)
mars_values = lonma.degrees

jupiterpos = planets['sun'].at(t0).observe(planets['jupiter barycenter'])
latj, lonj, distancej = jupiterpos.frame_latlon(ecliptic_frame)
jupiter_values = lonj.degrees
```

Aqiuring Data:
Building a Heliocentric ecliptic degree dataset into dataframe structure

TERMINAL PORTS PROBLEMS OUTPUT DEBUG CONSOLE

```
PS F:\Documents\data_vis\projects> & C:/Users/EnglishMuffin/AppData/Local/Programs/Python/Python312/python.exe f:/Documents/data_vis/p
```

	earth	moon	mercury	venus	mars	jupiter	saturn	uranus	neptune	pluto
0	339.055451	339.115177	25.733693	217.532254	46.893915	67.659947	345.788419	54.362271	358.388006	301.052483
1	339.095780	339.154382	25.963245	217.599065	46.917435	67.663626	345.789777	54.362743	358.388260	301.052679
2	339.136109	339.193583	26.193054	217.665876	46.940954	67.667305	345.791136	54.363214	358.388514	301.052875
3	339.176440	339.232781	26.423119	217.732685	46.964472	67.670984	345.792494	54.363686	358.388767	301.053070
4	339.216771	339.271976	26.653440	217.799493	46.987988	67.674663	345.793853	54.364158	358.389021	301.053266
..	...	...	...	...	...	...	...	...	...	...
390	354.843004	354.814097	124.311718	243.492446	55.941766	69.093378	346.318494	54.546222	358.486952	301.128775
391	354.883636	354.856104	124.550159	243.558776	55.964642	69.097049	346.319853	54.546692	358.487205	301.128970
392	354.924270	354.898116	124.788347	243.625105	55.987516	69.100719	346.321211	54.547163	358.487457	301.129164
393	354.964904	354.940131	125.026283	243.691433	56.010388	69.104390	346.322570	54.547634	358.487710	301.129359
394	355.005539	354.982149	125.263965	243.757759	56.033259	69.108061	346.323929	54.548104	358.487962	301.129553

Cleaning Data:
Mapping based on degrees surrounding 346 degree to 0-5 range

mapping_helio_values.py > ...

```python
def map_value_with_decimal(x):
        elif int_part == 346:
            int_part = 0
        elif int_part == 345:
            int_part = 1
        elif int_part == 344:
            int_part = 2
        elif int_part == 343:
            int_part = 3
        elif int_part == 342:
            int_part = 4
        elif int_part <= 341:
            int_part = 5

        # Combine the modified integer part with the original decimal part
        new_value = int_part + decimal_part
        return new_value

# Apply the mapping function to the DataFrame as a new column and dropping the colu
df['earth_mapped_value'] = df['earth'].apply(map_value_with_decimal)
df = df.drop(columns=['earth'])

df['moon_mapped_value'] = df['moon'].apply(map_value_with_decimal)
```

TERMINAL PORTS PROBLEMS OUTPUT DEBUG CONSOLE

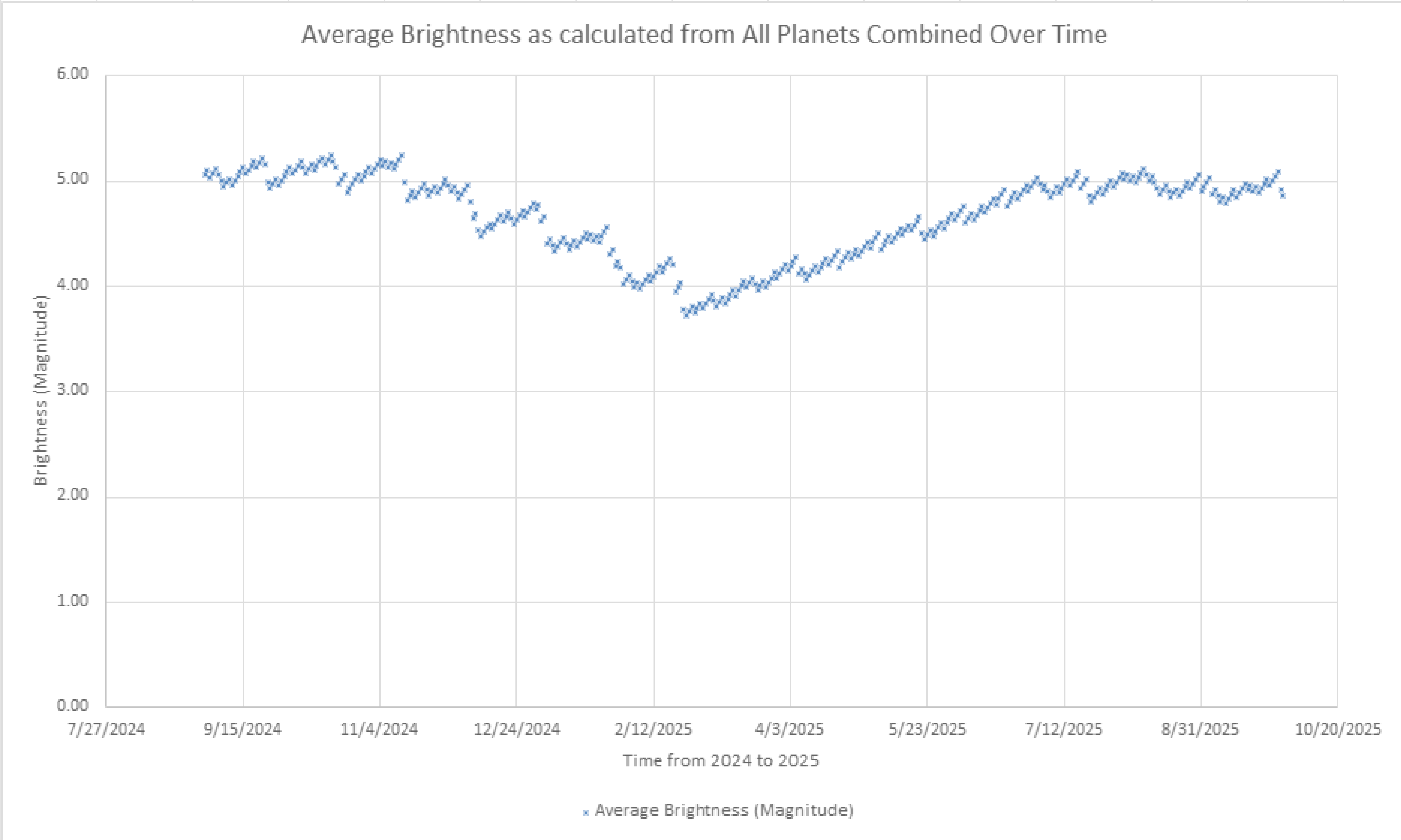
```
[395 rows x 10 columns]
     earth_mapped_value  moon_mapped_value  mercury_mapped_value  venus_mapped_value  ...
0                  5.06               5.12                  5.73                5.53  ...
1                  5.10               5.15                  5.96                5.60  ...
2                  5.14               5.19                  5.19                5.67  ...
3                  5.18               5.23                  5.42                5.73  ...
4                  5.22               5.27                  5.65                5.80  ...
..                  ...                ...                   ...                 ...  ...
390                5.84               5.81                  5.31                5.49  ...
391                5.88               5.86                  5.55                5.56  ...
392                5.92               5.90                  5.79                5.63  ...
393                5.96               5.94                  5.03                5.69  ...
394                5.01               5.98                  5.26                5.76  ...
```

2 | =SUM(B2:K2/10)

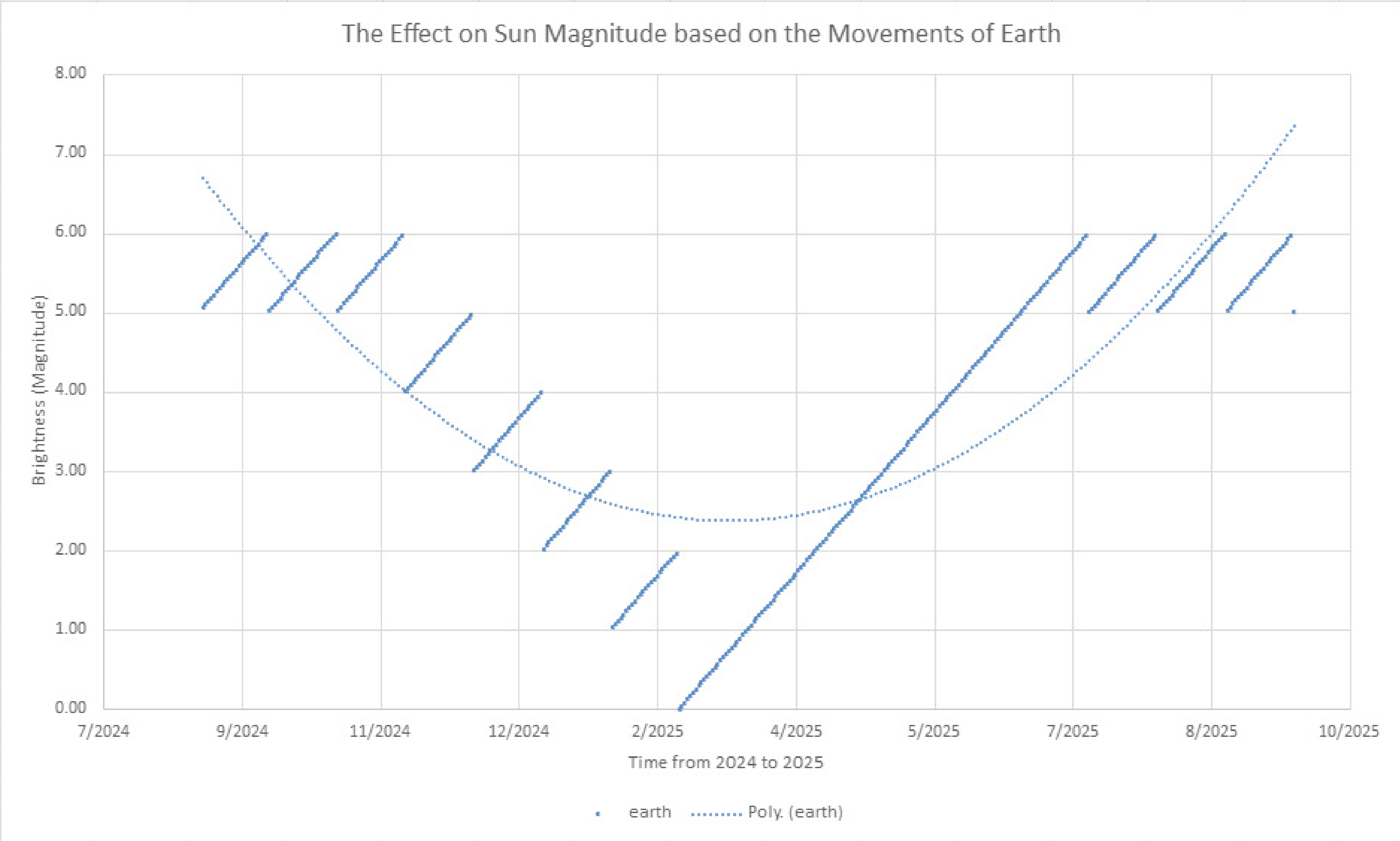
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Date	earth	moon	mercury	venus	mars	jupiter	saturn	uranus	neptune	pluto	Average	
2	9/1/2024	5.06	5.12	5.73	5.53	5.89	5.66	1.79	5.36	5.39	5.05	5.06	
3	9/2/2024	5.1	5.15	5.96	5.6	5.92	5.66	1.79	5.36	5.39	5.05	5.10	
4	9/3/2024	5.14	5.19	5.19	5.67	5.94	5.67	1.79	5.36	5.39	5.05	5.04	
5	9/4/2024	5.18	5.23	5.42	5.73	5.96	5.67	1.79	5.36	5.39	5.05	5.08	
6	9/5/2024	5.22	5.27	5.65	5.8	5.99	5.67	1.79	5.36	5.39	5.05	5.12	
7	9/6/2024	5.26	5.31	5.88	5.87	5.01	5.68	1.8	5.36	5.39	5.05	5.06	
8	9/7/2024	5.3	5.35	5.11	5.93	5.04	5.68	1.8	5.37	5.39	5.05	5.00	
9	9/8/2024	5.34	5.39	5.35	5	5.06	5.69	1.8	5.37	5.39	5.05	4.94	
10	9/9/2024	5.38	5.43	5.58	5.07	5.08	5.69	1.8	5.37	5.39	5.05	4.98	
11	9/10/2024	5.42	5.47	5.81	5.13	5.11	5.69	1.8	5.37	5.39	5.05	5.02	
12	9/11/2024	5.46	5.51	5.04	5.2	5.13	5.7	1.8	5.37	5.39	5.05	4.97	

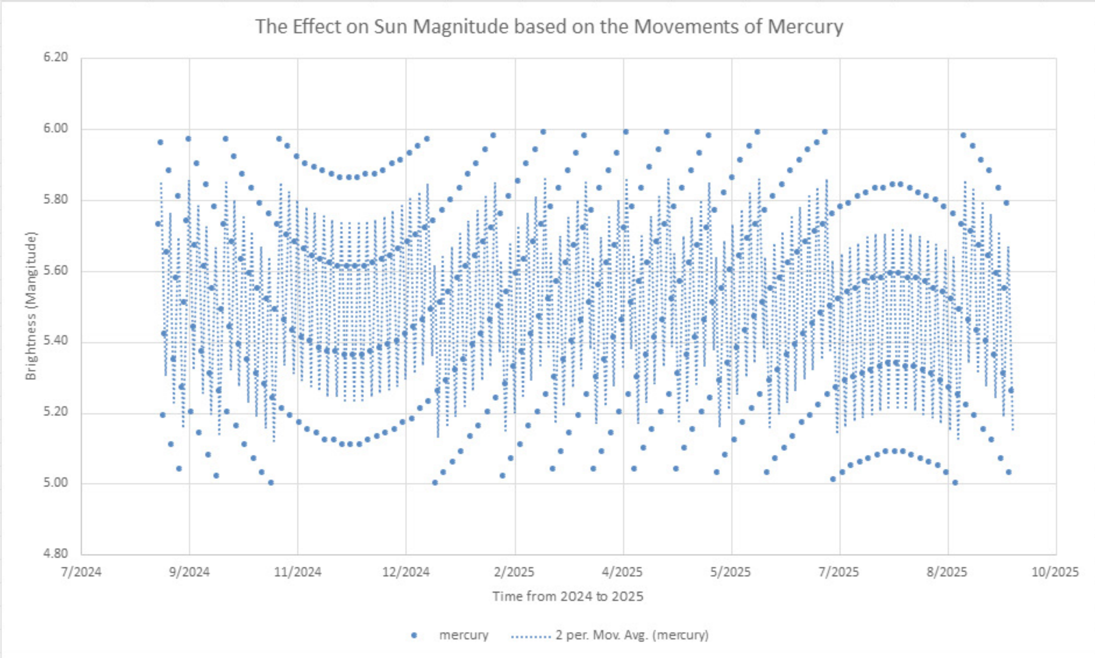
Cleaning & Analysing Data: Table structure, Average & Conditional Formatting

	A	B	C	D	E	F	G	H	I	J	K	L
1	Date	earth	moon	mercury	venus	mars	jupiter	saturn	uranus	neptune	pluto	Average
2	9/1/2024	5.06	5.12	5.73	5.53	5.89	5.66	1.79	5.36	5.39	5.05	5.06
3	9/2/2024	5.1	5.15	5.96	5.6	5.92	5.66	1.79	5.36	5.39	5.05	5.10
4	9/3/2024	5.14	5.19	5.19	5.67	5.94	5.67	1.79	5.36	5.39	5.05	5.04
5	9/4/2024	5.18	5.23	5.42	5.73	5.96	5.67	1.79	5.36	5.39	5.05	5.08
6	9/5/2024	5.22	5.27	5.65	5.8	5.99	5.67	1.79	5.36	5.39	5.05	5.12
7	9/6/2024	5.26	5.31	5.88	5.87	5.01	5.68	1.8	5.36	5.39	5.05	5.06
8	9/7/2024	5.3	5.35	5.11	5.93	5.04	5.68	1.8	5.37	5.39	5.05	5.00
9	9/8/2024	5.34	5.39	5.35	5	5.06	5.69	1.8	5.37	5.39	5.05	4.94
10	9/9/2024	5.38	5.43	5.58	5.07	5.08	5.69	1.8	5.37	5.39	5.05	4.98
11	9/10/2024	5.42	5.47	5.81	5.13	5.11	5.69	1.8	5.37	5.39	5.05	5.02
12	9/11/2024	5.46	5.51	5.04	5.2	5.13	5.7	1.8	5.37	5.39	5.05	4.97
13	9/12/2024	5.5	5.55	5.27	5.27	5.15	5.7	1.8	5.37	5.39	5.05	5.01
14	9/13/2024	5.54	5.59	5.51	5.33	5.18	5.7	1.8	5.37	5.39	5.05	5.05
15	9/14/2024	5.58	5.62	5.74	5.4	5.2	5.71	1.81	5.37	5.39	5.06	5.09
16	9/15/2024	5.62	5.66	5.97	5.47	5.22	5.71	1.81	5.37	5.39	5.06	5.13
17	9/16/2024	5.66	5.7	5.2	5.53	5.25	5.72	1.81	5.37	5.39	5.06	5.07
18	9/17/2024	5.7	5.74	5.44	5.6	5.27	5.72	1.81	5.37	5.39	5.06	5.11
19	9/18/2024	5.74	5.78	5.67	5.67	5.29	5.72	1.81	5.37	5.39	5.06	5.15
20	9/19/2024	5.78	5.82	5.9	5.73	5.32	5.73	1.81	5.37	5.39	5.06	5.19
21	9/20/2024	5.82	5.86	5.14	5.8	5.34	5.73	1.81	5.37	5.39	5.06	5.13
22	9/21/2024	5.86	5.9	5.37	5.87	5.36	5.73	1.82	5.37	5.39	5.06	5.17
23	9/22/2024	5.9	5.94	5.61	5.94	5.39	5.74	1.82	5.37	5.39	5.06	5.22
24	9/23/2024	5.94	5.98	5.84	5	5.41	5.74	1.82	5.37	5.39	5.06	5.16
25	9/24/2024	5.98	5.02	5.08	5.07	5.43	5.74	1.82	5.37	5.39	5.06	5.00
26	9/25/2024	5.02	5.06	5.31	5.14	5.46	5.75	1.82	5.37	5.39	5.06	4.94
27	9/26/2024	5.06	5.09	5.55	5.2	5.48	5.75	1.82	5.37	5.39	5.06	4.98
28	9/27/2024	5.1	5.13	5.78	5.27	5.5	5.76	1.82	5.37	5.39	5.06	5.02

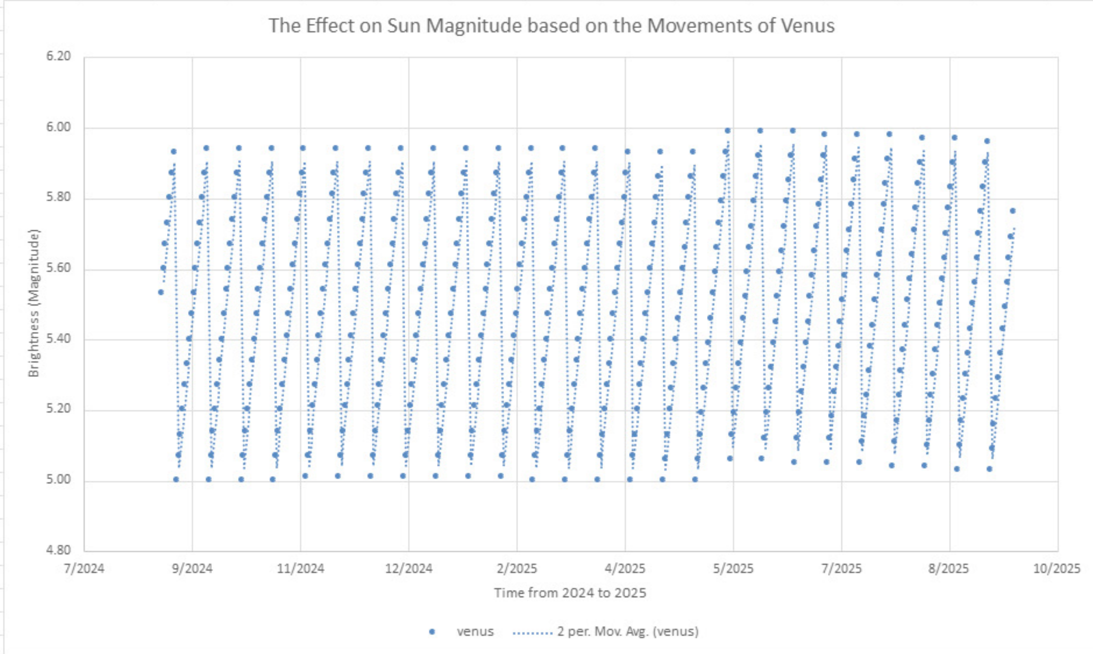


Average Brightness as calculated from All Planets Combined Over Time
Brightness (Magnitude)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
7/27/2024
9/15/2024
11/4/2024
12/24/2024
2/12/2025
4/3/2025
5/23/2025
7/12/2025
8/31/2025
10/20/2025
Time from 2024 to 2025
Average Brightness (Magnitude)

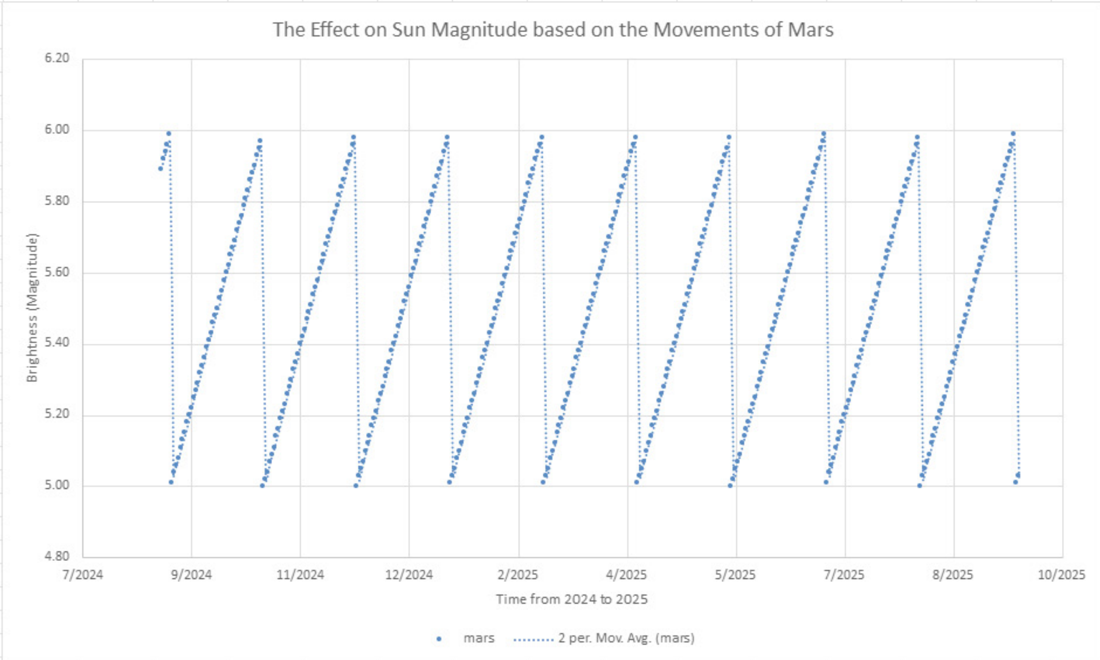

The Effect on Sun Magnitude based on the Movements of Earth
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Brightness (Magnitude)
7/2024
9/2024
11/2024
12/2024
2/2025
4/2025
5/2025
7/2025
8/2025
10/2025
Time from 2024 to 2025
earth
Poly. (earth)



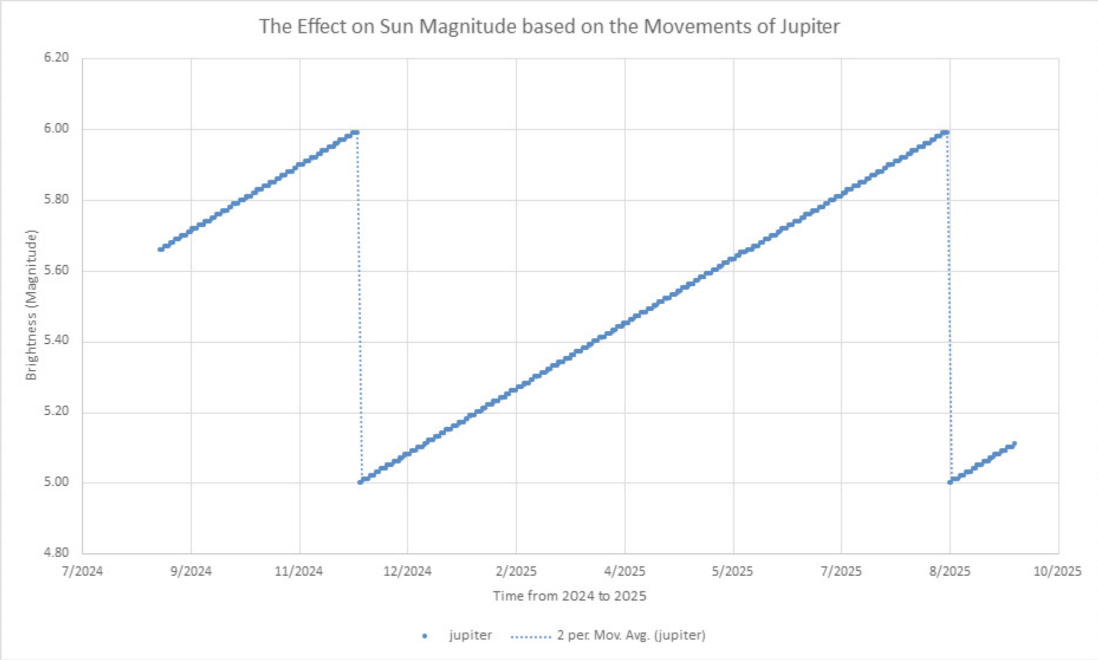
The Effect on Sun Magnitude based on the Movements of Mercury
Brightness (Magnitude)
6.20
6.00
5.80
5.60
5.40
5.20
5.00
4.80
7/2024
9/2024
11/2024
12/2024
2/2025
4/2025
5/2025
7/2025
8/2025
10/2025
Time from 2024 to 2025
mercury
2 per. Mov. Avg. (mercury)

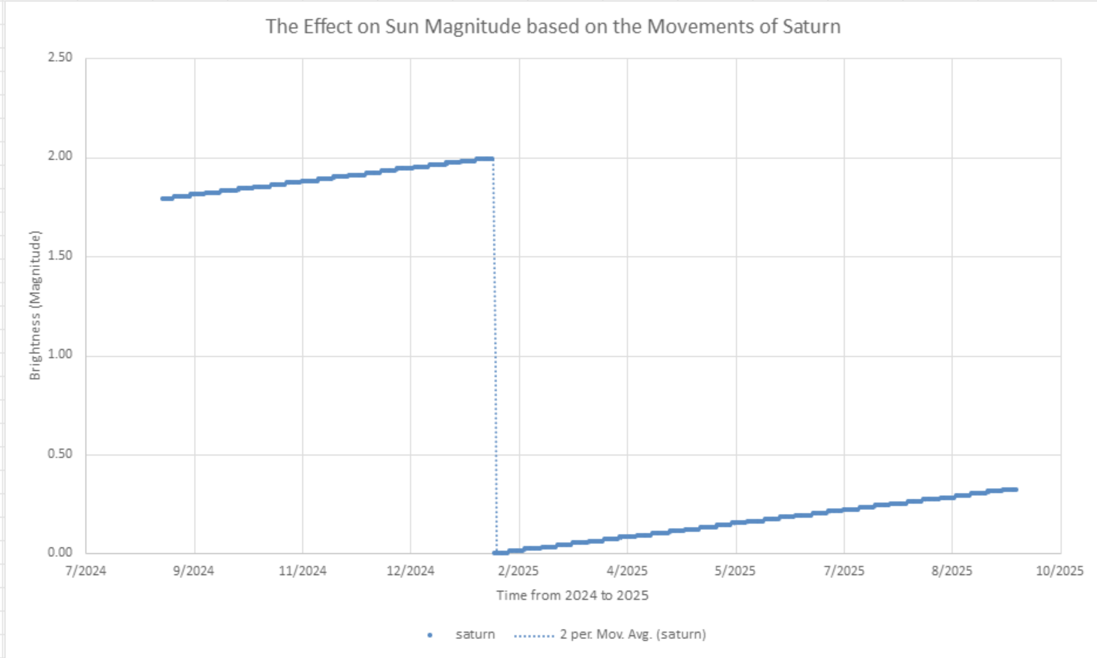


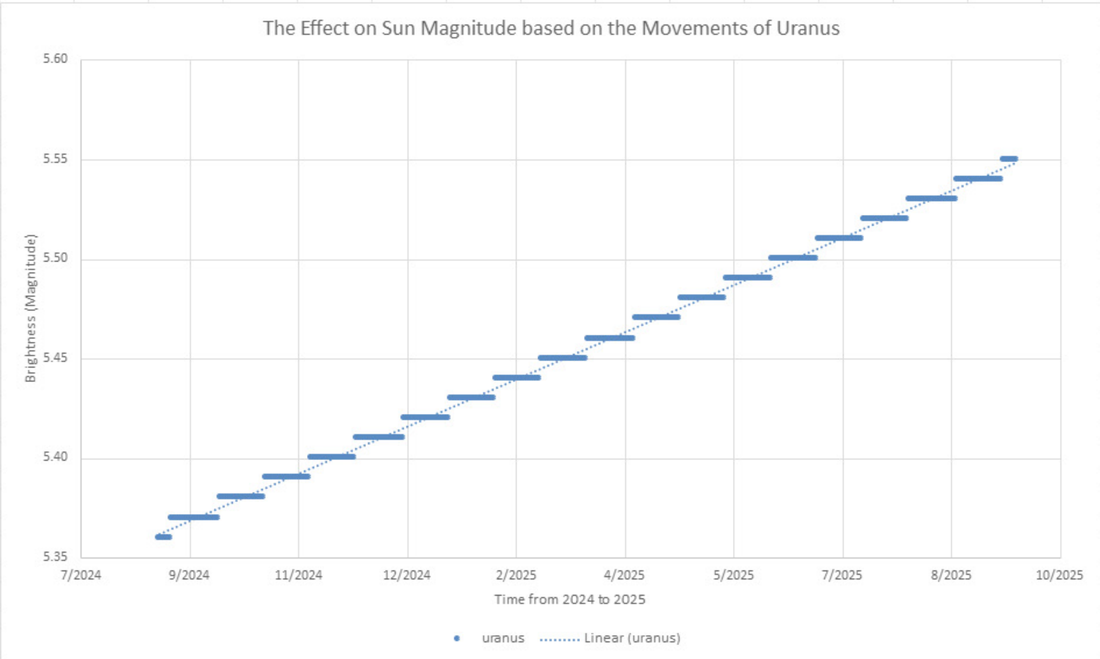
The Effect on Sun Magnitude based on the Movements of Venus
Brightness (Magnitude)
6.20
6.00
5.80
5.60
5.40
5.20
5.00
4.80
7/2024
9/2024
11/2024
12/2024
2/2025
4/2025
5/2025
7/2025
8/2025
10/2025
Time from 2024 to 2025
venus
2 per. Mov. Avg. (venus)

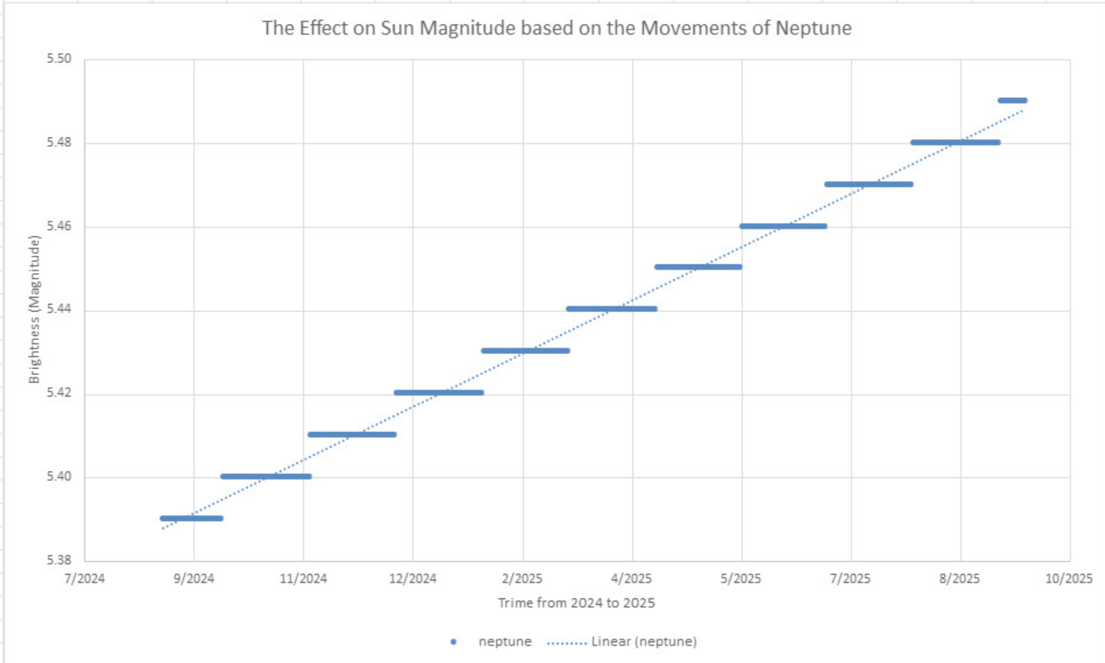


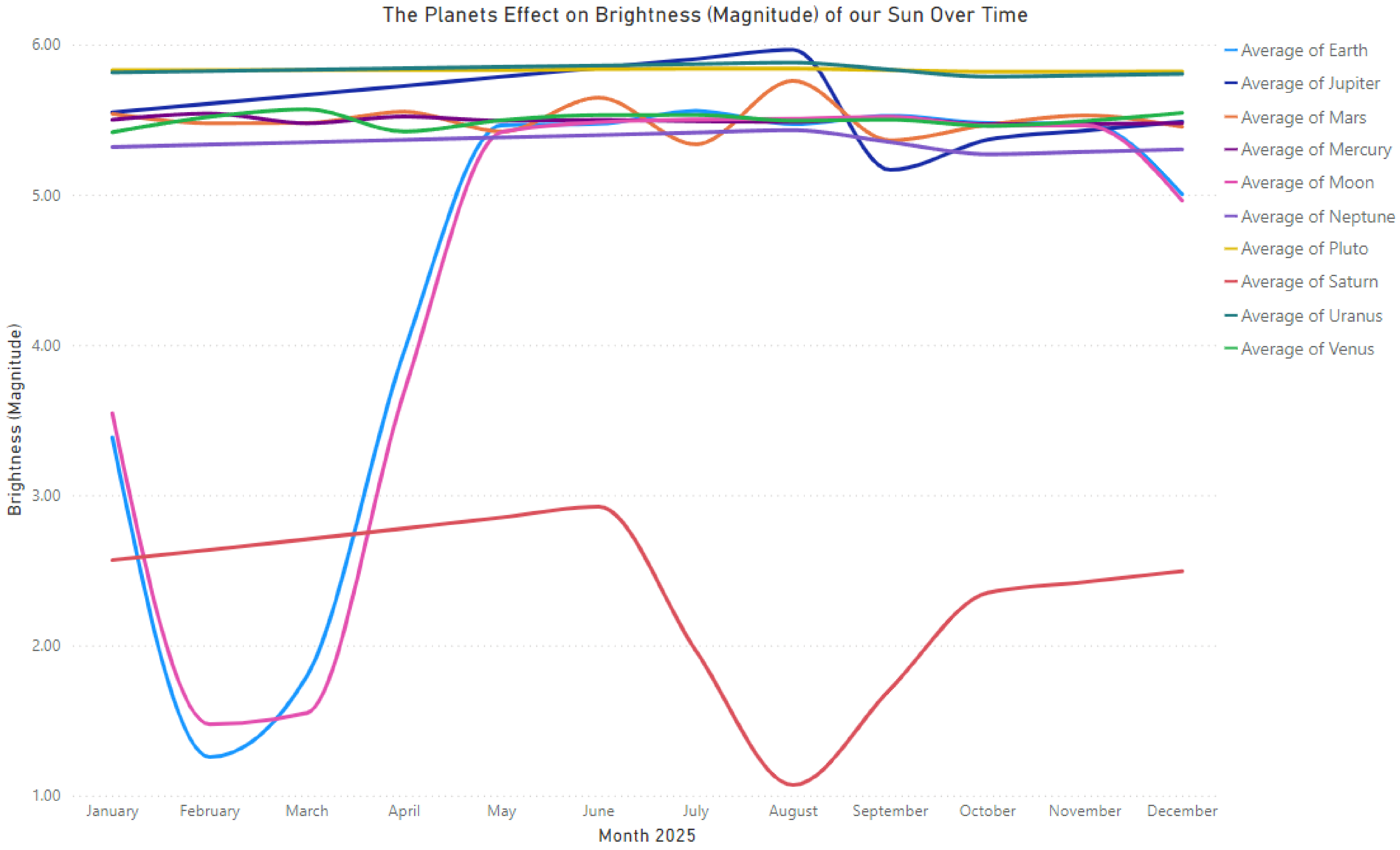
The Effect on Sun Magnitude based on the Movements of Mars
Brightness (Magnitude)
6.20
6.00
5.80
5.60
5.40
5.20
5.00
4.80
7/2024
9/2024
11/2024
12/2024
2/2025
4/2025
5/2025
7/2025
8/2025
10/2025
Time from 2024 to 2025
mars
2 per. Mov. Avg. (mars)


The Effect on Sun Magnitude based on the Movements of Jupiter
Brightness (Magnitude)
6.20
6.00
5.80
5.60
5.40
5.20
5.00
4.80
7/2024 9/2024 11/2024 12/2024 2/2025 4/2025 5/2025 7/2025 8/2025 10/2025
Time from 2024 to 2025
jupiter
2 per. Mov. Avg. (jupiter)


The Effect on Sun Magnitude based on the Movements of Saturn
Brightness (Magnitude)
2.50
2.00
1.50
1.00
0.50
0.00
7/2024 9/2024 11/2024 12/2024 2/2025 4/2025 5/2025 7/2025 8/2025 10/2025
Time from 2024 to 2025
saturn
2 per. Mov. Avg. (saturn)


The Effect on Sun Magnitude based on the Movements of Uranus
Brightness (Magnitude)
5.60
5.55
5.50
5.45
5.40
5.35
7/2024 9/2024 11/2024 12/2024 2/2025 4/2025 5/2025 7/2025 8/2025 10/2025
Time from 2024 to 2025
uranus
Linear (uranus)

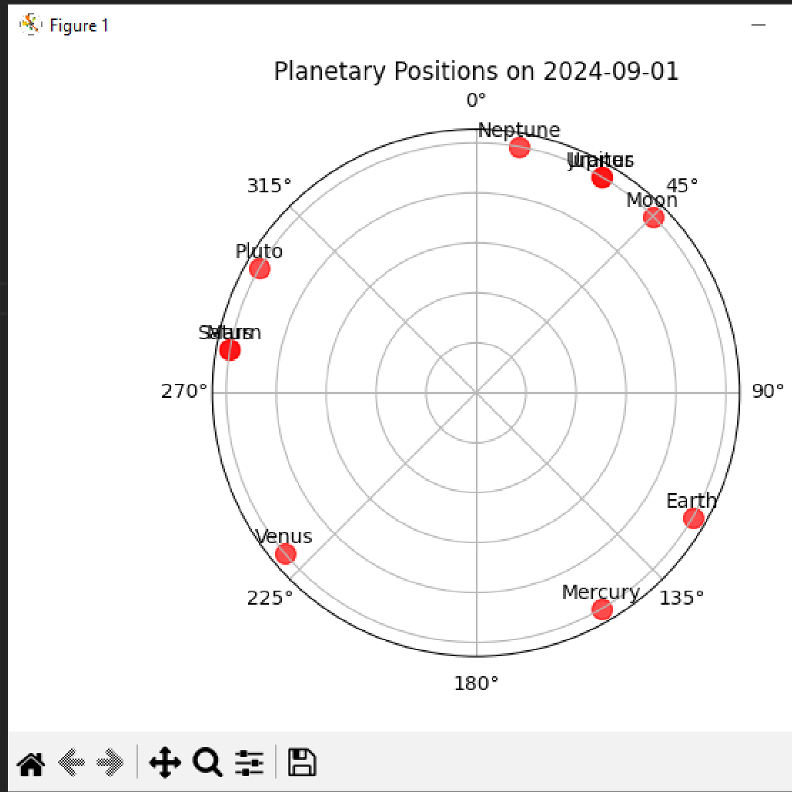

The Effect on Sun Magnitude based on the Movements of Neptune
Brightness (Magnitude)
5.50
5.48
5.46
5.44
5.42
5.40
5.38
7/2024 9/2024 11/2024 12/2024 2/2025 4/2025 5/2025 7/2025 8/2025 10/2025
Time from 2024 to 2025
neptune
Linear (neptune)


The Planets Effect on Brightness (Magnitude) of our Sun Over Time
6.00
5.00
4.00
3.00
2.00
1.00
Brightness (Magnitude)
January
February
March
April
May
June
July
August
September
October
November
December
Month 2025
Average of Earth
Average of Jupiter
Average of Mars
Average of Mercury
Average of Moon
Average of Neptune
Average of Pluto
Average of Saturn
Average of Uranus
Average of Venus

experiment.py | galatic.py | mapping_values.py | expansion.py | plots.py

plots.py > ...

```python
# Circular Plots
angles = np.deg2rad([120, 45, 150, 230, 280, 30, 280, 30, 10, 300])
labels = ["Earth", "Moon", "Mercury", "Venus", "Mars", "Jupiter", "Saturn", "Uranus", "Neptune", "Pluto"]

fig, ax = plt.subplots(subplot_kw={'projection':'polar'})
ax.set_theta_offset(np.pi/2)
ax.set_theta_direction(-1)

ax.scatter(angles, np.ones_like(angles), s=100, color='r', alpha=0.75)

for i, label in enumerate(labels):
    ax.annotate(label, (angles[i], 1), textcoords="offset points", xytext=(0,5), ha="center")

ax.set_yticklabels([])
ax.set_title('Planetary Positions on 2024-09-01')
plt.show()
```



Choosing an Ephemeris

Here are the most popular general-purpose ephemeris files, from the JPL's famous
Development Ephemeris series.

Issued	Short	Medium	Long
1997		`de405.bsp` 1600 to 2200 63 MB	`de406.bsp` −3000 to 3000 287 MB
2008	`de421.bsp` 1900 to 2050 17 MB		`de422.bsp` −3000 to 3000 623 MB
2013	`de430_1850-2150.bsp` 1850 to 2150 31 MB	`de430t.bsp` 1550 to 2650 128 MB	`de431t.bsp` −13200 to 17191 3.5 GB
2020	`de440s.bsp` 1849 to 2150 32 MB	`de440.bsp` 1550 to 2650 114 MB	`de441.bsp` −13200 to 17191 3.1 GB

Acknowledgements

Katy Long and supporting tutors

Skyfield API - Elegent Astronomy for Python
https://rhodesmill.org/skyfield/

Pandas / Matplotlib

Honourable mention and message to
TRAPPIST-1e Aeronautics and Space Administration

"In the event the only thing we share is the light of the stars, this is our system, saying hello"

Thank you for your time

Questions?