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P3_8 Interplanetary Tourist Attraction

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Abstract

The paper looks at the claim that Earth is unique in the sense that the Moon appears to be almost exactly the same size as the Sun when looking up from the surface of the Earth. The paper investigates other moons in the solar system and the size they, and the Sun, appear to be from the surface of the planets the moons orbit. It is found that the Earth is indeed unique in the solar system in having a moon that is "perfectly" sized to cause a total eclipse.

Introduction

Ian Banks mentions in one of his science fiction books that, if ever, we discover sentient beings that live on other planets and that tourism between planets was to occur, Earth could become a tourist attraction for those people or beings interested in natural phenomena. Earth experiences total eclipses of the Sun which are unique in that the Earth's moon comes very close to perfectly covering the Sun. This paper explores the claim that this "perfect" sizing is unique. In order to do this data is used for other satellites orbiting planets in our solar system.

Method

The "perfect" size of the Moon comes from the four factors, the distance of the Earth from the Sun, the distance of the Moon's orbit from the Earth and the radius of the Sun and Moon. From these four values the half angular size of the moon and the Sun from the Earth can be calculated and compared. The calculations are done as follows.

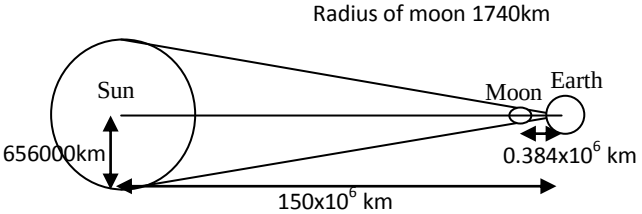

Figure 1: This figure shows the orbital properties of the Earth from the Sun and Moon from the Earth.

From the diagram of the Sun, Moon and Earth in figure 1 we can draw two triangles to find the half angle that the Sun and Moon occupy when looking at them from the Earth.

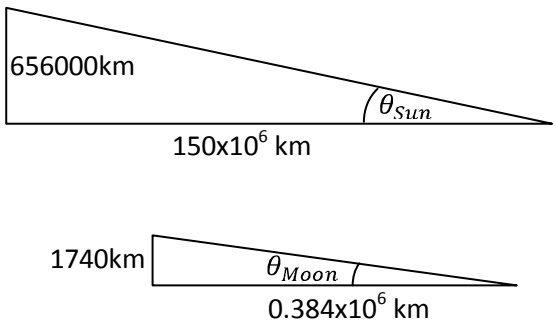

Figure 2: This figure shows the how the half angle of the moon and sun, when standing on the earth, was found.

In order to find θ_{Sun} and θ_{Moon} we must use trigonometry.

$$\theta_{Sun} = \tan^{-1}\left(\frac{656000}{150 \times 10^6}\right)$$

In the same way we can find θ_{Moon}. It is found that the two values are very close, 0.266 and 0.260 for the Sun and Moon respectively. We have assumed that the Earth has a circular orbit with a radius equal to the semi-major axis of its orbit. The same assumption was made for the Moon. Note this paper will continue to assume that all orbits are circular with a radius equal to the semi-major axis length of the actual orbit and that all Moons are spherical with a radius equal to their

largest actual dimension. All results will be quoted to three significant figures.

This calculation was repeated for several planets and their moons.

Results

In order to present the results in a logical fashion each planet and their major moon or moons will be considered consecutively. For each planet the half angle of the Sun will first be given followed by a table showing the half angles of their moon or moons.

Jupiter

Jupiter has four major moons, Io, Europa, Ganymede and Callipso. It orbits the Sun at a distance of 776×10^6km and the Sun makes a half angle of 0.0514°

Moon	Orbit from planet (km)	Radius of moon (km)	Half angle of moon (degrees)	Angular size of moon/ angular size of sun
Io	422000	1820	0.247	4.81
Europa	671000	1560	0.133	2.59
Ganymede	1070000	2630	0.141	2.74
Callisto	1880000	2410	0.0734	1.43

Table 1: This table show the properties of Jupiter's moons

Saturn

Saturn has eight major moons. It orbits the Sun at a distance of 1430×10^6km and the Sun makes a half angle of 0.0279°

Moon	Orbit from planet (km)	Radius of moon (km)	Half angle of moon (degrees)	Angular size of moon/ angular size of sun
Mimas	186000	280	0.0863	3.09
Enceladus	238000	257	0.0629	2.22
Tethys	294000	538	0.105	3.76
Rhea	377000	563	0.0856	3.07
Dione	527000	765	0.0832	2.98
Titan	1220000	2580	0.121	4.34
Hyperion	1480000	180	0.00697	0.250
Iapetus	3560000	746	0.0120	0.431

Table 2: This table show the properties of Saturn's moons

Neptune

Neptune has one major moon, Triton. It orbits the Sun at a distance of 4500×10^6km and the Sun makes a half angle of 0.00886°

Moon	Orbit from planet (km)	Radius of moon (km)	Half angle of moon (degrees)	Angular size of moon/ angular size of sun
Triton	355000	1350	0.218	24.6

Table 3: This table show the properties of Neptune's moon

Mars

Mars has two major moons, Phobos and Delimos. It orbits the Sun at a distance of 228×10^6km and the Sun makes a half angle of 0.138°

Moon	Orbit from planet (km)	Radius of moon (km)	Half angle of moon (degrees)	Angular size of moon/ angular size of sun
Phobos	9380	13.4	0.0819	0.591
Deimos	23500	7.50	0.0183	0.132

Table 4: This table show the properties of Mar's moons

Uranus

Uranus has three major moons, Titania, Oberon and Umbriel. It orbits the Sun at a distance of 2870×10^6km and the Sun makes a half angle of 0.0139°

Moon	Orbit from planet (km)	Radius of moon (km)	Half angle of moon (degrees)	Angular size of moon/ angular size of sun
Titania	436000	789	0.104	7.46
Oberon	584000	761	0.0747	5.73
Umbriel	266000	585	0.126	0.110

Table 5: This table show the properties of Uranus' moons

Conclusion

It seems that, at least in our solar system, the "perfect" size of the Moon to cause a total eclipse where the Sun is perfectly covered is unique. It seems that Callisto is the closes to perfectly covering the Sun. When standing on Jupiter it will appear 1.4 times the size of the Sun. This is calculated by comparing the half angle of the Sun and of Callisto. Note that although not all moons in the solar system were considered, all moons that were close to being the same angular size as the Sun, when viewed from the surface of their respective planets were considered.

References

Please note that all values throughout the paper are taken from: accessed on 9/03/2011 *http://nssdc.gsfc.nasa.gov/planetary*