Measuring the Earth-Moon Distance by Using Parallax Method during Total Lunar Eclipse

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Abstract

The Earth-Moon distance was measured by using parallax method from joint observation between Thailand and Japan students during total lunar eclipse phenomenon on December 10, 2011. The measured value is 428,375 kilometers, difference from the reference value (397,254 km) [1] by around 8%.

Introduction

The parallax is the appearance movement of an object, when we observed from the different points. It is once of ancient Greek's method to measure a distance between the Earth to other planets or near star. This method needs a pair of distance observers to collaborative observes at the same time for obtaining the parallax angle between the object to the reference stars. During total lunar eclipse phenomena, the Moon's brightness is dimmed enough to see a near bright star. Thus it is a good time for using parallax method to measure the Earth-Moon distance. We have the opportunity to join with the Japan Observer Network, Astro-HS Project, for observing the total lunar eclipse that occurred on December 10, 2011. With the help from Mr.Noritaka Tokimasa and observation data from High school of University of Hyogo, we are able to measure the Earth-Moon distance by using parallax method.

Method

When we combine the images were taken during total lunar eclipse from Thailand (**A**) and Japan (**B**) at the same time (21.40 JST), The Moon has a bit movement with reference to the background stars as shown in Figure 1.

Figure 1 Combined images for measuring the parallax angle.

From Figure 1, we can measure the parallax angle **(P)** directly from measuring the appearance movement of the Moon on the image in millimeters and compare with the actual angular size of the Moon in degree (around 0.5˚). Then, we assume the geometric model of the parallax measurement as shown in Figure 2.

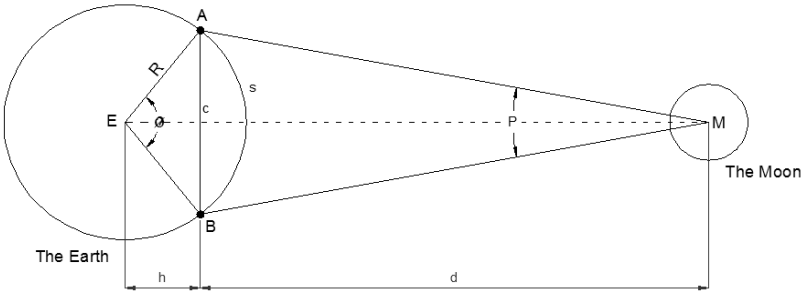

Figure 2 A diagram of parallax measurement.

From above diagram, the Earth-Moon distance is equal to **d+h**. So, we try to create a set of the equations that relate together by using trigonometric theory for obtaining the **d** and **h** values as shown below:

$$d = \frac{c}{2\tan(p/2)}, \quad h = \frac{c}{2\tan(p/2)}, \quad c = 2R\sin(\theta/2) \quad \text{and} \quad \theta = \frac{S}{R} \times \frac{\pi}{180}$$

Then, we find the distance between two observers (**S**), Kirdkao Observatory in Thailand and Nishi-Harima Observatory in Japan, from Google Earth software. Next, we substitute the measured parallax angle (**P**), distance between two observers (**S**) and the earth's radius (**R**) as we knew already (R = 6,371 km) to the set of equations above for obtaining the **d** and **h** values. Finally, the summation of the both values is the Earth-Moon distance.

Result

After we use this method to determine the Earth-Moon's distance by using observation data between Thailand and Japan, the obtained value is 428,375 kilometers, difference from the reference value (397,254 km) [1] by around 8%.

Conclusion

The parallax method cloud result a quite precise value for the Earth-Moon distance. However, we think a small error around 8% may cause of our assumption. We assume the geometric diagram of parallax as basic as shown in figure 2, but the actual is more complicated. The direction AB isn't perpendicular to the direction Earth-Moon's center.

Reference

[1] Heavens-Above. **Moon Data**. Available Source: http://www.heavens-above.com/, Jan. 9, 2012.