

Correction Moon's Profile with Occultation Methods

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Abstract: One of the important type of occultation with the moon is called grazing occultation. The causes of this phenomenon are the lunar mountains and edge features. In the past few years, the scientific values of grazing occultation have changed. Even a visual observation with the precision of 0.5 second, would lead to very precise information about the moon edge features. More precise information about the exact lunar edge would lead to better determination of the star's positions. Understanding the precise structure of the moon edge, which is detectable during a solar eclipse, has still a great significance. For instance, for measuring the variation in sun diameter by using the observation of Bailey's beads.

Keywords: Occultation, Moon, and Timing

1. GRAZE OCCULTATION AND MOON'S EDGE FEATURES

One type of occultation with the moon is called grazing occultation. It happens when the moon and the target star have occultation for a short time in one of the lunar poles and the target star crosses one of the lunar poles in a so-called grazing way. The following picture is an example, which illustrates the grazing occultation. The star is close to the north lunar pole and the occultation will begin from the dark side of the moon. This type of star occultation is one of the shortest kinds of star occultation with the moon. In a grazing occultation, it would be possible to observe the appearance and disappearance of the target star for many times. The causes of this phenomenon are the lunar mountains and edge features. The grazing occultation is one of the most exciting astronomical occultation. One will observe a star that passes slowly in a grazing manner through one of the lunar poles mountains in absence of atmosphere and in this interval the star appears and disappears repeatedly. Normally the people who are interested to observe a grazing occultation should wait for a long time in order to observe such an event in their regional location. Therefore, in many cases, people who want to observe such an event need to travel. Right now, after the passing of Japanese spacecraft, Kaguya, from the lunar poles, accurate laser topography of that region, where the grazing occultation happen, were performed. These features are almost known with high accuracy; however, the visual or instrumented observations are still valuable and might lead to the improvement of Kaguya mapping. Therefore, as it was mentioned before, the grazing occultations are still very useful. In many cases, the observers of grazing occultations are placed on a line in order to obtain more precise data. In many of the occultations, the observations team is an important factor while without good teamwork obtaining accurate and appropriate information is almost impossible. In order to obtain an accurate demonstration of moon poles, many grazing occultations have been observed (Figure-1). In spite of different types of photographs provided by various satellites, the characteristics of moon polar features are still improved by grazing occultations (Figure-2). Therefore, as it was mentioned before, the grazing occultations are still very useful. Sometimes there are two simultaneously grazing occultations at two poles of the moon. This event is a very good opportunity for the improvement of the moon diameter via timing [1].

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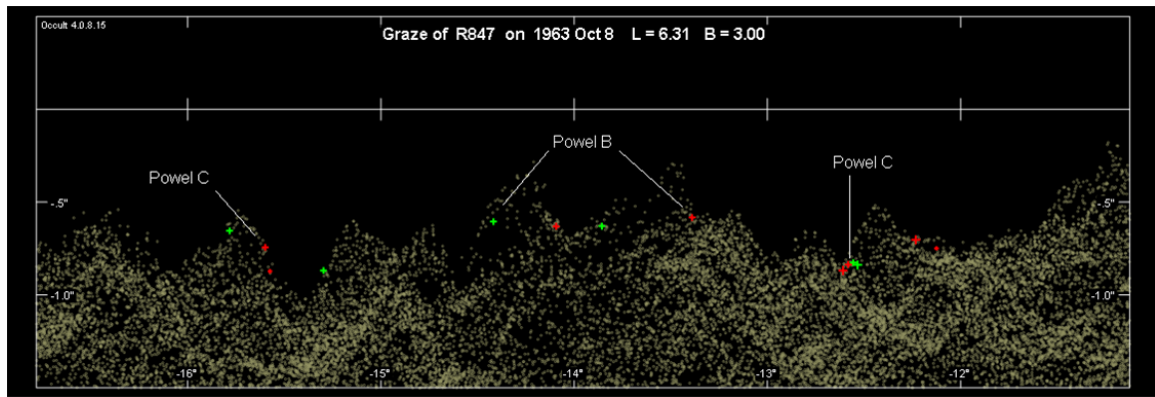


Figure-1. Reduction of grazing occultation observations

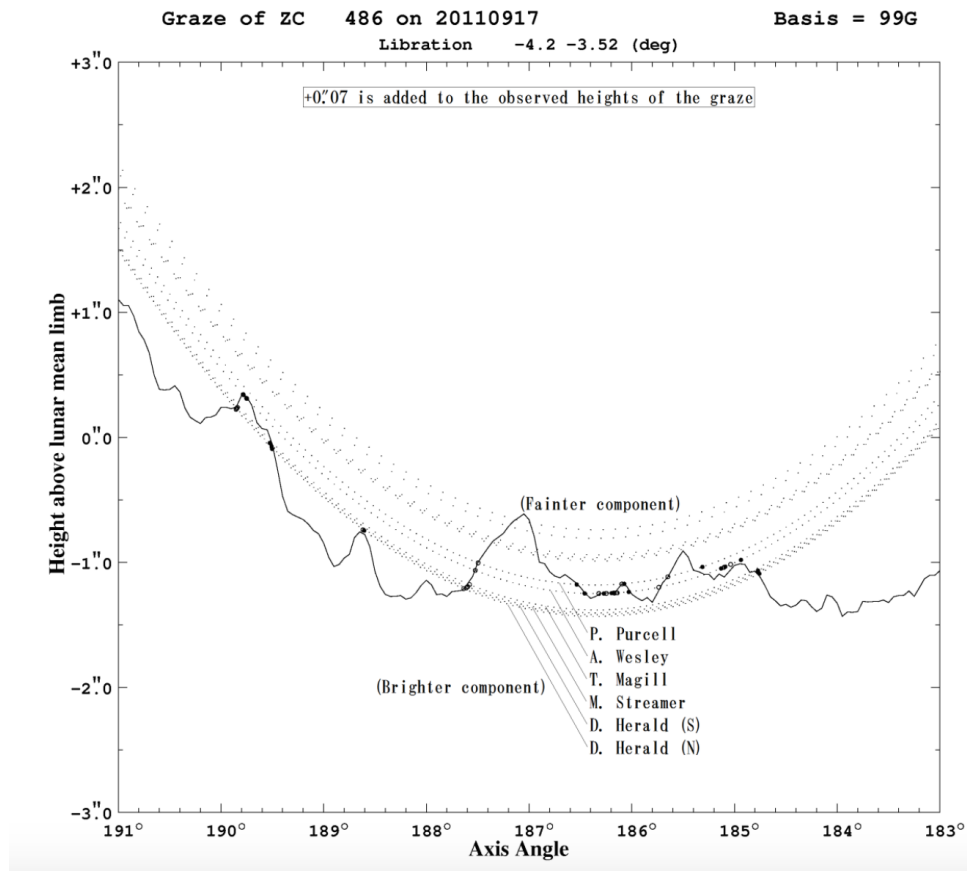


Figure-2. Reduction of grazing occultation

2. THE EFFECTS OF LIBRATION IN MOON CRESCENT SIGHTING

- You might expect that if the Moon always keeps the same face pointed toward Earth, that we can only see 50% of the Moon. However, the Moon appears to rock back and forth. This back and forth rocking is called libration.
- In its elliptical orbit around Earth, the Moon moves faster when close to the Earth and slower when farther. Since its rotation is fairly constant, we get to see a little bit around each limb.
- In addition, the orbit of the Moon is tilted with respect to the ecliptic, so we get to see some beyond the poles as the Moon moves above and below the ecliptic.
- 59% of the Moon is visible to us on Earth.

The variation of libration causes the Moon's limb features in different crescents to vary and as a result, an observer would sight different arc lengths, for crescent with the same elongation (Figure-3). The necessity of studying the libration effect gets importance when observing and sighting ultra-thin crescent is needed. Another application of libration and also shading effect is prediction and justification of discontinuous crescents. Sometimes, the existence of high mountains beside low regions gives rise to generation of high shadows that can darken some sections of the crescent, whereas in thinner edges of crescent there are not dark regions because of the existence of valleys, and the bright arc of the moon is distinguishable.

The effect of the mountain's shade of the Moon edge, that causes long shades, is one of the explanations of the Danjon limit. As a result, a bright section of the Moon is omitted. Most of the Moon's limb features caused by Moon's valleys. Danjon believed that the effective factor of occurring this limit was the shadows of Moon's mountains. Now researchers based on new data obtained the decreasing dependence of length of arc versus elongation. Researchers have shown that these effects can reduce the length of the arc. Also, libration and roughness of the lunar terrain of the Moon have effects on forming the moon crescent [2].

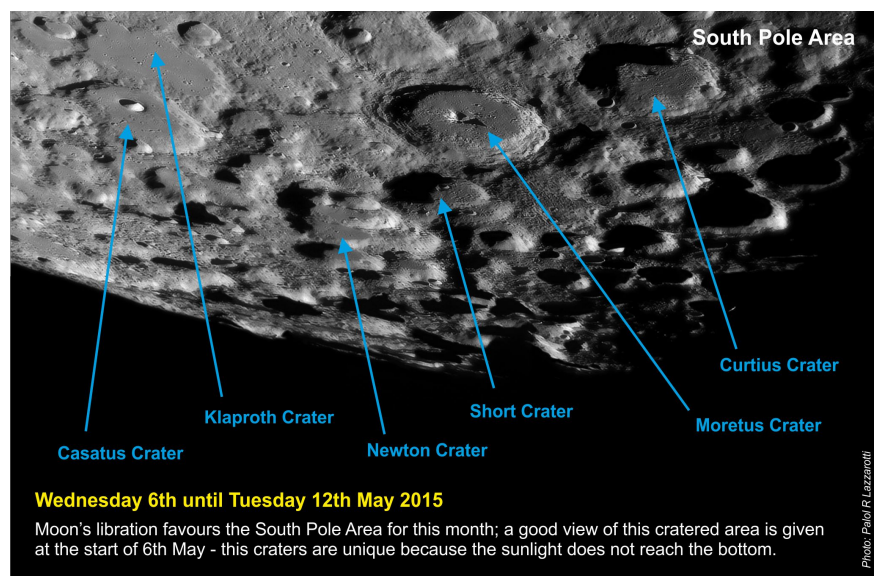


Figure-3. Moon's libration effects

3. RESULTS OF KAGUYA IN MOON'S EDGE FEATURES MAPPING

The Japan Aerospace Exploration Agency (JAXA) launched "KAGUYA (SELENE)" by the H-IIA Launch Vehicle at 10:31:01 a.m. on September 14, 2007 (JST) from Tanegashima Space Center. The topic for this exploration is "How was the Moon formed and how has it changed?" The scientific theme is called "the Moon's origin and evolution." The major objectives of the KAGUYA mission are to obtain scientific data on lunar origins and evolution and to develop the technology for future lunar exploration. The scientific data will be also used for exploring the possibility of future utilization of the Moon [3].

The Moon has been observed and explored extensively as the most familiar body. Although the Moon is more thoroughly studied than any other planetary bodies in the solar system, its origin and evolution process are still controversial. The KAGUYA mission targets are the global characterization of lunar surface and detailed gravimetry. This mission will provide globally the high-quality and high-resolution data on element abundance, mineral assemblage, surface topography, sub-surface structure, magnetic and gravity field, and precession. We aim to better understand the origin and evolution of the Moon by these observations (Figure-4). The KAGUYA mission investigates energetic particles, electromagnetic field, and plasma, around the Moon. The measurements on the lunar environments are highly valuable scientifically, and also provide important information for the future human activity on the Moon.

KAGUYA's results follow; 11/10/2015 Two-Stage Development of the Lunar Farside Highlands Crustal Formation (Keiko Yamamoto et al. P&SS), 05/09/2015 Surface vector mapping of magnetic anomalies over the Moon using Kaguya and Lunar Prospector observations (Hideo Tsunakawa et al. JGR-Planets)[†]

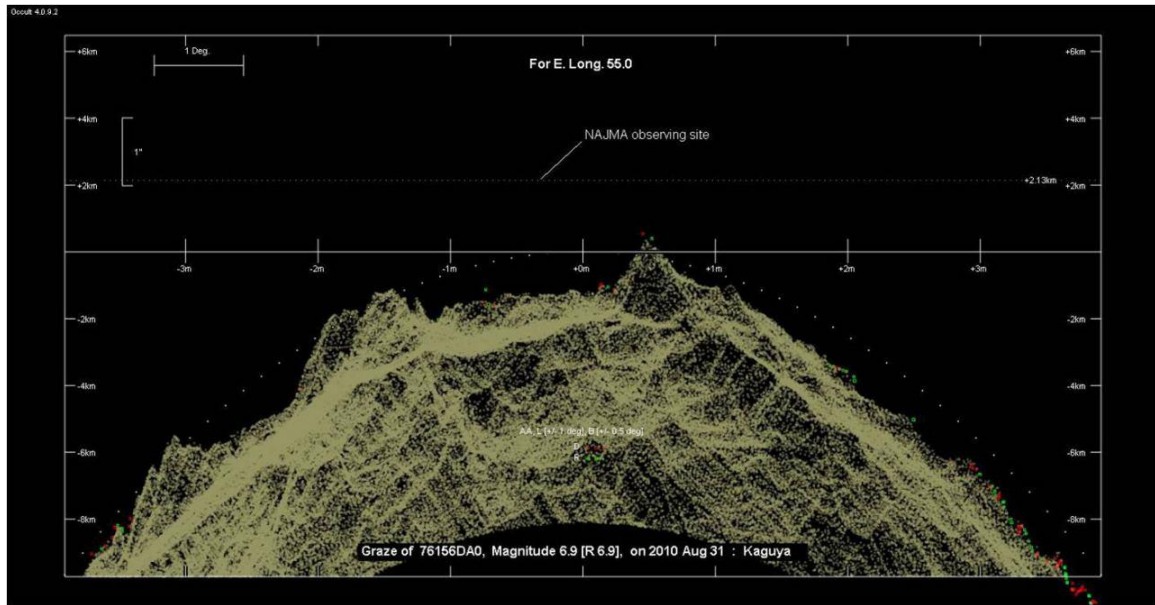


Figure-4. KAGUYA's reduction of an occultation

4. CONCLUSION

Grazing occultations can be so useful in the Moon's topology and its edge features and its scientific values have changed, even a visual observation would lead to very precise information about the Moon's edge features, which actually occurs by the lunar mountains and edge features. Kaguya mission played an important role in accurate laser topography from the lunar poles, where the grazing occultations happen. However, the visual or instrumented observations are still valuable and might lead to the improvement of Kaguya mapping. In spite of different types of photographs provided by various satellites, the characteristics of moon polar features are still improved by grazing occultations.

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