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Observation of the lunar ionosphere by dual-spacecraft method in KAGUYA mission

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Radio occultation experiments using natural radio sources which were performed in the 1950's and 1960's and those in the Russian Luna Mission in the 1970's indicated the existence of the lunar ionosphere with large electron densities of the order of 1000cm^{-3}. On the other hand, theoretically the lunar ionosphere is thought to have densities on the order of 1cm^{-3} when we consider the solar wind electric field which sweeps ions and electrons away and the very low density of the lunar neutral atmosphere. Because of this theoretical difficulty and the limited observations, there are not any widely accepted conclusions.

The radio science(RS) experiments in the SELENE(KAGUYA) mission aims at solving this problem. The mission consists of a main orbiter and two sub-satellites (Rstar and Vstar). Similarly to the previous studies, we have carried out observations many times by using coherent S-band(2218MHz) and X-band(8456MHz) radio waves transmitted from a single sub-satellite(Vstar) to discriminate plasma contribution from the fluctuation of the oscillator output frequency. However, this method can't avoid the effects of the Earth's ionosphere and the interplanetary plasma, and thus it is difficult to detect the lunar ionosphere clearly. In parallel with this single-spacecraft method, we have tried to detect the lunar ionosphere by receiving the radio waves emitted from the two sub-satellites at the same time. In this dual-spacecraft method, Rstar is used to measure the Earth's ionosphere contribution while Vstar is occulted by the moon; the difference between the two measurements gives the lunar ionosphere component. However, Rstar has coherent downlink frequencies only in S-band, and thus we are forced to use two S-bands which have frequencies close to each other(2218MHz and 2287MHz). This results in a relatively large uncertainty in the derived electron density. Moreover, the two sub-satellites must be present within the beam diameter of the ground antenna, and consequently, the number of opportunities of observations is much less than that of the single-spacecraft method.

In this presentation, we will show the results of the dual-spacecraft observation and discuss the derived electron densities. A theory about the production mechanism of the lunar ionosphere will also be presented.