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Author: Dr. Mingyuan Wang
National Astronomical Observatories, Chinese Academy of Sciences, China, wangmy@nao.cas.cn

Prof.Dr. Jinsong PING
National Astronomical Observatories, Chinese Academy of Sciences, China, jsping@bao.ac.cn
Dr. Songtao Han
Science and technology on aerospace flight dynamics laboratory, China, justdoit_doing@126.com

EXPLORING OBVIOUS LUNAR IONOSPHERE BASED ON THE SERVICE MODULE OF CIRCUMLUNAR RETURN AND REENTRY SPACECRAFT

Abstract

The existence of lunar ionosphere has been under debate for a long time. In Apollo 14 mission, the electron density detected by the charged particle lunar environment experiment (CPLEE) was $10^4 el/cm^3$ at several hundred meters high during lunar day time. In Luna-19/22 mission, the electron density profiles were detect and the peak densities were about $10^3 el/cm^3$. In the last decade, European mission SMART-1 and Japanese mission SELENE also performed radio occultation experiment for lunar ionosphere. The results of these missions don't well-matched. In order to explore the lunar ionosphere, a very low frequency radio astronomical payload has been suggested to be sent to the surface of lunar far-side by the Chinese Chang'E-4 lunar lander mission in 2019. The payload will record the Type II solar burst, which may cover the frequency of electro-magnetic wave as low as several dozen kilo-Herz. The possible lunar ionosphere above the payload with certain electron density may truncate or block the solar burst signal as corresponding plasma frequency. To estimate the possible truncate frequencies for these observations by the new kind of payload, and to determine the lunar ionospheric distribution, an lunar radio occultation experiment with the service module of Chinese circumlunar return and reentry spacecraft has been performing. The service module provides a stable and reliable frequency source, whose short-term stability is $n \times 10^{-9}$, for both X-band and S-band signal. The signals transmitted from the spacecraft in S and X band passed through lunar ionosphere, interplanetary plasma, Earth ionosphere and atmosphere, finally received by the ground tracking stations. So the extrapolation algorithm was used here to deduct the interference error of the earth ionosphere and the interplanetary plasma. Based on the above work, the electron column concentrations of lunar ionosphere was explored preliminary. The maximums of electron column concentrations are between $0.4 - 0.5 \times 10^{16} el/m^2$, are two times of the maximum result from Luna 19/22, are 1-2 orders higher than the SELENE result, but well-matched with the result from CPLEE. These results show that the lunar ionosphere is clearly exist and much stronger than we expected. The result here gives a positive support and some dynamical constrains for the scientific objective of the very low frequency radio astronomical payload onboard the Chang'E-4 lander mission. But it also raises a new question that the characteristics and formation mechanism of a stronger lunar ionosphere is remain unknown. More observations will be performed for further scientific targets.