On the origin of the ionosphere at Moon : a study using results from Chandrayaan-I S-Band Radio Occultation Experiment and a photochemical model

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The existence and characteristics of atmosphere and ionosphere at Moon has remained an enigmatic question in front of the scientific community. Debates are still going on among scientists on various explanations and observations of lunar ionosphere (T. J. Stubbs et.al., Planet. Space Sci., 1659–1664, 2011; Imamura, T., et al., J. Geophys. Res., 2012). The large angular shifts observed in the stellar radio experiments proposed the existence of lunar ionosphere with electron density of the order 1000cm^{-3} and thickness of several kilometers. As the existing understanding about atmosphere at Moon fails to explain such a large electron densities, Stubbs et al. [2011] put forward the concept of dusty plasma for the formation of lunar ionosphere. In this study, we revisit the origin of ions at Moon using a photo chemical model, developed using measurements from a Mass Spectrometer (CHACE), and electron density using Radio Occultation experiment abroad Chandrayaan-I .

Using Chandrayaan-1 communication link between orbiter and ground (S-band frequency), the presence of ionosphere at Moon has been explored using Radio Occultation technique. Results obtained from the observations conducted between July 30 and August 14, 2009 show evidence for the existence of the Ionosphere at Moon. A few seconds before the occultation of Chandrayaan-1 radio signals, extra fluctuation in the rate of change of difference between the theoretically estimated Doppler and observed Doppler was observed. Using standard “onion-peeling” technique to invert the phase changes in radio signals to the refractivity of the medium, we estimated the electron density profiles for the Lunar medium. The estimated electron density is shown in Figure 1. It was of the order of 400 - 1000 cm-3 near the Lunar surface which decreased monotonically with increasing altitude till about 40 km above the surface where it became negligible. The observed electron density was compared with the results from a photochemical model (Figure 2) which was developed based on CHACE measurements abroad Moon Impact Probe of Chandrayaan-I. We propose that the ionosphere over Moon could have molecular origin with O_2^+ and H_2O^+ as dominant ions.

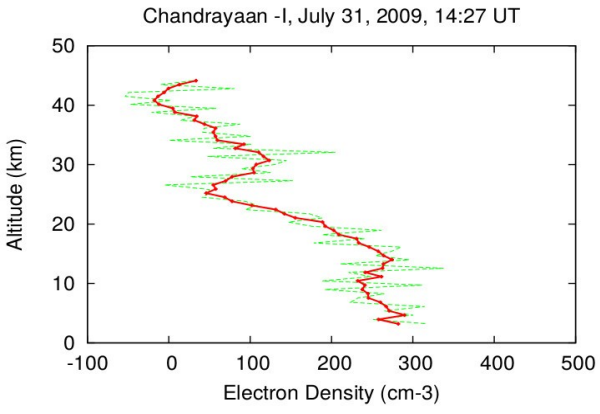

Figure 1: Altitude profile of electron density at Moon using Chandrayaan-I's radio signal.

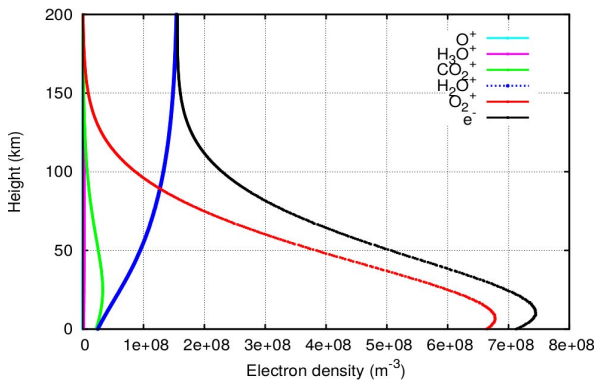

Figure 2: Photochemical model : Individual ion density and electron density