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Micro/Nano-satellite-based Planetary Exploration: Study of noble gases in the lunar exosphere using CHACE mass spectrometer in the Moon Impact Probe (MIP) in Chandrayaan-1

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In 2008, a microsatellite called Moon Impact Probe (MIP) was launched as a piggyback to the Chandrayaan-1 orbiter during India's first lunar mission. MIP was an impactor, which weighed ~35 kg, and was a half-meter sized cuboid, with its own propulsion system. It studied the Moon from a close range, during its travel from 100 km lunar altitude, till the surface, covering a latitude range of 40 deg N to 89 deg S, along the 14 deg E meridian. In the history of India's planetary exploration, so far, that was the only microsatellite launched.

MIP housed the Chandra's Altitudinal Composition Explorer (CHACE) quadrupole mass spectrometer, which studied the lunar neutral exospheric composition in the dayside of the Moon for the first time. Earth's Moon has an extremely thin atmosphere (~10^5 to 10^7 atoms cm^{-3}, accounting for its variability), where the gas atoms and molecules rarely collide, rendering it to the category of 'exosphere'. The lunar exosphere is a typical example of surface-boundary-exosphere, which is a result of the dynamic equilibrium between several source (influx of solar material, internal release, delivery from meteoritic bombardment, desorption, sputtering) and sink (gravitational escape, ion escape, condensation loss) processes.

The CHACE/MIP conducted an investigation of the sunlit side of the lunar neutral exosphere in the mass range of 1 to 100 amu and studied its dynamics using lunar exospheric noble gases (Ar, Ne, He) and H_2 as tracers.

The important science results of this microsatellite based investigations include the following.

1. Two dimensional (latitude versus altitude) distribution of lunar exospheric Ar, Ne and H2 based in the sunlit lunar exosphere along the plane of the MIP trajectory is established.

2. Results on the spatial heterogeneity and indications of inter-hemispherical asymmetry of radiogenic activity in the lunar interior through the measurement of the ^{40}Ar:^{36}Ar ratio.

3. Empirical formula connecting the surface number density of lunar Ne and the surface temperature is proposed.

4. Upper limit of the He density in the sunlit lunar exosphere under extreme astronomical conditions is proposed.

5. Spatial heterogeneity of H_2 in the lunar exosphere is brought out.

These results evoked enough scientific curiosity which prompted detailed in-situ investigation of the lunar exosphere from a polar orbiting platform in Chandrayaan-2, and are potential inputs for constraining the lunar exospheric models.