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Angular Scattering of Energetic Neutral Hydrogen Atoms off the Lunar Surface

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Planetary surfaces, such as the lunar surface, which are not shielded by an atmosphere or a global magnetic field, are constantly bombarded by the surrounding plasma, e.g. by solar wind ions. When these ions hit the lunar surface, a large percentage is backscattered as energetic neutral atoms (ENAs). Measurements conducted by IBEX and Chandrayaan-1 showed that the backscatter fraction lies in the range 10–20% of the impinging solar wind ions (McComas et al., GRL 2009, Wieser et al., PSS 2009, and Rodríguez et al., PSS 2012). The energy of the backscattered ENAs is sufficiently high so that the individual trajectories can be mapped back onto the lunar surface in a straight forward manner and imaging of the surface using the ENAs is possible. To guarantee a quantitative imaging of the lunar surface, the angular distribution of the released ENAs has to be taken into account, though. It was formerly assumed that most of the impinging solar wind ions are absorbed by the lunar surface. Before CENA, no analysis of in-flight measurements concerning the angular scattering profile was available. We therefore analysed all available measurements conducted by CENA, the Chandrayaan-1 Energetic Neutral Analyzer, to derive the scattering profile of low energetic hydrogen atoms coming off the lunar surface. Our analysis shows that the angular scattering profile exhibits 4 distinct features for increasing solar zenith angle: 1) amplitude decrease, 2) increased azimuthal structure, 3) bigger ratio of sunward versus anti-sunward flux and 4) shallower polar scattering. We derived four mathematical functions, each of which describes one feature, and the product of which describes the ENA angular distribution function. The directional ENA flux can then be described as the product of the impinging solar wind flux, the reflection ratio at the sub solar point and the ENA angular distribution function. This function has been derived from lunar backscatter data, but it should be applicable to mapping of any planetary surface that is not protected by an atmosphere or a global magnetic field.