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Scattering function for lunar ENAs: Observations from SARA on board Chandrayaan-1

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Abstract

When solar wind particles hit the lunar surface, a large amount is backscattered as neutral hydrogen. The backscattered ENAs exhibit a distinct angular distribution, depending on the solar zenith angle. We analysed ENAs, measured by SARA on board Chandrayaan-1, to determine a mathematical description of this scatter distribution as a function of the solar zenith angle and the observation angles.

1. Introduction

The Sub-keV Atom Reflecting Analyzer (SARA) provided us with a large amount of measurements of energetic neutral atoms (ENAs) originating from the lunar surface. Wieser et al. [1] showed that these ENAs were originally solar wind ions, which are backscattered as neutral hydrogen. The backscattered hydrogen shows an angular distribution that strongly depends on the angle under which the solar wind ions had impinged onto the lunar surface. We therefore analysed all available measurements and derived a mathematical description for the complete observation space.

2. Observations

Almost 30'000 observations on the sunward facing side of the moon were conducted by SARA during the time Chandrayaan-1 was in orbit around the moon. The solar zenith angle reaches from 0 to 90 degrees for this side of the moon. Seven angular sectors of SARA provide a full coverage of the elevation angle. Together with the angle between the orbit plane and the solar incidence direction these set of observations represents a full coverage of the observation azimuth angle.

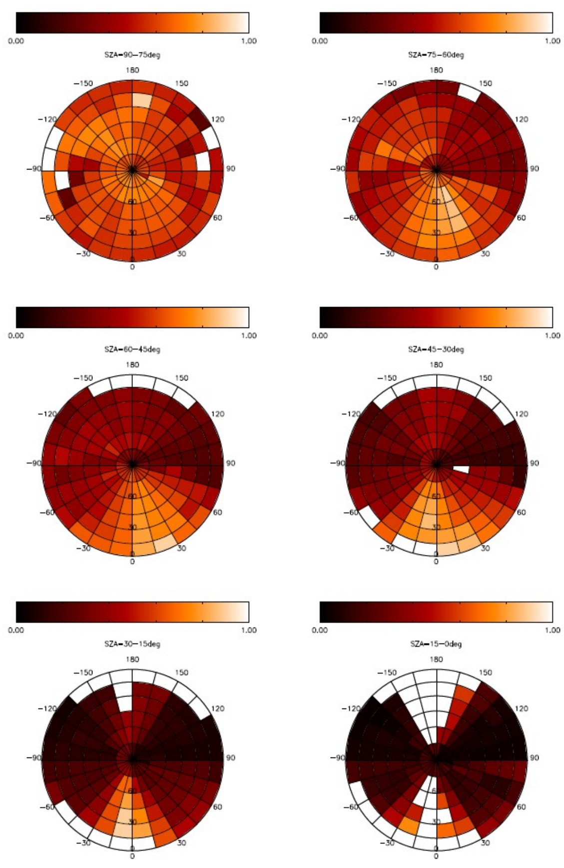

Figure 1: Normalized measured counts for 15 degree solar zenith angle intervals. The solar zenith angle increases from left to right and top to bottom.

3. Results

We found that the emission function can be broken down into three components representing certain characteristics of the ENA emission: azimuthal uniformity, ratio of flux reflected back towards the sun vs. flux reflected in an anti-sunward direction, and the elevation angle at which the reflected flux has its maximum.

3.1 Uniformity

The azimuthal uniformity can be described by a $\cos(2\phi)$ function, with ϕ the azimuth angle of emission. The data show that the shallower the solar zenith angle, the less uniform the emission function becomes.

3.2 Sunward vs. anti-sunward flux

We observe that ENAs have a stronger tendency to be reflected back toward the incoming ion direction than to continue on at a grazing angle. This effect can be described by a $\cos(\phi)$ function, with ϕ the azimuth angle of emission. This effect is stronger the shallower the solar zenith angle.

3.3 Elevation angle

The elevation angle at which the emission function shows its maximum follows closely the solar zenith angle: The shallower the solar zenith angle, the shallower the emission profile. This dependency can again be described by a $\cos(\theta)$ function, with θ the elevation angle of emission.

4. Summary and Conclusions

We derived a mathematical description of the emission function as function of the solar zenith angle and the observation angles. This function provides the basis for ENA imaging of the lunar surface and possibly any other planetary surface not protected by an atmosphere.

References

[1] Wieser et al.: Extremely high hydrogen reflection from regolith in space, Planetary and Space Science, Vol. 57, pp. 2132-2134, 2009.