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Protons observed in the near lunar wake by the SARA/SWIM sensor onboard Chandrayaan-1

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We report significant proton fluxes detected in the near wake region of the Moon by the ion mass spectrometer SWIM on board Chandrayaan-1 spacecraft. These nightside protons are even detected close to the lunar equatorial plane at a solar zenith angle of 140˚, i.e. about 50˚ behind the terminator at a height of 100 km. The observed energy of these nightside protons is slightly higher than that of the upstream solar wind protons. The density of them is 1000 times less than that of the upstream solar wind. The arrival direction of the nightside proton fluxes is just above the local horizon, but in the solar wind stationary frame the fluxes move along the magnetic field. Therefore, we concluded that the nightside proton fluxes are of the solar wind origin, but are accelerated along the magnetic field during their expansion into the lunar wake. We have then compared the observed proton fluxes with the predictions from analytical models of an electrostatic plasma expansion into a vacuum. Two analytical models are examined. Both uses a set of equations based on 1-D gas-dynamics, but one assumes a Maxwell-type electron velocity distribution function and the other assumes a Kappa-distribution. It is found that both models qualitatively agree with the observations, however, the observed proton density is lower by a factor of 5-10, and the observed velocity in the solar wind reference frame is higher by a factor of 2-3 compared to the model predictions. This discrepancy between the observations and the models may be explained by the absorption of the plasma particles by the lunar surface at the terminator region where the solar wind proton expansion is initiated.