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Ionospheric cold ions in the magnetotail lobes

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Abstract

Ions with energies in the eV range are notoriously hard to detect outside a few Earth radii geocentric distance, as the low plasma density typical of the outer magnetosphere result in a highly positive spacecraft potential, repelling ions from a satellite and preventing their detection by onboard ion detectors. By a method relying on the observed properties of the wake formed behind a spacecraft in a cold ion flow, we have mapped such "invisible" ions in the terrestrial magnetotail as far as the apogee of the Cluster satellites, around 19 Earth radii. We show that these ion flows are very common and sums up to a total ionospheric loss of about 10^{26} ions per second. While we cannot unambiguously separate ion masses, we note that the method is more sensitive to protons than to oxygen ions, and argue that the dominant species in our observations is hydrogen. We also present verifications of the centrifugal acceleration of the ions, based on observed magnetic and electric field data. To estimate the real efficiency of the Earth's magnetosphere for the quenching of solar wind erosion of the atmosphere, the net outflow is the crucial parameter, so we also discuss the fractions of our observed outflow that can be expected to return the Earth or escape into the solar wind.