Early Results from ASPERA-3 on Mars Express

Analyzer of Space Plasmas and Energetic Atoms

Presenter: James R. Sharber
On the Mars dayside we show evidence of accelerated heavy ions (e.g. O+) at low altitudes (~300 km).

We have evidence of direct solar wind electron and ion penetration to low altitudes in restricted regions of the Mars dayside (“cusps”).

As MEX approaches Mars, electrons show a ramp-up, shocked sheath region, and a clear transition region to the ionospheric photoelectron population.

On the nightside of Mars there is evidence of electron acceleration to several hundreds of eV with characteristics similar to those of suprathermal bursts observed at Earth. At times concurrent ions (O+, O₂+) are observed.
ASPERA-3
Analyzer of Space Plasmas and Energetic Atoms

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Swedish Institute of Space Physics + 14 teams from Finland, France, Japan, Germany, Ireland, Italy, Russia, Switzerland, UK, and USA

**Question:** Is the solar wind erosion the prime reason for the present lack of water on Mars?

**Objective:** To measure solar wind scavenging: The slow escape of volatiles (atmosphere, hydrosphere) from Mars.
ASPERA Instrumentation

Main Unit:
- Neutral particle imagers (NPI, NPD)
- Electron spectrometer (ELS)
- Data processing unit (DPU)
- Mechanical scanner

Ion Mass Analyzer (IMA)
**Instrumentation**

**Main Unit:**
- Neutral particle imagers (NPI, NPD)
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**Ion Mass Analyzer**
Electron Spectrometer (ELS)
Mar 1, 2004
Electrons in the Mars Ionosphere

Magnetic Anomaly
Ionospheric Plasma
Sheath Plasma
Transition Region
Protection Grid Cut-Off
Photoelectrons

Aug. 18, 2004
ELS Spectra - Mar 22, 2004
Transition Region

The magnetosheath has an inner boundary consistent with Crider mechanism.

In the transition region magnetic field lines must be long enough that the photoelectrons suffer significant atmospheric degradation, which would not occur in a vertically stratified non-magnetized model.

As MEX moves further down in altitude, we are reach a region where the mass density along the path becomes significantly less, enabling a measurement of the photoelectron peaks near their production altitude.
Expected Mars Photoelectron Spectrum at 145 km
from the ASPERA-3 Electron Plasma (ELS) Instrument
2004061/08:11:00 - 2004061/08:22:00, Corrected for -8V Spacecraft Potential; Flux Multiplied by 2

Mantas and Hansen, 1979
Expected Mars Photoelectron Spectrum at 145 km
from the ASPERA-3 Electron Plasma (ELS) Instrument
Instrument Response, Instrument Threshold (2 count), and Poisson Errors

Log Electron Intensity [cnts/(cm^2-sr-eV)]

Log Electron Energy [eV]

Electron Energy [eV]
Electrons in the Mars Ionosphere

Protection Grid Cut-Off

Magnetic Anomaly

Ionospheric Plasma

Sheath Plasma

Transition Region

Log Electron Energy (eV)

Mars Express Altitude Distance (km)

2004/06/1 07:59
Pc Lat -85.07 -76.54 -56.44 -33.01 -8.86 13.05 31.25
Pc ELon 144.98 264.77 272.64 274.14 274.37 274.24 274.06

Aug. 18, 2004
ASPERA-IMA, ELS  1 March 2004

IMA March 1, 08:10-08:13 UT

E (eV)

Log Count

Mass Channel

32

1

10000

1000

100

10

E (eV), H+, He++

Log Count

Mass ch 6-14

Log C/S

E (eV) Electrons

UT

08:00 08:10 08:20 08:30

H (km)

1250 510 270 700

Long (°)

144 -89 -86 -66

LAT (°)

-85 -64 -25 13

PEB IMB

Mars Aeronomy Workshop
Aug. 18, 2004
1. The Solar wind may protrude very deep into the atmosphere - down to pericenter altitudes ≈270 km

2. Acceleration processes responsible for the erosion of atmosphere - the planetary wind - start as low as ≈270 km above the surface of Mars.

3. Accelerated/outflowing O\(^+\) may reach several keV at 300 km altitude.

4. The planetary wind also contains molecular species (e.g. CO\(_2\)\(^+\) and O\(_2\)\(^+\)), consistent with acceleration processes reaching low altitudes.

5. Statistical results on dayside magnetosphere boundaries (Photoelectron Boundary and Induced Magnetosphere Boundary)
Atmospheric Outflow from Mars

Induced Magnetosphere Boundary (IMB)

270 - 500 km

650 - 1200 km

Solar Wind

Bow Shock

Photoelectron Boundary (PEB)
Electron Acceleration - Nightside

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Aug. 18, 2004
Summary

The neutral atom imagers are in operation but are still in commissioning phase.

Several study areas are continuing with the in-situ instrumentation:

Photoelectron spectrum: work in progress to determine our ability to measure the identifying peaks in order to use ELS as a remote sensor of atmospheric properties at distant locations along the magnetic field line.

Characteristics and dynamics of the various plasma regions and the locations of their boundaries will continue with the objective of further specifying the nature and causes of the escape of ions from the atmosphere.

Comparison of particle observations with magnetic anomaly locations will continue in an effort to determine the effect of the anomalies on entry of particle populations into the Mars atmosphere and outflow of planetary atmospheric constituents.