ASYMMETRY OF PHOTOELECTRON DISTRIBUTION AND ITS DEPENDENCE ON SPACECRAFT POTENTIAL OBTAINED FROM GEOTAIL DATA

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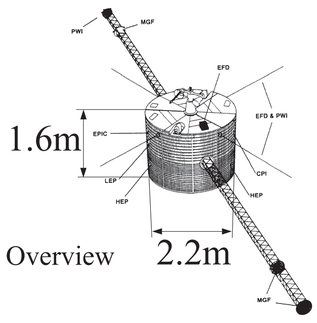
Abstract

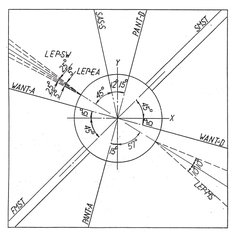
In the Earth's magnetosphere where the spacecraft potential is usually positive, photoelectrons emitted from the spacecraft surface are attracted back to the spacecraft and some of them are detected by electron analyzer onboard. Then photoelectrons are unnecessary contamination. By analyzing such a component detected by LEP/EA-e onboard GEOTAIL spacecraft, we examined velocity/energy distribution functions of photoelectrons, and their relationship to the spacecraft potential.

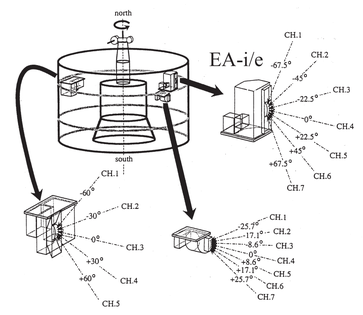
We found that the ratio of the duskward photoelectron flux to the dawnward flux increases when the spacecraft potential is large, and decreases when it is small. Further analysis revelaed, by plotting the ratio as a function of the photoelectron energy normalized by the spacecraft potential (E/Vsc), that it is largest when E/Vsc is about one third. This result implies the existence of an azimuthal component of electric field as well as the radial component which is regarded to be dominant in an ordinary case around the spacecraft surface, although it is not clear why such electric field is generated around GEOTAIL.

GEOTAIL Spacecraft

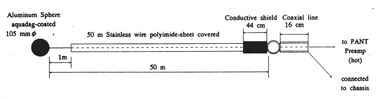
Launch: Jul. 24, 1992
Spin period: 3 sec
θs: 87±2° (before Jan, 1998)
Surface: InO_3







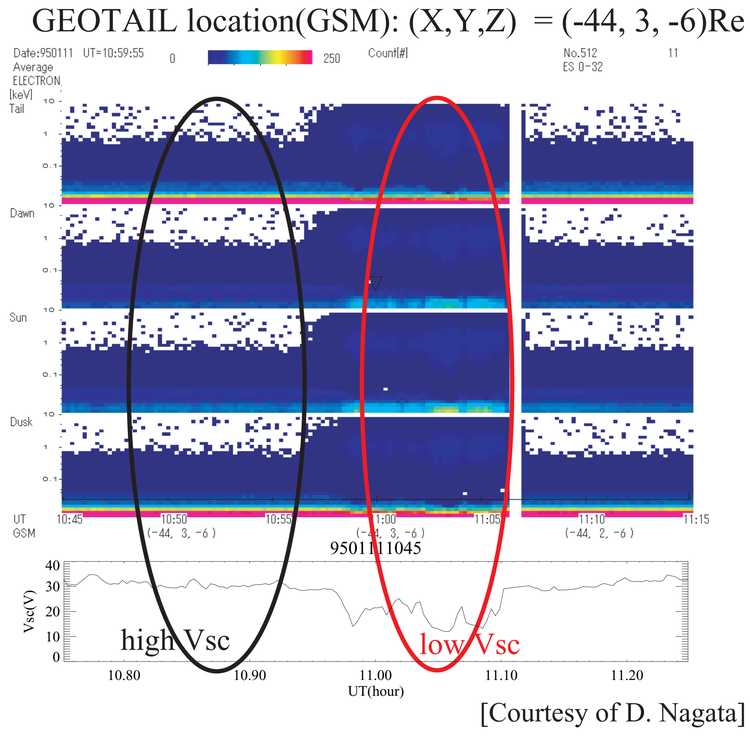
LEP
- 3D distribution function of ions and electrons on every 12 sec
Elevational channels: 7
Azimuthal sectors: 16
Energy steps: 32
- Energy range of EA-e (for electrons)
RAM-A: 60eV - 38keV
RAM-B: 8.3eV - 7.6keV



EFD-PANT
- Electric field and spacecraft potential

Event Study

1045-1115UT on Jan. 11, 1995
GEOTAIL location(GSM): (X,Y,Z) = (-44, 3, -6)Re



[Courtesy of D. Nagata]

- Dawnward photoelec. < Duskward photoelec.
- Dawnward and sunward photoelec. counting rates decrease as Vsc increases.
- Duskward and tailward photoelec. counting rates increase as Vsc increases.

→ Dependence of photoelectron asymmetry on Vsc

Statistical Results

Data selection
- Data from LEP/EA-e worked in RAM-B (low energy) mode & GEOTAIL was sunlit in the magnetosphere

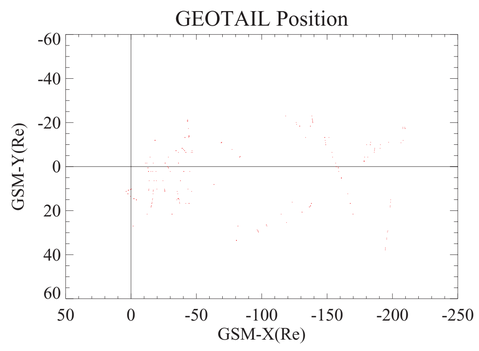
Criteria for GEOTAIL being out of the magnetosphere
(In the magnetosheath or the solar wind)

- $N_i > 0.5 cm^{-3}$
- $V_{ix} < -200 km/s$
- $T_i < 400 eV$

and
- $P_d = M_i N_i V_{ix}^2 > 0.5 nPa$

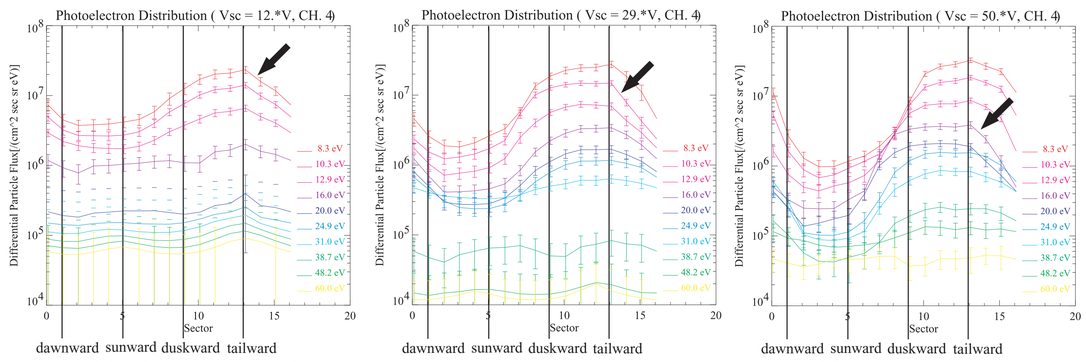
[Nakamura et al., 1997] (with some modification)

→ 168,166 samplings



Data sorting
- by spacecraft potential with one-volt bin

Averaged 2-D differential flux of electrons of each Vsc-bin (using only Ch. 4 data of LEP/EA-e)



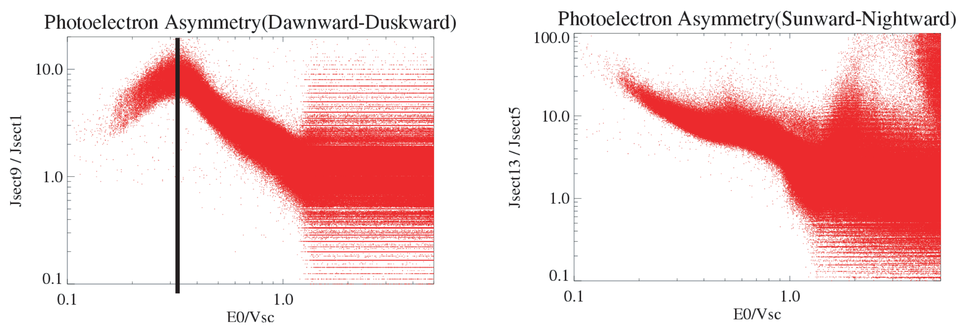
(a) 12V < Vsc < 13V (b) 29V < Vsc < 30V (c) 50V < Vsc < 51V

Strong dawn-dusk asymmetory is seen at (a) 8.3eV, (b) 10.3eV, and (c) 16.0eV.

Lowest energy step Vsc/3

→ Does phoelectron asymmetry depend on Energy/Vsc rather than Vsc itself ?

Relation between photoelectron distribution and Energy/Vsc



The ratio of duskward photoelec. flux to dawnward photoelec. flux

The ratio of tailward photoelec. flux to sunward photoelec. flux

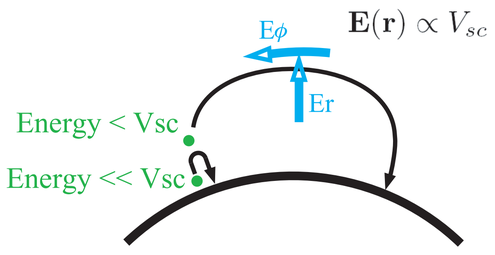
both as a function of Energy/Vsc

→ Strong dependence of photoelectron asymmetry on Energy/Vsc

Discussions

A possible reason for the asymmetry

Azimuthal electric field generated by spacecraft charging



An azimuthal electric field and dawnward-shifted photoelectrons

Azimuthal electric field of spacecraft origin is the most probable reason.

However,
a couple of masts are deployed symmetrically with respect to FOV of LEP/EA-e.

→ How to explain the source of such azimuthal electric field ??

Other possibilities

- Gyromotion of electrons due to the ambient magnetic field

Electron gyroradius:
$r_c = 3.4 \cdot 10^3 \sqrt{K}/B$
(K: elec. energy, B: magnetic field)
For K = 1eV and $B \approx$ 30nT (in lobe)
$r_c \approx 110\mathrm{m} \gg$ Spacecraft Size
→ Not effective

- Effect of ambient electric field (dawn-dusk direction)

Ambient Ey ~ 0.1 - 1mV/m
Comparison with Er
$E_r \approx V_{sc}/\lambda_D \sim V_{sc}/\lambda_{D\,ph}$
cf. Debye length of photoelec.
$\lambda_{D\,ph} \sim 4.7\mathrm{m}$ (6V < Vsc < 25V)
[Nakagawa et al., 2000]
Debye length of ambient elec.
$\lambda_{D\,amb} \sim$ 100 - 1000m
[Baumjohann and Treumann, 1997]
$E_r \sim 1\mathrm{V/m} \gg E_y$
→ Not effective

Summary and Conclusion

We examined a 2-D photoelectron distribution around GEOTAIL and its dependence on spacecraft potential.

Dawn-dusk asymmetry as well as day-night asymmetry was found. They strongly depend on the ratio of photoelectron energy to spacecraft potential.

Such dependence suggests the existence of the azimuthal electric field of spacecraft origin, although the source of such an electric field has not been identified.