

Plasmasphere Brainstorm Meeting

IASB, Brussels

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Minutes (F. Darrouzet)

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Agenda:

Presentations (24/02/2003):

VP: Electric Field Models in the Plasmasphere
FD: Plasmasphere Measurements from Spacecraft
HL: Polar Results in the Plasmasphere
AM: Density Determination from EFW and WHISPER
JGT: Density Determination from WHISPER
PD: AGU 2001 and COSPAR 2002 Talks
HL: Cluster Results in the Plasmasphere
GC: Barycentric Tools for Cluster
JL: VHS-Video animation on plasmasphere

Discussions (25/02/2003):

Events already studied
Review of all plasmasphere crossings in 2001/2002
List of new interesting events (small separation scale)
Review physical mechanisms and models
Tools available for plasmaspheric studies
Papers in preparation
Future conference/meeting
Use of other instruments on Cluster (EDI, FGM, WBD, CIS, PEACE)
Miscellaneous...

See also the file: Agenda_IASB_PLS_24_25FEB2003.doc

Presentations:

VP: Electric Field Models

cf.: *PLS_24_25FEB2003_BXL_V.Pierrard_Plasmasphere.ppt*
PLS_24_25FEB2003_BXL_V.Pierrard_Plasmasphere_Figures.zip

- * 3 different electric field models:
 - Uniform dawn-dusk (Volland-Stern, 1973)
 - E3H (McIlwain, 1974)
 - with data from ATS 5 and 6; OK for low Kp (<2)
 - E5D (McIlwain, 1986)
 - dependent on Kp, LT \Rightarrow dawn-dusk and noon-midnight asymmetries
- * Magnetic field model:
 - M2 (McIlwain)
 - not dependent on Kp, but more complicated than a simple dipole
- * Spacecraft Data-Simulation of the plasmopause formation by interchange motion:
 - 24/05/2000: IMAGE data: shoulder
 - Simulation (with E5D and M2): shoulder and tail in the afternoon sector
 - 06/2001: Cluster and simulation: plasmopause like a circle (low Kp).
- * Ground-Based Data-Simulation:
 - Position of plasmopause at different LT, comparison between Whistlers and simulation: good.
- * Conclusion on simulation:
 - Advantages:
 - Independent on plasmopause position
 - Continuous dependence on Kp
 - Dawn dusk and noon midnight asymmetries
 - Disadvantages:
 - When Kp increases, E is disturbed and is non-stationary while E5D represented by stationary equipotential surfaces.
 - B independent on Kp

FD: Plasmasphere Measurements from Spacecraft

cf.: *PLS_24_25FEB2003_BXL_F.Darrouzet_Measurements_Spacecraft.ppt*

- * Particles and waves experiments; history divided in 3 parts (...-1970, 1970-1980, 1980-...).
- * ...-1970:
 - First ion density measurements with LUNIK 2: good agreement with whistlers results (Carpenter)
 - ELECTRON and OGO missions: size of plasmasphere decreases as Kp increases
 - Plasmopause position from L=3 to 7
 - Temperature measurements: ion with LUNIK 2 and electron with IMP 2 and OGO 5
 - \rightarrow not very good measurements
 - OGO 3 and 5: helium and oxygen ions measured

- * 1970-1980:
 - PROGNOZ 2: dawn-dusk asymmetry
 - GEOS 1 and 2: 3 different instruments measuring density (\Rightarrow comparison)
 - ISEE 1: negative temperature gradient below $L=3$
higher temperature in nightside than dayside for $L>4$
- * 1980-...:
 - DE 1: lots of various categories of density profiles
 - DE 1: heated superthermal population in addition to the cold one seen only in the equatorial plane
 - EXOS-D: measurements of bulk velocities
 - ACTIVNY: observations of thermal O^{++} ions
 - CRRES: large frequency-time spectrograms (40 Hz - 400 kHz) \Rightarrow waves in the plasmasphere
 - INTERBALL: differences between nightside and dayside plasmopause (with 2 satellites)

HL: Polar observations in the plasmopause/trough region

cf.: *PLS_24_25FEB2003_BXL_H.Laakso_Polar.ppt*

- * Polar orbit \Rightarrow 4 crossings per orbit \Rightarrow 10000 crossings !!
 - power law coefficients for the plasmasphere and trough densities
 - plasmopause location and thickness
 - as a function of MLT and K_p .
 - V_{sc} from EFI (04/1996-12/1999) $\rightarrow N_e$
- * Velocity measurements \Rightarrow convection and co-rotation regions
- * Case 11-12/05/1999: evolution of plasmopause position with a substorm ($L=12 \rightarrow L=7$)
- * Power law to fit electron density in plasmasphere and trough (comparison with Carpenter curves), statistic on the parameter of the power law in the trough:
 - generally decreases with K_p
 - strongly asymmetric with MLT for all K_p
- * Plasmopause location and thickness (MLT, K_p):
 - K_p increases \Rightarrow thickness decreases
 - K_p increases \Rightarrow L-position decreases
 - in MLT = 12-18, ΔL is \approx constant for different K_p
 - dawn-dusk asymmetry for increasing K_p
 - **PD**: one should winter and summer data in the statistic
for dayside, use average K_p , for nightside, use exact K_p
 - **JL**, **VP**: good agreement with simulation and whistlers data at 2 LT.
 - **HL**: V_x not used because calculated from $E \times B$, and E_y poorly measured on POLAR.
 - cf. power point presentation for more conclusions

AM: Electron Density and Spacecraft Potential

cf.: *PLS_24_25FEB2003_BXL_A.Masson.ppt*

- * V_{sc} every 0.2 seconds on Cluster, and working on all spacecraft with 100% coverage

* Old technique: 1 power law, without interference treated and on whole time interval
New technique: 2 power laws (for low and high density, separation around $\Delta V_{sc} = 2$ Volts), with interference treated, estimation error, and chosen time intervals.

JL: Perhaps better to use Kappa function (= Maxwell at low energy and power law at high energy)

* Comparison with WBD data by extrapolation of fitting curve to validate the method:
good, but just a few cases.

* Future:

- More comparisons with data (electrons and ions measurements, systematic comparisons with WBD)
- Study the bias current and the satellite aging on the relation between N_e and V_{sc} .
- Study the influence of the magnetic field (Bouhram et al., 2002) on this relation.
- Study the influence of the geometry of the tetrahedron on this relation.

RQ: Not possible to derive electron temperature from WHISPER (too much electronic noise)

JGT: Determination of F_p from WHISPER

* Active case:

- valid for a Maxwellian plasma
- determination of f_p done with f_q : with the Hamelin diagram, the well aligned f_p observed on the spectra give the f_p .
- sometimes, all the f_q are not well aligned: all the f_q that can be aligned give the f_p that corresponds to the cold plasma population, and the peak observed on the spectra corresponds to the total electron plasma frequency.
- the maximum of the spectral energy gives an upper limit for f_p .
- in the plasmasphere, there are 95% of cold electrons, so all the f_q are almost always aligned.

PD: AGU 2001: Outer plasmaspheric Structures, Topology and Dynamics: Views from the Whisper instrument on Cluster

cf.: PLS_24_25FEB2003_BXL_P.Decreau_OutPS_NdeT2.ppt

* General context:

- 1 pass in both hemispheres every 57 hours
- plasmasphere different with MLT and geophysical conditions

* 05/06/2001:

- s/c 1 and 4 on same LT, s/c 2 closest to the Earth
- irregularities: the large inbound one is seen on the 4 s/c \Rightarrow structure stagnant (in 1h00 at least)
the small ones are almost identical on s/c 1 and 4, but different on s/c 2 because s/c 2 is at different LT than 1 and 4)
the outbound structure is seen on 1 and 4 (problem in density data of s/c 4)
- 2D view: plan OXM (but this M point is not the same for the 4 s/c !!)

* Drift velocity and irregularities should be further studied.

PD: COSPAR 2002: Properties of density structures measured by the Whisper instrument on-board Cluster

cf.: *PLS_24_25FEB2003_BXL_P.Decreau_WHI_COS_V3.ppt*

- * Large separation
 - density structures, generally field aligned
 - too dynamic on 24/06/2001 to be resolved by this large separation
 - remarkable similarity on the 4 s/c for the 13/06/2001.
- * Small separation
 - 09/05/2002: IB structures superposed on the 4 s/c, and then not superposed → spatial effect
 - 08/02/2002: density gradient towards the Earth (OK), change in direction in the YZ plane, comparison between EDI velocity and velocity derived from time differences
- * Problem with the magnetic field obtained with the models which is quite different from the FGM data
 - use FGM to improve models??

HL: Cluster Observations in the plasmopause region

cf.: *PLS_24_25FEB2003_BXL_H.Laakso_Cluster_Plasmopause.ppt*

- * Short separation, 08/02/2002 (1-2 MLT):
 - lots of plasmopause crossings
 - 2 min waves on azimuthal electric field
 - larger radial inward drifts (due to waves)
 - ⇒ 2 min waves on the plasmopause
- * Large separation, 15/01/2002 (3 MLT):
 - crossings in 2.5 hours
 - plasmopause with a flow separatrix layer
 - radial flow speed is positive on both sides of plasmopause !!
 - ⇒ narrow flow separatrix
- * Large separation, 22/01/2002 (3 MLT):
 - again large outward flow
 - ⇒ breathing plasmopause
- * Large separation, 29/01/2002 (2 MLT):
 - large scale structure, the same in term of density on 4 s/c, not the same in term of radial velocity
 - ⇒ plasma tail close to plasmopause

GC: Barycentric Tools for Cluster

cf.: *PLS_24_25FEB2003_BXL_G.Chanteur_Tools.ps*

- * Tools based on the use of reciprocal vectors and reciprocal tensor
 - ⇒ gradient of a field (scalar or vector)
- * Covariance of the s/c positions
 - ⇒ covariance of reciprocal vectors

- * Example of a planar surface in uniform motion crossed by the 4 s/c
 - timing normal + normal velocity + covariance \Rightarrow cone of uncertainty
 - * Curvature of field lines
 - tangent and normal of a field, gradient of the field \Rightarrow curvature
 - GC: will develop a program in IDL to compute this new tool
 - FD: will create some files with spacecraft positions and magnetic field data from FGM, as input to test this new tool
- [These 2 last items have been done the Wednesday 26th at IASB]

JL: VHS-Video Animation on Plasmasphere

“The plasmopause formation and deformation” (J. Lemaire, 1983).

Cluster plasmasphere crossings:

HL and PC: with EFW and WHISPER

- * 4-L scale systematic plots of the plasmasphere crossings with
 - density from spacecraft potential
 - electric field
 - drift velocity
- * Examples of crossings with small separation between spacecraft (after 01/02/2002):
 - 27/02/2002: small separation
 - 22/02/2002: differences between spacecraft, even with small separation
 - 20/02/2002: plasmopause at L=6.6
 - perhaps SAID (Sub Auroral Ion Drift)
 - PC: Whisper \rightarrow very asymmetric
 - 17/02/2002: simple plasmopause
 - 08/02/2002: lots of irregularities
- * Examples of crossings with large separation between spacecraft (in 2001):
 - 10/01/2002: PC: plasmopause not sharp
 - electrostatic and electromagnetic emissions
 - low density at perigee
 - 03/01/2002: large plasmopause
 - 27/12/2001: steep plasmopause
 - radial flow??
 - PC: burst emission just before the inbound crossing
 - 03/12/2001: disturbed in 1 hemisphere
 - very different in the other hemisphere (double plateau)
 - strong difference with s/c 3
 - PC: waves on Whisper (3 type III bursts)
 - 26/11/2001: lots of structures
 - strong electric field variations
 - 14/11/2001: similar pattern on 3 s/c
 - PC: hole in the Whisper data for the outbound crossing

- 12/11/2001: structures inside plasmasphere
 - PC: symmetric case
- 05/11/2001: structures
- 24/10/2001: large structure, perhaps shoulder
- 07/10/2001: plasmopause not seen
- 30/09/2001: ULF waves in trough
- 15/09/2001: lots of variations in electric field
 - PC: wave activity
 - low density at perigee
 - electrostatic emission in plasmasphere
- 09/09/2001: steep plasmopause
- 25/08/2001: low frequency waves
- 09/08/2001: plasmopause seen in southern hemisphere, but not in northern
- 04/08/2001: high density outside plasmasphere (20 part at L=8)
- 21/07/2001: lots of structures
- 18/07/2001: very high density
- 27/06/2001: large density structure
- 13/06/2001: flow separatrix at plasmopause
- 29/05/2001: density structures
- 13/05/2001: strange case !!!
- 08/05/2001: structure in plasmasphere and then strange density profile
- 26/04/2001: very sharp plasmopause
- 14/04/2001: very sharp plasmopause
- 07/04/2001: very sharp plasmopause

* Remarks on Harri's plots:

- JL: Add geomagnetic index on the Harri's plots
- HL: Change drift velocity into eastward and westward velocity
- JL: Add fitting curves (with power law) on the density plots for the plasmasphere and the trough

* Remarks:

- AM: PEACE data at perigee since 08/01/2003
- JL: AE or/and Dst index perhaps better than Kp (just every 3 hours)
- JL: Better to use R_m than L (R_m = radial distance, where the magnetic field intensity has a minimum along the magnetic field lines passing through the position of the spacecraft)

FD: Cluster-IMAGE-Kp orbit plots

* Plots with Kp index and radial distance of the orbits of Cluster and IMAGE (on the same plot), with time intervals of available IMAGE-EUV data and Cluster plasmasphere crossings, in order to select the plasmasphere crossings with Cluster-IMAGE conjugations. The LT_{GSE} of the first Cluster plasmasphere crossing of each plot is also indicated.

FD and PC: with WHISPER and EDI

* List of a selection of plasmasphere crossings with EDI data available and small separation:

- 11/03/2002: irregularities
- 11/04/2002: 2 tails, continuum radiation trapped between the tail and the plasmopause
- 25/04/2002: asymmetry
- 30/04/2002: sharp gradient, smooth transition, small tail (substorm onset near the inbound crossing)

- 07/05/2002: plume in the inbound crossing
- 09/05/2002: differences between satellites, densities irregularities
- 31/05/2002: sharp gradient and then smooth plasmopause on both hemispheres
- 02/06/2002: large irregularities, trapped continuum radiation
- 07/06/2002: asymmetric plasmopause, detached elements in both hemispheres
- 09/06/2002:
- 12/06/2002: tail, irregularities and $3/2f_{ce}$ emission
- 14/06/2002: irregularities at the outbound crossing

* Other plasmasphere crossings in 2001:

- 17/05/2001: asymmetry, tail on s/c 3
- 27/06/2001: large irregularities

HL: Other Cluster plasmasphere crossings

- 13/03/2002: plumes on both hemisphere, eclipse data gap
- 18/03/2002: steep density gradients at plasmopause, bite-out and irregularities during the outbound crossing
- 23/03/2002: strong irregularities
- 30/03/2002: SAID ??, quick plasmopause encounter
- 08/04/2002: differences in drift velocities between four satellites?
- 18/04/2002: no plasmopause crossing
- 20/04/2002: no plasmopause encounter but plumes on both hemispheres

Possible papers:

* 13/06/2001:

- Topics:
 - narrow shear flow
 - curvature of plasmopause
 - motion of the plasmopause
 - irregularities along **B**
 - density variation along field line
- Data:
 - EDI: contact Matias Förster
 - EFW
 - CIS available?

* 05/06/2001:

- Topics:
 - detached regions
 - irregularities
 - time versus space issues
 - velocity of irregularities with error bars
- Data:
 - IMAGE data available (but not exactly at the time of the crossing by Cluster)

* 08/02/2002:

- Topics:

irregularities: significant differences between the satellites even during short separations
low-frequency waves in **E** and **B**
density hole at equator
where is Roche limit?
density gradients
flow patterns near & within the irregularities

- Data:

IMAGE data available!

Conclusions (input from HL taken during the meeting):

1) Wave activity on the plasmopause:

- 08/02/2002 case
- EFW-FGM 2-minute waves on the plasmopause, Poynting flux?
- density irregularities, detached plasma elements

2) Detached regions, plasmaspheric tails, and shoulders

- vs. MLT, Kp, AE
- comparison with IMAGE:
- June 5, 2001: detached, plumes, irregularities etc
- July 2, 2001
- July 16, 2001
- July 21, 2001
- August 8, 2001: drifting patches
- August, 21, 2001
- August 25, 2001
- September 9, 2001
- September 25, 2001: detached elements
- October 24, 2001: shoulder
- December 15, 2001: morning side detached element
- January 29, 2002: flows within the tail
- February 8, 2002

3) Small-scale irregularities at the plasmopause

- statistics [vs. MLT, Kp, AE]
- distribution: size, amplitude
- surface curvature – local characterization
- interchange motion
- Roche-limit surface: erosion
- parallel-E events? – use Polar data

4) Radial flow across the plasmopause, from trough into plasmasphere

- during substorms at different MLT
- EFW-EDI comparison useful for EFW calibration
- Feb 8, 2002 & Jan 15, 2002: net flow inward and outward, respectively

5) Velocity shear near the PP

- June 13, 2001: clear shear
- January 15, 2002: thin flow separatrix

- 6) Breathing PP - radial motion of the plasmopause
 - January 22, 2002
- 7) SAID (sub-auroral ion drifts)
 - relationship to SAR
 - relationship to plasmopause location
 - February 20, 2002
- 8) sub-auroral arcs (SAR)
 - precipitation data from low-altitude red auroral arcs needed
- 9) Particle distributions near the plasmopause (cf. case 21/07/2001)
 - PEACE data available since 08/01/2003
- 10) Density distribution along field lines
 - flux tube refilling
- 11) Lunar effects on plasmasphere – plasmaspheric tides
 - superposed epoch analysis of Polar data
- 12) Quality of symmetry of the Cluster orbit
- 13) Summary plots on the web
 - EFW: density, azimuthal drift, geomagnetic index
 - Whisper: daily plots from Pierrette; detailed plots from Patrick
 - Cluster-IMAGE orbit plots from Fabien
- 14) fq cold-hot population, Maxwell-Kappa functions

Miscellaneous:

- * Web site for Polar data: <ftp://pwgdata.gsfc.nasa.gov/pub/00readme.html>
 - EFI, MFE and Orbit/Attitude