THE EARTH'S PLASMASPHERE
A CLUSTER, IMAGE AND MODELLING PERSPECTIVE

Wednesday 19 September 2007 14h00 –

Friday 21 September 2007 18h00

Belgian Institute for Space Aeronomy (IASB-BIRA) in Brussels, Belgium

WEDNESDAY 19 SEPTEMBER – 14h00-15h30

1) Introduction (history, physical processes)

a) History → Storey (whistler), Carpenter (whistler), Gringauz (satellites)

i) **DON:** History, involving Storey, Gringauz, Carpenter, in regard to early discoveries.

b) First missions → DE, ISEE, PROGNOZ, OGO, GEOS, AKEBONO, ...

i) **DON:** Ogo 2 and 4 on the light ion trough; Alouette 1 and 2 on the lower hybrid resonance noise breakup at the plasmapause and first echoes at ~2000 km from a steep plasmapause.

ii) **FABIEN:** Plasmasphere measurements from spacecraft (1970-1980 and after 1980).

c) Physical processes → plasmapause formation and position, refilling, density structures formation, co-rotation or sub-co-rotation, SAPS, SAID, ...

i) **DON:** Physical processes: Park's demonstration that dayside coupling fluxes are large enough to make the plasmasphere a reservoir for the night-time ionosphere. The dynamic duskside bulge (now the base of the plume).

ii) **JOHN+JERRY:** Sub-auroral electric fields (SAPS/SAID) and plasmasphere erosion plumes.

iii) **MARK:** Storm-time dynamics of plasmasphere.

iv) **DENNIS:** Abridged history of plasmasphere refilling.

v) **BILL:** Sub-corotation of the plasmasphere.

vi) **VIVIANE:** Formation of the plasmapause (different mechanisms: last closed streamline/ quasi-interchange instability, dynamical simulations, development of plumes and other structures, influence of the geomagnetic activity level -storms and substorms-, different models of electric fields and magnetic fields).

d) Methodology

i) **JOHAN:** Computation of gradients in the plasmasphere from multi-point measurements.

ii) **FABIEN:** New techniques to analyse data from multipoint missions.

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2) Fields (electric and magnetic)

a) Magnetic field → global orientation (gradient), models

i) **JOHAN:** Physical implications of overall plasmaspheric gradient computations.

ii) **FABIEN:** Magnetic field (spatial gradient) from CLUSTER data and models.

iii) **DENNIS:** Derive from EUV images quantitative plasmaspheric flow fields (plasmaspheric flows are the result of a variety of forces, which include the influence of electric and magnetic fields).

b) Electric field → statistic, drift velocity, plasmaspheric flows, SAID, models

i) **DON:** Night-side cross L substorm-associated plasma drifts. Dayside cross-L SQ system drifts. Strong duskside flow drifts.

ii) **HIROSHI:** Electric fields in the inner magnetosphere measured by Cluster Electric field measurement by EDI instrument; merging EDI and EFW data; various types of electric fields measured: solar wind origin, SAPS or SAID, ionospheric dynamo, ULF wave components (as large as DC components).

iii) **JOHAN:** Modelling of SAID and their relation with the plasmasphere.

iv) **HIROSHI:** Plasmaspheric structure around the SAID region (Magnetospheric and ionospheric conjunction events measured by Cluster and DMSP; ionospheric density trough observed at SAID location at DMSP altitude, while plasmasphere observed at Cluster altitude).

v) **JERRY:** Inner magnetospheric electric fields and the plasmasphere.

vi) **HIROSHI:** Effort for modelling electric fields; future possibility to put electric field model developed from Cluster data set into simulations.

vii) **JOHN:** SAPS and plasma transport in the SED/erosion plumes.

viii) **VIVIANE:** Electric field models used in simulations.

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3) Waves (electrostatic and electromagnetic)

a) Electrostatic waves → equatorial at (n+)F_{ce}, echoes (diffuse echoes, field-aligned echoes, resonance echoes, F_{cp} echoes)

i) **FARIDA:** (n+½)Fce, statistical results, n(1.1)Fce, …

ii) **DON:** IMAGE: Z mode and whistler mode probing (new tools for diagnostics in the transition region from the ionosphere to the plasmasphere).

iii) **JIM:** RPI observational aspects of the plasmasphere from the IMAGE perspective (passive and radio sounding)...

iv) **MARK:** Using ULF resonance data to study plasmaspheric mass density.

b) Electromagnetic waves → non thermal continuum, kilometric continuum, whistler, hiss, chorus

i) **PIERRETTE:** Continuum, waves close to plasmasphere, role of irregularities of density, statistical analysis, new event (2007), …

ii) **ARNAUD:** Hiss near the plasmapause.

iii) **FRANTISEK:** Magnetosonic Equatorial Noise (the most intense among all the natural emissions below lower hybrid frequency; occurrence rate of about 60%; observed both inside and outside of the plasmapause; possible role in acceleration of radiation belt electrons, transferring energy from the ring current ion population to hot electrons).

iv) **FRANTISEK:** Whistler-mode Chorus (among the most intense naturally occurring emission in the inner magnetosphere; nonlinear generation process (theory and simulations); can play a significant role in the process of local acceleration of electrons in the outer radiation belt, transferring energy from the denser low energy populations).

v) **FRANTISEK:** Observations of cut-off below the local hydrogen cyclotron frequency (observed by low orbiting spacecraft; reflects the local ion composition; could be used to localize the light ion through connected to the plasmapause).

vi) **JIM:** RPI observational aspects of the plasmasphere from the IMAGE perspective (passive and radio sounding)…

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4) Plasma (density structures, electron and ion composition)

a) Density structures → duskside bulge, plume, notch, shoulder, ...

i) **PIERRETTE:** Density structures seen by WHISPER.

ii) **DENNIS+BILL:** Plasmaspheric morphology: a new look and language for plasmaspheric structures.

iii) **MARK:** Using GPS-TEC tomography to study plasmaspheric plumes and plasmapause.

iv) **FABIEN:** Density irregularities (CLUSTER) and plasmaspheric plumes (CLUSTER, IMAGE).

v) **JERRY:** "Residual Plumes", i.e., plumes left over from prior epochs of erosion, and how they might contribute to density structure inside new plumes.

vi) **JOHN+JERRY:** Plasmaspheric plume and enhanced ionospheric/polar cap tong of ionization.

vii) **JOHN:** Low-altitude observations of plasma redistribution, the dusk-sector bulge, and erosion plumes.

viii) **ARNAUD+DENNIS:** Plasmaspheric notches.

ix) **DENNIS:** Plasmaspheric fingers; visual evidence of globally driven ULF oscillation?

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b) Plasma composition → hydrogen, oxygen, helium

i) **DON:** Loss of plasma during disturbed periods from within the eroded plasmasphere. Helium abundance at topside altitudes. Plasmasphere as a target for radio sounding (IMAGE); rough outer surface and internal field aligned irregularities causing scattering of sounder pulses.

ii) **IANNIS:** Analysis of ion distribution function measured in-situ by the Cluster spacecraft, and ion composition results.

iii) **RICHARD:** Comparison of mass density from Alfven waves to electron density yielding the average ion mass.

iv) **BODO:** 2-D electron density images along the IMAGE orbit can be used to differentiate different plasma regions that have distinct density distribution characteristics: the solar wind/IMF effects should be included in any statistical study of the electron density distributions in those regions.

v) **JERRY:** …

c) Global orientation and velocity of structures

i) **NICOLAS:** At L=2, 10-15 % corotation lag observed → Implication on plasmasphere dynamics.

ii) **JOHAN:** Physical implications of overall plasmaspheric gradient computations.

iii) **FABIEN:** Electron density (spatial gradient) from CLUSTER data and models.

iv) **BILL:** Longitudinal and seasonal variations in plasmaspheric density, and another studied plasmaspheric densities during a prolonged disturbed interval by combining field line resonance, whistler, and EUV measurements.

v) **RICHARD:** Field line dependence of electron density and mass density in the plasmasphere and plasmatrough (for electron density, power law dependence assumed; mass density very flat within about 20 degrees from the magnetic equator).

vi) **JERRY:** Storm-time redistribution of ionospheric plasma and the plasmasphere.

vii) **BODO:** Smooth transitions of the electron density from the plasmasphere to the auroral region can occur at various magnetic local times: plasmaspheric wind??

d) Refilling

i) **BILL:** Global view of refilling of the plasmasphere (EUV, RPI, radial variations in [He+]/[electrons], interspecies differences in refilling rates).

ii) **DENNIS:** Study the plasmaspheric refilling physics using IMAGE RPI data.

iii) **BODO:** Plasmasphere depletion/refilling processes investigated by analyzing the density variations through the life cycle of a storm as observed by the Radio Plasma Imager (RPI) on the IMAGE satellite; comparison of simulation results with IMAGE RPI observations.

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5) Simulations, modelling

a) MHD simulations

i) **JERRY:** …

b) Simulations based on interchange instability

i) **JOSEPH:** Study the oscillations/instability of interchange and quasi-interchange in the magnetosphere.

ii) **NICOLAS:** Interchange instabilities in the plasmasphere → Necessity of a plasmaspheric wind.

iii) **JOSEPH:** Plasmaspheric wind …

iv) **NICOLAS:** The plasmasphere during prolonged periods of quiet geomagnetic activity ($Kp < 3$) → Evidence for a plasmaspheric wind?

v) **VIVIANE:** Model of plasmasphere and plasmatrough (exospheric model, number of trapped particles, temperature).

c) Density models (equatorial, 3-D, ...)

i) **VIVIANE:** Model of plasmasphere and plasmatrough (three dimension model, comparison with CLUSTER and IMAGE observations, comparison with other models).

ii) **HIROSHI:** Evolution of plasmaspheric electron density simulated by the ring current-atmosphere interactions (RAM) model: location of the plasmapause depends on choice of electric field models.

iii) **MARK:** Development of plasmasphere density and plasmapause location models; using ULF resonance data to study plasmaspheric mass density.

iv) **JERRY:** …

v) **BODO:** Field-aligned density profiles along the filled and depleted flux tubes can be well fitted by the a simple functional form, but with two different groups of fitting parameter values: potential to construct realistic global empirical plasmasphere/plasma trough models; potential to determine the density profiles along the depleted flux tubes for plasmasphere refilling studies.

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6) Conclusions

a) CLUSTER

i) **FABIEN:**

ii) **JOHAN:**

b) IMAGE

i) **JERRY:**

c) Simulations

i) **VIVIANE:**

ii) **JERRY:** …

d) Perspectives

i) **VIVIANE:** Missions ChangE2 and KuaFu

ii) **JOHAN:** Mission WARP

iii) **Others:** Future Missions … ???

e) Varia

i) **???:** …

FRIDAY 21 SEPTEMBER – 09h00-12h00

Organization of the Publication and Final Discussion