Counter−Streaming Electron Beams in the Plasma Sheet Associated with Auroral Activity

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Aurora and Auroral
Processes II Posters

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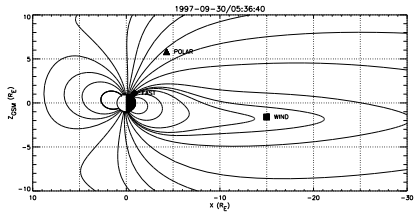
Abstract

Electron observations by the WIND plasma instruments in the near−Earth plasma sheet (at a radial distance of about 15 Earth radii) during a substorm expansion and recovery reveal the presence of counter−streaming electron beams. The beams, which appear shortly after large fluctuations in the magnetic field, are centered about 1 keV and are confined to pitch angles less than about 10°. These beams appear to be unstable and rapidly decay resulting in bi−directional field−aligned electron distributions. The bi−directional field−aligned distributions are observed for more than one hour. Simultaneous FAST plasma measurements near the magnetic foot−print of WIND in the auroral region show a similar electron spectrum. The source of the field−aligned beams is unknown, but based on the narrowness of the beams in the plasma sheet, we contend that the source is at low altitude and that the source mechanism is related to the auroral acceleration processes.

Introduction

- The presence of strongly field−aligned electron distributions in the equatorial near−Earth plasma sheet has been known for some time [*McIlwain*, 1975; *Parks et al.*, 1977; *Lin et al.*, 1979; *Hada et al.*, 1981; *Klumpar et al.*, 1988].
- We observe counter−streaming electron beams (df/dv > 0) at 15 R_E during a substorm.
- The beams decay leaving electron distributions peaked in the field−aligned direction; the field−aligned distributions persist for at least one hour.
- What is the source of these beams?
  - Magnetospheric processes (e.g. X−line reconnection) *or*
  - Ionospheric processes (e.g. auroral acceleration)
- We conclude that the beam properties are consistent with an ionospheric source

Configuration of Spacecraft

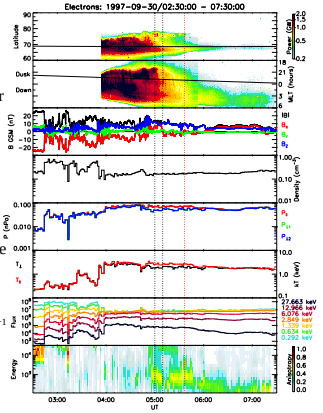


References: Hada, T., *et al.*, *J. Geophys. Res.*, *86*, 11,211, 1981; Klumpar, D. M., *et al.*, *Geophys. Res. Lett.*, *15*, 1295, 1988; Lin, C. S., *et al.*, *J. Geophys. Res.*, *84*, 2651, 1979; McIlwain, C. E., in *Physics of the Hot Plasma in the Magnetosphere*, Plenum, 1975; Parks, G. K., *et al.*, *J. Geophys. Res.*, *82*, 5208, 1977.

Acknowledgements: WIND/MFI data are courtesy of R. P. Lepping

Summary of Observations

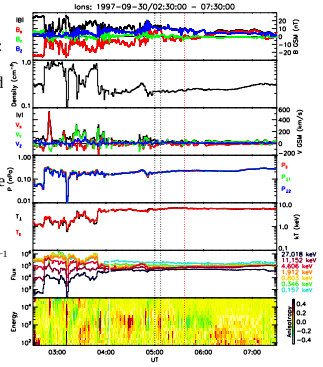
Top to bottom:
- Keogram (auroral power vs. latitude)
- Auroral power vs. MLT
- Plasma sheet magnetic field
- e^- density
- e^- pressure (// and ⊥ components)
- e^- temperature (// and ⊥ components)
- e^- flux ($cm^2/s/keV/st)^{-1}$
- e^- anisotropy vs. energy



Anisotropy = A(E) = $\int f(E,\alpha)\cos(2\alpha)\,d\alpha \,/\, \int f(E,\alpha)\,d\alpha$
(after *Hada et al.* [1981])

- e^- most anisotropic *after* magnetic fluctuations ~ 5 UT
- Anisotropy peaks at energies ~ 1 keV (decreases with time)
- Strong anisotropy persists for over an hour

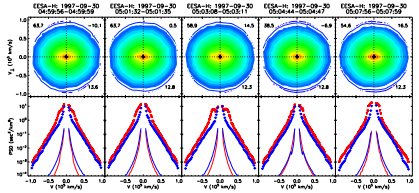
Top to bottom:
- Plasma sheet magnetic field
- i^+ density
- i^+ pressure (// and ⊥ components)
- i^+ temperature (// and ⊥ components)
- i^+ flux ($cm^2/s/keV/st)^{-1}$
- i^+ anisotropy vs. energy



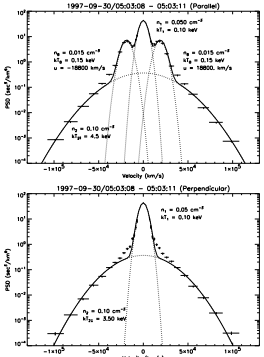
- i^+ anisotropy is small during interval of large e^- anisotropy

−−− e^- and i^+ distributions shown at right
−−− Time of WIND−FAST conjunction (far right)

Anisotropic and Beam Distributions

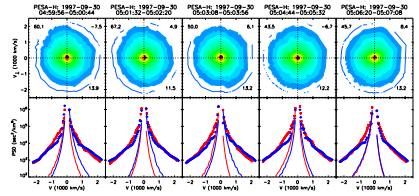


- Isocontours of electron phase space density in the **B**−**V** plane (magnetic field azimuth and elevation angles in GSM and |**B**| are shown in the upper left, upper right, and lower right)
- 1−D cuts parallel (*) and perpendicular (◊) to **B**



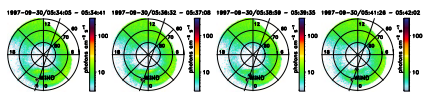
- (At least) four−component e− distribution
- Counter−streaming e− beams of equal intensity
  => bouncing population
- Most anisotropic distributions are flat−topped
  => decayed beam
- Ions are relatively isotropic

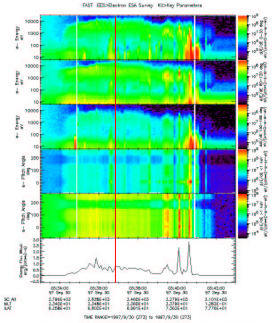
- Model 4−component distribution plotted with electron observations



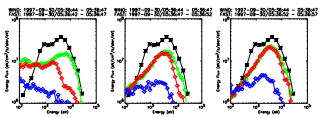
- Isocontours of ion phase space density in the **B**−**V** plane (magnetic field azimuth and elevation angles in GSM and |**B**| are shown in the upper left, upper right, and lower right)
- 1−D cuts parallel (*) and perpendicular (◊) to **B**

FAST−WIND Conjunction





Top to bottom:
- Downgoing
- Locally mirroring
- Upgoing e^- energy spectrograms
- < 1 keV
- > 1keV e^- pitch angle spectrograms
- e^- energy flux mapped to 100 km



- WIND downgoing e^- energy flux spectrum (*)
- FAST downgoing e^- energy flux spectrum (◊)
- FAST locally mirroring e^- energy flux spectrum (◊)
- FAST upgoing e^- energy flux spectrum (◊)

- FAST and WIND footprints approach a few 10s of km of each other during substorm recovery
- WIND observes anisotropic decayed beam remanent
- FAST does not observe this component
- Caveat: WIND mapping is uncertain!

Summary and Conclusions

- Electron beams observed in the equatorial magnetosphere near 15 Earth radii are narrowly confined in pitch angle, suggesting a source at high **B** (relative to plasma sheet), and cold (~ 150 eV), suggesting an ionospheric source.
- Similar beams are not apparent at FAST.
- However, beams are observed by WIND ~ ½ hour before FAST overflight (temporal offset).
- WIND magnetic mapping may be incorrect (spatial offset).
- Acceleration mechanism between FAST and WIND(?)