Simple Approach to Salvaging THEMIS ESA Moments Prior to Boom Deployment

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Motivation

- THEMIS data proved to be quite valuable (in part, for the study of magnetosphere). Unfortunately, it took a considerable time to deploy the EFI booms enabling measurements of s/c potential (until January 15, 2008 on th-a). The absence of information on s/c potential makes the measurements of the electron component of plasma unreliable.

- Meanwhile, it happened a number of interesting events before January 15, 2008. Is there any way to salvage the data, to eliminate contribution of spurious electrons to ESA measurements?

- We offer a simple approach consisting in determination of a Cutoff Potential (CP) such that the electrons with the energy below it are deemed to be spurious. Approach uses a reasonable physical requirement of the absence of large-scale (~$R_{\text{Earth}}$) space charges.

- The approach gives meaningful results, which can be tested when s/c potential was measured by conventional methods. However, we do not identify s/c potential with CP, the latter being rather measure of environment local to sensor.
Spacecraft Charging

The immediate environment of a s/c differs from the ambient plasma due to the presence of spurious charged particles (e.g. photoelectrons) and induced fields.

S/c potential measurements can be used to remove spurious particles prior to moment calculation (see extensive review in the papers of J. McFadden et al).

Existing methods for removing the spurious particles suppose some scenarios. New methods can provide additional checks.
Identify the Cutoff V needed to Ensure the Charge Neutrality

By modifying a single parameter – the cutoff voltage $U$ used to remove photoelectrons – we can bring 1200 data points for electron and ion densities to a plausible agreement.

Result remains consistent throughout a 12 hour time interval and for two different probes (D and E in this case).

Adjusted $U=25V$ (D) and $U=22V$ (E).
Fitting procedure

The fitting procedure minimizes the average relative quadrature difference \( R \). It shows a threshold behavior allowing easy automation.
Salvaging THEMIS-A Data

The booms of th-a were not deployed at the time. So, a default value of 1.7 Volts was used. Applying the fit, we find a cutoff value of 10 Volts.
Testing and Applying the Procedure

Cutoff potential found with 20-min moving time window is in a good agreement with measured th-c potential (left). The same procedure allows to salvage data for th-b without booms (right). Potential pattern is similar (string-of-pearl s/c configuration).
Cutoff Potential as a Research Tool

In a string-of-pearl configuration, we get similar time dependence for cutoff potential (C-B-D-E, top to bottom). However, circled features show dependence on s/c orientation (opposite for C, B and D, E).

This and other observations suggest underlying physical processes with major factors being photoeffect, electron charging, and secondary emission.
Conclusions

• Cutoff potential (CP) determined by condition of minimal deviation of ion and electron densities in a moving time window proves to be a simple, robust, and physically-justified tool to salvage plasma data in the absence of information about s/c potential.

• Method does not work within the inner magnetosphere and in cold plasma when s/c speed is comparable with thermal ion speed. It is also unable to correct for wrong ion counts produced by energetic electrons.

• CP seems to reflect major physical processes creating spurious electrons around s/c: electron charging, photoeffect, and secondary emission.

• Questions. Can we use CP gaps to detect plumes? Do some CP data point to negative s/c potential even under sunshine? What is correlation with plasma parameters – B and $T_e$?
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