ANALYSIS OF ENERGY CONVERSION PROCESSES AT KINETIC SCALES ASSOCIATED WITH A SERIES OF DIPOLARIZATION FRONTS OBSERVED BY MMS DURING A SUBSTORM

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Abstract

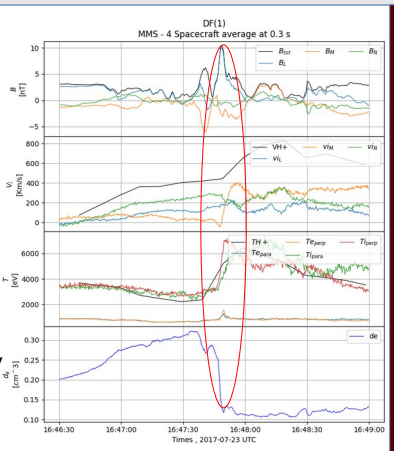
On 23 July around 16:19 UT, MMS was located at the edge of the current sheet which was in a quasi-static state. Then, MMS suddenly entered in the central plasma sheet and detected the local onset of a small substorm as indicated by the AE index (400 nT). Fast earthward plasma flows were measured for about 1 hour starting with a period of quasi-steady flow and followed by a saw-tooth like series of fast flows associated with dipolarization fronts (DF's). This plasma transport sequence finished with a flow reversal still occurring close to the magnetic equator. We have shown that DF's have the general characteristics with a good agreement (within 10nA/m2) between current density from the particle measurement and curlomtere. Electrons remain magnetized through the DF crossing as shown by the electron's Ohm's law whereas ions can be decoupled due to large Hall fields. When both ions and electrons are frozen-in to the magnetic field (E+ve,i×B)=0, no energy conversion can occur in their respective fluid frame. We investigate the energy conversion processes at ion and electron scales with particular attention on the processes in the vicinity of the DF's, and we found the energy conversion is not homogeneous at the scale of the tetrahedron.

Overview

DF/fast flow properties [e.g. Runov et al., GRL 2009, Sergeev et al., GRL, 2009]

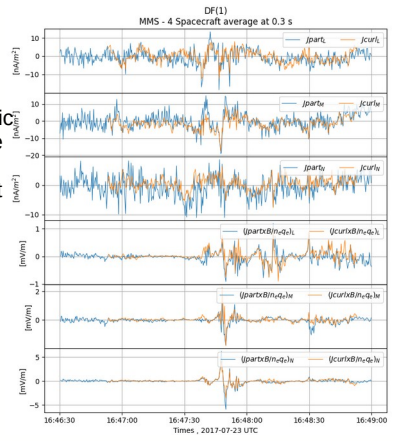
Transition between cold dense plasma at rest to hot tenuous fastly moving plasma

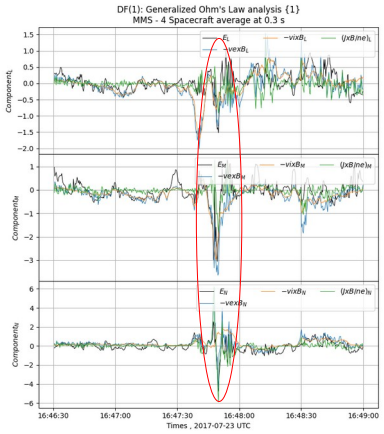
Increase of BL
Increase of Ve,x&Vi,N
Decrease of density
Increase of Tpara,e~Tperp,e~1 keV
Increase of Tpara,i~Tperp,i~6 keV



Current density comparisons

Current density comparison:
Jpart=en(vi-ve) &
Jcurl = (CurlB/mu)
Jpart is calculated from particle (FPI) data and Jcurl from magnetic field (FGM) data, all data are time average 0.3 s.
Small values but good agreement within <10nA/m2
Hall electric field comparison between
E_Hall = JpartxB/(nqe) &
JcurlxB/(nqe)
=> Good confidence in curl and particle
moments calculations.
Good agreement within 1 mV/m





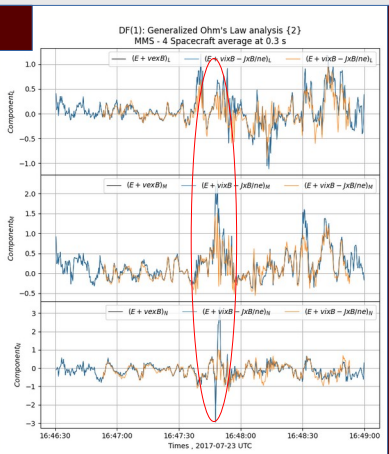
Ohm's Law

Ohm's Law Electrons

Good agreement E&(-vexB)~1mV/m, except at the DF.
Electrons most of the time are magnetized but more investigations needed at DF (curl (E+vexB)=0 ?).

Ohm's Law Ions

Good agreement E, (-vixB)M,L and (JxB/ne)
Ions can be decoupled from B due to large Hall fields at DF.



Energy conversion

Max of Jpart,y ~ 23 nA/m2
E field Maximum around 1647:45 UT
with (E+vexB) ~ 8.3 mV/m
with (E+vixB) ~ 4.3 mV/m
positive value = Dissipation (energy goes from field to particles)
negative value = Dynamo (energy goes from particles to field)

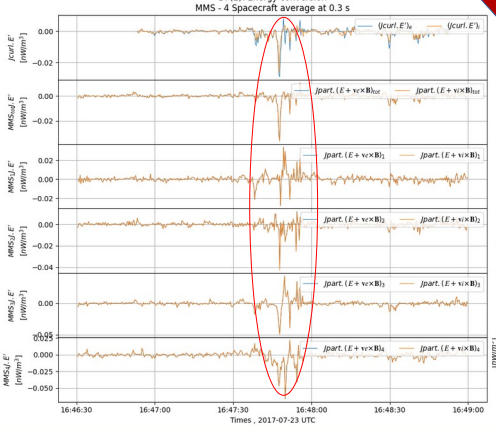
Conclusion
Energy conversion is not homogeneous at the scale of the tetrahedron

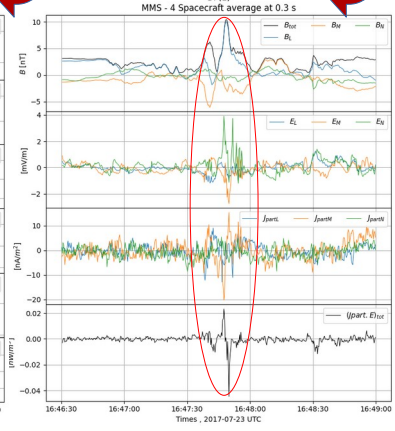
Summary

We have shown a DF event detected by MMS during a subsorm event on July 23rd 2017 with classical signatures consistent with general properties of DF.

We have found a good agreement between current densities calculated from particles and curl B. From Ohm's law, we have shown that electrons are almost always magnetized whereas ions can be decoupled from B due to Hall field.

Energy conversion given by (J.(E+vexB) or (J.(E+vixB)) is not homogeneous at the scale of the tetrahedron:
4 s/c average value indicates an energy transfer from particle to field at the beginning of the DF crossing whereas individual s/c values can be positive or negative which require further investigations.





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