3D ion-scale dynamics of BBFs in Earth's magnetotail using 3D hybrid simulations and MMS multi-spacecraft observations: preliminary results

H. Breuillard, N. Aunai, O. Le Contel, R. Smets, F. Catapano, A. Alexandrova, A. Retino, G. Cozzani, and the MMS team

Laboratoire de Physique des Plasmas (LPP), UMR-7648 CNRS/Ecole Polytechnique/Sorbonne Université, Paris, France

hugo.breuillard@lpp.polytechnique.fr

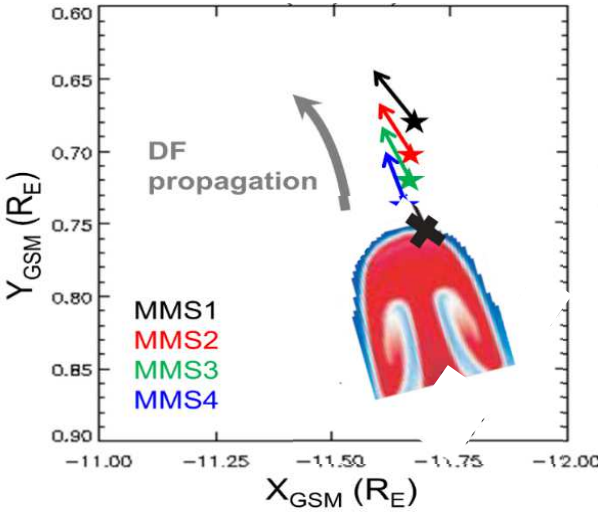
A. ABSTRACT

Dipolarization fronts (DFs), embedded in bursty bulk flows, play a crucial role in Earth's plasma sheet dynamics because the energy input from the solar wind is partly dissipated in their vicinity. This dissipation is in the form of strong low-frequency waves that can heat and accelerate energetic electrons up to the high-latitude plasma sheet. However, the dynamics of DF propagation and associated low-frequency waves in the magnetotail are still under debate due to instrumental limitations and spacecraft separation distances. In May 2015 the Magnetospheric Multiscale (MMS) mission was in a string-of-pearls configuration with an average intersatellite distance of 160 km, which allows us to study in detail the microphysics of DFs. Thus, in this letter we employ MMS data to investigate the properties of dipolarization fronts propagating earthward and associated whistler mode wave emissions. We show that the spatial dynamics of DFs are below the ion gyroradius scale in this region (~500 km), which can modify the dynamics of ions in the vicinity of the DF (e.g., making their motion nonadiabatic). We also show that whistler wave dynamics have a temporal scale of the order of the ion gyroperiod (a few seconds), indicating that the perpendicular temperature anisotropy can vary on such time scales.

B. MMS OBSERVATIONS

- BBF event detected in the magnetotail on May 15th 2015 during commissioning phase
- MMS was located close to midnight at X~ – 12 RE
- MMS fleet was in string of pearls configuration (Inter-satellite distance of ~160 km)

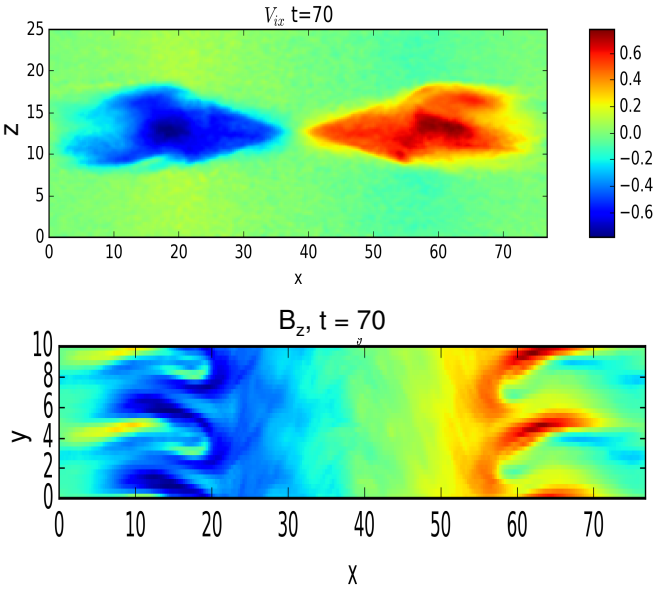
➢ First four-point measurements available at such scales in the near-Earth tail



➢ XY (equatorial) plane: DF rotates earthward at ion gyroradius scale (~500 km)

C. 3D HYBRID SIMULATIONS

- We make use of the heckle code (Smets & Aunai) to perform 3D hybrid simulations of magnetotail reconnection
- Simulations reproduce earthward propagating cross-tail DF-like structures observed on MMS in the equatorial plane:
- Local increase of Bz
- Local density increase
- Structures have a cross-tail (Y direction) size of ~4-5 ion gyroradii



D. PRELIMINARY RESULTS / OPEN QUESTIONS

1. Ion-scale dynamics of a BBF in the magnetotail were shown for the 1st time due to the small separation distance (~160 km) of MMS string-of-pearls configuration in May 2015 (Breuillard et al., 2016)
2. Whistler wave dynamics associated with DFs are of the order of ion gyroperiod (~2s)
3. Large-scale 3D hybrid simulations performed for the first time: Sheet "flapping" might be able to reproduce the typical signature of finger-like structures of DFs