Geophysical Research Abstracts
Vol. 19, EGU2017-9295, 2017
EGU General Assembly 2017

Electromagnetic waves and electron phase-space hole like signatures detected by MMS during a substorm

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In August 2016, the MMS constellation was in the magnetotail with an orbit apogee of 12 Earth radii and an average inter-satellite distance of 60 km (i.e. between electron and ion scales). On August 10, 2016 although MMS was located quite far from the magnetic equator, it detected multiple dipolarization signatures associated with substorm events. In this study, we focus on the wave activity detected during one of the dipolarization event and in particular we analyze in details the electromagnetic electron phase-space hole like signatures observed by three of the four MMS spacecraft. Such signatures have been already detected by one of the THEMIS probes under similar magnetospheric conditions. However, the MMS tetrahedral configuration with its small inter-satellite separation allows us to better analyze the characteristics of these structures such as their velocity, their direction of propagation, their internal structure and/or their time evolution. The consistency of these observations with existing models will be discussed.