Project Details

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Program Element: Focused Science Topic

Topic: Understanding the Response of Magnetospheric Plasma Populations to Solar Wind Structures

Project Title:
How are Magnetospheric Field and Plasmas Impacted by Impulsive Changes in Interplanetary Parameters?

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Summary:
Science Goals and Objectives: The solar wind flowing past the terrestrial magnetosphere changes in time, sometimes abruptly. Some of these changes are associated with shocks or field/plasma discontinuities that involve one or more parameters. Even for discontinuities involving single parameters one has to take into account the different background plasma and field conditions they occur in (e.g. a density rise in a plasma with strongly northward B; or a north-south deflection of a strong B in a tenuous plasma). Also, shocks may be isolated or may be driven by CMEs and CIRs, and they may be propagating inside a CME. Although the interplanetary (IP) drivers are of short duration, their effects on magnetospheric plasmas and fields can be spread out in time. The strength of the response clearly depends on the amplitude of the impulsive change. Combinations of simultaneous impulsive changes introduce additional features in the magnetospheric response. For example, velocity deflections at a tangential discontinuity introduce a vortex sheet element and the latter results in tangential stresses being exerted on the magnetopause.
Our overall science objective is to understand the effects elicited on the magnetosheath and magnetosphere by specific discontinuities and shocks, with a focus on solar cycle 24. As such, we aim at understanding the wide spectrum of responses of the magnetosphere and magnetosheath to IP discontinuities. To reach this objective, we focus on three science questions: 1) how do discontinuities and shocks affect the magnetosheath and induce asymmetries in plasma and fields at the magnetopause, thereby altering the interaction of the solar wind with the magnetosphere (for example the reconnection rate at the dayside magnetopause)?, 2) how do discontinuities and shock excite waves, field-line resonances, tail-flapping, that affect the magnetospheric plasma?, and 3) can extreme and rapid changes lead to saturation of the magnetospheric response?
Methodology: Our approach is to focus on a set of IP discontinuities: tangential and rotational discontinuities (TDs/RDs) and shocks. The period we examine is that of solar cycle 24, 2007-2018 (11 years). During these years, there is complete coverage of the IP medium from Wind and ACE, and several probes and ground-based data to monitor the response from magnetosheath to the tail. For convenience, we split our investigation into two periods: I. 2007-2014 and II. 2015-2018. First, we isolate the DDs in each period, using Wind or ACE data. We classify them by their strength, any accompanying parameter changes, the background solar wind, etc. We then use observations from a chain of spacecraft in the magnetospheric system. By using multi-spacecraft observations, we cover a wide spread of MLTs and radial distance from Earth, ideally so that one can track the effects from the bow shock to the geomagnetic tail. For Period I, we use geospace data from THEMIS + CLUSTER + GEOTAIL + GOES and for Period II, we add data from MMS and RBSP.
We undertake mainly analysis and interpretation of field (B and E) and plasma (protons + electrons) observations from space probes and ground-based assets.
Contributions to the Focused Science Team (FST) Effort: The proposed work is directly relevant to the FST as it explores how the magnetospheric plasma and fields respond to various IP drivers. By the end of the investigation, we shall have produced a detailed view of the myriad ways in which the magnetosphere reacts to impulsive changes and any detrimental effects this may occasion in our technology-based society. As a team combining expertise in the study of IP and magnetospheric phenomena, the PI and Co-I will provide their expertise to the entire FST to better understand the complex coupling between the IP and magnetospheric plasma population.

Publication References:

no references