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Project: Turbulence and Magnetic Reconnection in Earth's Space Environment

C. ABSTRACT OF THE PROJECT

1. Research project objectives/Research hypothesis

Magnetic reconnection generated by turbulence is a complex phenomenon that still remains a challenge for contemporary science. The physical mechanisms producing reconnection are still not clearly understood. Collissionless space and geophysical plasmas can be considered natural laboratories for investigating the complex dynamics governing turbulence and reconnection. Our works related to magnetohydrodynamical (MHD) theory have resulted in phenomenological models for turbulence in solar wind plasmas on relatively large scales that were based on observations by the *Voyager*, *Ulysses*, and more recently *THEMIS* (*Macek et al. 2015*) missions. These studies lead to the research hypothesis that studies on much smaller scales are essential for understanding of the physical mechanisms of reconnection, and we therefore need to investigate the experimental data on scales smaller than those in the inertial range. The aim of this project is to analyze the available data on kinetic ion and even electron scales, which should lead to a better understanding of complex dynamics of space environment of the Earth.

2. Research project methodology

Following our current studies of reconnection and turbulence in the Earth's magnetosphere by using the *Magnetospheric Multiscale* (*MMS*) mission (*Macek et al. 2018, Macek et al. 2019a, b*), we will further examine the characteristics of reconnection on kinetic ion and electron scales in different regions of space plasmas, including the magnetopause and the magnetotail, using *WIND*, *THEMIS*, *Cluster*, and *MMS* observations, which will allow to find electric fields responsible for reconnection even on the very small scales, where ions decouple from electrons and electron physics dominates. We will employ both traditional statistical classical analysis for turbulence, e.g., using energy density spectra and probability distribution functions. More advanced modern nonlinear methods based on numerical simulations for different regimes of scales will help us in analysis of the experimental *MMS* data with unprecedented millisecond time resolution. In addition, we will analyze both small-scale and large-scale fluctuations of the magnetized plasma parameters in the heliosheath and the interstellar medium, i.e. beyond the heliopause based on *Voyager* 1 and 2, which is the ultimate boundary separating the solar system from the very local interstellar medium.

3. Expected impact of the research project on the development of science

This project will hopefully allow us to grasp the physical mechanisms driving magnetic reconnection generated by turbulence, leading to a better understanding of space and geophysical plasmas. In particular, we will proof that in the region where electron decouple from ions, electron physics dominates. This will help us to a better understanding magnetic reconnection processes responsible for distribution of various kinetic and magnetic types of energy in the Universe. Finally, we hope that the results obtained in this project will be essential for the magnetohydrodynamical and kinetic theories, and also for the general theory of turbulence, which is still unresolved issue in natural sciences.