オーロラアークに付随した電気伝導度非一様性と電離層キャビティの解析

平木康隆[1]、小川泰信[1]
[1] *国立極地研究所*

Conductivity anomaly and field line cavity related to auroral arc dynamics

Yasutaka Hiraki[1] and Yasunobu Ogawa[1]
[1]*National Institute of Polar Research*

The dynamics of auroral arcs has been vigorously studied in the context of magnetohydrodynamic (MHD) instabilities and their nonlinear evolution in the magnetosphere-ionosphere (M-I) coupling system. The feedback instability was proposed for a mechanism [Sato, 1978; Lysak, 1991], where destabilization of shear Alfven waves is induced through a resonant coupling with density waves propagating in the ionospheric convection electric field. Linear analysis with field line cavities clarified feedback properties of Alfven eigenmodes, especially as the fast growth of fundamental field line resonance with 10-km scale perpendicular wavelength [Hiraki and Watanabe, 2011]. Generation of hybrid Alfven resonant modes, through coupling of ionospheric Alfven resonant modes with global field line oscillations, was also discovered [Hiraki and Watanabe, 2012]. Other numerical studies were performed on the view point of formation of ionospheric cavity resonances, parallel electric field, and accompanied density depletion [Streltsov et al., 1998; Rankin et al., 2005; Lysak and Song, 2008]. The relationship between the global auroral arc system (currents and MHD waves) and the ionospheric plasma response such as conductivity anomaly and a field line cavity is still under investigation.

The purpose of this study is to obtain comprehensive understanding for evolution of auroral arcs and the related ionospheric plasma response, especially focusing on effects of conductivity anomaly and field line cavity. We have developed a three-dimensional M-I coupling model that includes nonlinear ionospheric density modulations caused by the field-aligned currents associated with Alfven waves. Our model basically treats Alfven wave dynamics driven by the M-I coupling process and covers a local dipole flux tube in the vicinity of auroral arc system [Hiraki, 2013]. The magnetospheric plasma is described by the reduced MHD equations of electric and magnetic perturbations with small perpendicular scale variations and long time evolution, as well as non-uniformity of Alfven velocity. The ionospheric plasma and the related density waves are described by the compressible two fluid equations with collisional effects and are characterized by the Pedersen and Hall currents. Field-aligned current carried by the Alfven wave flows into the ionosphere, producing an internal non-uniformity of plasma density or conductivity, which in turn triggers new wave propagation to the magnetosphere. In this talk, we will present initial results of our nonlinear simulations, from which conductivity anomaly in the vicinity of auroral arc is analyzed, and give implications to future highly-resolved observations of ionospheric plasma parameters.

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