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Alfven波をつうじたMI結合系でのCowling-channelの形成

Formation of Cowling channel through the ionosphere-magnetosphere coupling via shear Alfven wave

吉川 顕正[1*], Olaf Amm[3], 藤井 良一[3]

Akimasa Yoshikawa[1*], Olaf Amm[3], Ryoichi Fujii[3]

[1]九州大学大学院理学研究院地球惑星科学部門, [2]Finnish Meteorological Institute, [3]名古屋大学太陽地球環境研究所

[1]Kyushu University, [2]Finnish Meteorological Institute, [3]STEL,Nagoya University

An inclusive formulation of Magnetosphere-Ionosphere (MI) coupling system, which enables to describe the Cowling channel formation through the MI-coupling via the shear Alfven wave, is proposed. By applying the Walen-relation [Walen, 1944] to the Alfvenic disturbance near the ionosphere, arbitrary incompressible MHD fields (b,v) can be separated into the incident component to the ionosphere and the reflected component from the ionosphere. The separated incident component gives an electromotive force (emf) for the excitation of the MI-coupled system. In addition, the thermospheric wind dynamo also becomes a source of emf in the ionosphere, while the reflected components are generated as a result of the MI-coupling process. Using this separation, we clarify that the MI-coupling processes are composed of the direct reflection process for incident MHD field, the radiation process for the thermospheric wind-driven dynamo, and the polarization process for the charge separation originating from conductivity gradients. Clearly, the reflection and the radiation processes are caused by the cancellation process of the divergence of the primary Pedersen current (primary current means directly driven current by the emf field). The polarization process is caused by the both the divergent part of the primary Pedersen and of the primary Hall current.
Since the direction of the primary Pedersen current and the direction of the primary Hall current are perpendicular to each other, the reflected fields generated to cancel out these two irrotational parts of the primary currents are also expected to be perpendicular to each other. Thus, the MI-coupled ionospheric current system can be separated into two orthogonal irrotational current systems, the first channel originating from the primary Pedersen current divergence (generator-channel) and the second channel from the primary Hall current divergence (loading-channel). A combination of these two channels forms so-called the Cowling channel. The generator-channel is directly coupled to the external generator of the system, which supplies the emf for generating the MI-coupled system. In this channel, the Pedersen and the Hall currents flow in the same direction, and the reflected Alfvenic potential $P_G$is generated. On the other hand, the loading-channel does not directly couple to the external generator, but couples to the internal Cowling-generator, which mediates electromagnetic energy between the generator and the loading channels. In the loading channel, the Pedersen and the Hall current flows in the opposite direction to each other, and the reflected Alfvenic potential $P_L$is produced.
Our theoretical framework proposed in this paper uniquely describes how much of field-aligned currents (FACs) are closed in the generator-channel and in the loading-channel, respectively, and how these channels are coupled to each other in the context of energy conservation. Simulation results show that significant rotation and elongation of the potential structure is caused by the Hall

polarization field P_L which is generated in regions of steep conductivity gradients. We will present the theory in detail and show some numerical results of the formation process of the Cowling channel via Alfven waves.

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