Feedback instability in the magnetosphere-ionosphere coupling with collision-induced velocity shear

*Tomo-Hiko Watanabe[1]

1. Graduate School of Science, Nagoya University

Feedback instability in the magnetosphere-ionosphere (M-I) coupling is a physical mechanism explaining spontaneous growth of auroral arcs. Conventional formulation of the M-I coupling, which has been widely used in studies of the feedback instability, is based on the height-integrated ionosphere model where the two-fluid equations are used in the limit of high ion-neutral collisionality [1]. A vertically resolved ionosphere model is examined in a recent work by Sydorenko and Rankin [2], where a set of multi-fluid equations covering a wide range of the ion-neutral collision frequency is applied to the M-I coupling. From their numerical simulations, solving an initial value problem, they concluded stabilization of the feedback instability due to velocity shear induced by the collisions. The simulation results, however, involve ambiguity related to choice of the initial condition.

In this work, we have found the feedback unstable solutions even in the case with vertical inhomogeneity of the ionosphere by solving an eigenvalue problem. The exponentially growing solution exists in the M-I coupling model with the velocity shear induced by the Pedersen mobility varying with the ionospheric altitude. The present result confirms validity of the conventional M-I coupling model with the height-integrated ionosphere, at least for the low-frequency modes.

[1] T. Sato, J. Geophys. Res. 83, 1042–1048 (1978).
[2] D. Sydorenko and R. Rankin, Geophys. Res. Lett. 44, 6534-6542 (2017).

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