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Studies of interchange instability with reduced-MHD model

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It has been well known that auroras exhibit various structures such as arcs, spiral- and curl-like vortices. Recently, the fine structure of arcs with wavelength of 30 km during the recovery phase of substorm was measured by a ground-based observation (Shiokawa et al., 2008). They suggested that a sawtooth-like structure formed through a collapse of arc is originated from the Rayleigh-Taylor instability, or interchange instability. The interchange instability is driven by the pressure gradient and the curvature of magnetic field line, the growth rate of which becomes large in a scale less than 1 Re at equator. The scale of the sawtooth structure is estimated to be thousands of kilometer, mapping to the magnetic equator (L=7-9) in a quiet period, which corresponds to a few times as large as the ion Lamor radius. The problem becomes difficult in that scale since various microscopic effects should be introduced for the non-linear coupling of high frequency modes. Lewis et al. (2003) reported an undulation located in the dusk sector during a recovery phase by IMAGE/FUV satellite observations. They pointed out that the structure is associated with the kinetic drift wave instability.

In this study, we investigate the interaction between the interchange modes and the drift wave modes in the non-linear phase. We perform a 2.5D numerical simulation of interchange instability in the magnetic equator with four-field reduced MHD model. The model is based on the flute ordering, assuming small wave number in the parallel direction to magnetic field line, and can treat the ion finite Lamor radius (FLR) effect as the gyro-viscosity and the drift wave (Hazeltine et al., 1987; Braginskii, 1965). We obtain so far that the intermittent chaotic structure is formed through a collapse of arc-like (kx=0) interchange mode under the weak convective electric field along with high Rayleigh number. The similar feature was provided in the two-field model studies of electrostatic interchange instability by Takayama and Wakatani (1996), and the studies of Rayleigh-Benard convection by Yanagita and Kaneko (1995). We consider that the sawtooth structures in ~10 km scale are driven by the drift waves amplifying in a collapse phase of interchange zero-mode. In contrast to Lewis et al., we focus on the perturbation of field-aligned current, not of plasma pressure, mapped directly to the auroral dynamics in a quiet period. We also discuss on the maximum beta value that is a measurable parameter characteristic of the kinetic instabilities.