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# Structuring and nonlinear dynamics of auroral arc

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The dynamics of auroral arcs in the magnetosphere-ionosphere coupling system has been vigorously studied on the basis of magnetohydrodynamic instabilities and their nonlinear evolution. 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. Recently, two-dimensional simulations demonstrated formation of small-scale arcs and ionospheric cavity modes [Streltsov and Lotko, 2004; Lu et al., 2008]. Treating nonlinear terms appropriately, a three-dimensional simulation showed that Kelvin-Helmholtz type vortex structures are spontaneously excited in the magnetosphere [Watanabe, 2010]. A linear analysis with non-uniformity of the Alfven velocity clarified eigenmode properties of the field-line and cavity resonances [Hiraki and Watanabe, 2011; 2012]. Furthermore, their relationship to the occurrence of auroral vortices has been investigated with nonlinear simulations.

In this study, the magnetospheric plasma is described by the reduced-MHD equations, and nonlinearity of Alfven wave appears in the convective derivatives with Poisson brackets terms. The field-aligned current of the Alfven wave flows into the ionosphere, producing an internal uniformity of plasma density or conductivity. The ionospheric plasma motion is described by the compressible two-fluid equations and is characterized by the Pedersen and Hall currents; nonlinearity appears in the divergence of these currents. The purpose of this study is to understand effects of the above nonlinearities on the development of feedback unstable modes. Auroral structuring as a result of these instabilities could be related to observing phenomena: splitting of arc and spiral or vortex (bead) structures. Properties of cavity modes and field line resonances associated with auroral structuring can be understood in the nonuniform flux-tube system. Furthermore, the relationship between long-lived auroral arcs and feedback-unstable modes that grow up in a strong convection is investigated. Characteristics of vortex structures appearing in auroral break-up would be pursued.

Keywords: auroral arc, Alfven wave, nonlinear simulation