On the Formation of Mach-Cone Waves in the Ion-Electron Two-Fluid Plasma

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Lyu and Kan (1989) found a set of fully nonlinear isentropic solitary wave solutions in the ion-electron two-fluid plasma based on an electromagnetic pseudo-potential method. But due to the limitation of the pseudo-potential method, their solutions are limited to the time-independent one-dimensional problems and provide no information on how the waves are formed. Since nonlinear waves with scale length near the ion inertial length are commonly observed in the solar wind corotating interaction region. The velocity shear is believed to play an important role in the formation of these nonlinear waves. Lai and Lyu (2006, 2008) show that the free energy in the velocity shear layer can produce Mach-cone solitary waves by the constructive interference of the fast-mode waves or slow-mode waves emitting from the velocity shear layer and expanding based on their group velocities. Since the constructive interference of these waves can decrease the wavelength as the wave steepens, the finite-ion-inertial-length effect should become important in the formation of these Mach-cone solitary waves. In this study, we examine the group velocity distribution of the fast-mode, intermediate-mode, and slow-mode waves in the ion-electron two-fluid plasma at wavelength close to the ion inertial length. We then use the group velocity distribution to construct the dispersive Mach-cone waves based on the theoretical model proposed by Lai and Lyu (2006; 2008). A comparison between the Mach cone waves obtained in this study and the results obtained in previous studies will be discussed.

Keywords: Mach-Cone Wave; Corotating Interaction Region; Finite-Ion-Inertial-Length Effect;