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INTERSPECIES MOMENTUM TRANSPORT IN COLLISIONLESS PLASMAS DUE TO THE TWO STREAM INSTABILITY

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We study the linear development of the two-stream plasma instability in a system taken to represent the interaction of the solar wind and the ionosphere of non-magnetic solar system bodies. We consider the role of the instability in the interspecies momentum transfer in such systems.

Spacecraft *in situ* measurements indicate that several features in the interaction of the solar wind with the ionosphere of planets such as Venus and Mars or comets (with a weak magnetic field) can be explained if we consider a viscous-like interaction between the such collisionless plasmas (Perez de Tejada 1995; Reyes-Ruiz et al. 2010). Viscous-like forces are most probably related to the turbulent character of the flow and/or wave-particle interactions. In this paper we study the possibility that momentum transfer between species is related to the presence of the two-stream instability in such plasmas.

We consider a cold, uniform, and unmagnetized plasma, composed of 4 species, ionospheric electrons and ions (O^+) (stationary), and solar wind electrons and ions (H^+) which have velocity V_S. The 1D equations of motion for each species, in the direction of the solar wind, are coupled by Gauss law including all species.

Flow properties are written as the sum of an unperturbed value, denoted by the subindex 0, and a small fluctuating component:

$$n_{e,i}{}^{S,I} = n_0{}^{S,I} + \delta n_{e,i}{}^{S,I},$$

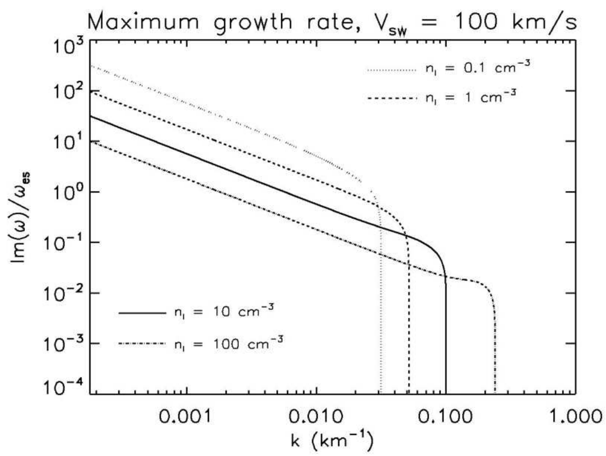
$$V_{e,i}{}^{S} = V_S + \delta V_{e,i}{}^{S},$$

$$V_{e,i}{}^{I} = V_S + \delta V_{e,i}{}^{I},$$

and the resulting equations are linearized. The unperturbed plasma is assumed neutral. We focus on electrostatic waves be of the form:

$$\delta f = \delta \tilde{f}\ \mathrm{e}^{-i(wt-kx)}$$

and obtain a set eight algebraic equations to be solved for the frequency, w, as function of wavenumber, k. The dispersion relation is obtained as a function of ionospheric density, n_0^I, solar wind density, n^S, and solar wind velocity, V_S with $\mathrm{Im}(w) > 0$, indicating instability. The fastest unstable mode is shown in Figure 1, as a function of k, for typical values for the shocked solar wind in the region.



Momentum transfer from solar wind electrons and ions to the ionospheric plasma can be estimated from a Reynolds averaged momentum flux in the ionspheric ions:

$$\langle \rho_i{}^I \delta V_i{}^I \delta V_i{}^I \rangle \approx \left(\frac{1}{2}\right) \rho_i{}^I (\delta \tilde{V_i})^2\ \mathrm{e}^{2\gamma t}\ >\ 0,$$

The fact that this quantity is positive and growing indicates that ionospheric plasma can be accelerated in the direction of the streaming solar wind.

These results suggest that the two stream instability develops under conditions similar to those observed in the ionosheath of nonmagnetic solar system bodies. Although a calculation of momentum flux must be conducted in the nonlinear regime, our results suggest the existence of non-collisional processes able to transfer momentum from the fast moving solar wind to ionospheric particles.

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