2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Collisionless regulation mechanism of solar wind electron heat flux

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It is widely believed that electron heat conduction is responsible for the expansion of the solar corona and the energy transport relevant to the flow of thermal energy in the solar wind and astrophysical plasmas. However, the physical processes for limiting the electron heat flux are not fully understood. Measurements in situ of electron heat flux at 1 AU have revealed that the collisional Spitzer-Härm theory is only valid for the collision-dominated solar wind plasmas corresponding to approximately 65% of 4 years data set obtained from *WIND* spacecraft [1]. This implies that the collisionless regulation mechanism of heat flux need to be taken into account for understanding of solar wind dynamics. For this reason, plasma kinetic instability, mainly linear Vlasov analysis, have been studied as candidate responsible for collisionless regulation of heat flux in the context of local wave-particle interaction [2, 3]. However, no study for numerical simulation has yet been reported within the solar wind context. The aim of the present study is to explore the physical processes of how the heat flux instability affects electron dynamics and regulates the collisionless heat flux within solar wind context by means of a particle-in-cell simulation. It is found that the enhanced whistler waves driven by the so-called whistler heat flux instability, which arises from the presence of the magnetic field-aligned drift velocity between a cold dense core and a hotter tenuous halo, play a role in scattering electrons and consequently suppressing the heat flux. We show that the ensemble of the numerically calculated heat fluxes with different values of the core electron parallel betas evolves toward the marginal stability threshold, which is consistent with the observational constraint on the values of the electron heat fluxes [4]. The numerical results support the ideas that the whistler heat flux instability may act on collisionless regulation of measured heat flux and is responsible for the generation of unidirectionally propagating whistler waves observed in interplanetary space [5, 6].

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