On the origin and implications of electron non-thermal distributions in the Solar Wind

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Abstract

There is wide evidence that in many space environments as the solar wind, the Velocity Distribution Function (VDF) of electrons presents interesting non-thermal behaviors as heavy tails (power-law behavior at large energies) and skewness in the direction of background magnetic field. By separate, the origin of both properties (power-law tails and skewness), and the consequences that they produce on space plasmas have been addressed in several observational and theoretical studies. However, a complete understanding on the origin of distributions exhibiting power-law tails is and skewness has already to be done.

Recently, a new model for solar wind electrons, called the "Core-Strahlo model", has been proposed [1,2]. This model describes the electron VDF as the superposition of a quasi-thermal core, plus a Skew-Kappa distribution (the strahlo), representing both, halo and strahl. In this work we present the results about our two complementary studies, which aim to answer the following questions: (1) how can we model the microscopic dynamics of a magnetized, turbulent and non-collisional space plasma so that the distribution has power-law tails and skewness at the same time? For this, we show an alternative Langevin type force equation to model [3] the first principles dynamics of electrons in a space plasma, exploring how the microscales relates to the macroscales, and we focus on quantifying the heavy tails and skewness throughout the moments of the VDF in the steady state; and (2), what is the role of these Skew-Kappa functions on the regulation of the electron heat-flux? For this, we analyze the effect of these skewed electrons on the excitation of the whistler heat-flux instability (WHFI).

Our results show that the WHFI can develop in this system, and we provide stability thresholds for this instability, as a function of the electron beta and the parallel electron heat-flux, to be compared with observational data. However, since different plasma states, with different stability level to the WHFI, can have the same moment heat-flux value, it is the skewness (i.e. the asymmetry of the distribution along the magnetic field), and not the heat-flux, the best indicator of instabilities. Thus, systems with high heat-flux can be stable enough to WHFI, so that it is not clear if the instability can effectively regulate the heat-flux values through wave-particle interactions.

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References

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