Kappa distributions and magnetospheric processes

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Magnetohydrodynamic (MHD) approach is overall used for the study of large-scale processes in the magnetosphere of the Earth. However the correct using of MHD requires the existence of collisions, which are extremely rare in the magnetosphere (the length of the free path is larger than the distance between the Earth and the Sun). The collisionless character of the magnetospheric processes requires the creation of the adequate substitution of the standard MHD on the system of equations taking into account a long-range interactions and based on the principles of non extensive statistical mechanics. Such substitution will permit to considerably modify the description of magnetospheric processes and improve the coincidence of theoretical predictions with the results of experimental observations. The real progress in such direction is now obtained [Livadiotis, 2015].

Experimental justification of using laws of non extensive statistical mechanics is connected with the possibility to comparatively precisely describe the really observed non-Maxwellian distribution functions by kappa-distributions. We made sure in the applicability of kappa-distributions analyzing electron and ion distribution functions in the magnetosheath (see [Kirpichev et al., 2015] and references therein), inside the magnetosphere and in the plasma sheet [Antonova and Stepanova, 2015]. Problems of such approximations are connected with different sensitivity of devices measured particle fluxes in different energy ranges and pitch angles. Another difficulty is connected with frequently observed mixtures of plasmas of different origins. For example, we observe mixture of plasma of solar wind origin and magnetosheric origin in the magnetosheth. The bi-kappa approximations are used in such cases.

The main difficulty of the approach development is connected with the absence of proper information about the processes of non-Maxwellian distribution function relaxations due to long-range interactions to kappa distributions and radial particle transport in the magnetosphere. Such information is obtained using data of multisatellite observations. We summarize the obtained results of the study of kappa-distribution parameters and spatial variations of the local entropy. We show that using of kappa approximations greatly improve the analysis of magnetospheric transport processes.

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