ON THE RELATION BETWEEN KAPPA DISTRIBUTION FUNCTIONS AND THE PLASMA BETA PARAMETER IN THE EARTH MAGNETOSPHERE: THEMIS OBSERVATIONS

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Abstract:

The Earth's magnetosphere represents a natural plasma laboratory that allows us to study the behavior of particle distribution functions in the absence of Coulomb collisions, typically described by the kappa distributions. We have investigated the properties of these functions for ions and electrons in different magnetospheric regions, thereby making it possible to reveal the κ-parameters for a wide range of plasma beta (β) values (from 10^{-3} to 10^{2}). This was done using simultaneous ion and electron measurements from the five Time History of Events and Macroscale Interactions during Substorms (THEMIS) spacecraft spanning the years 2008–2018. It was found that for a fixed plasma β, the κ-index and core energy (E c) of the distribution can be modeled by the power law □= AE□ for both species, and the relation between β, κ, and Ec is much more complex than earlier reported: both A and γ exhibit systematic dependencies with β. Our results indicate that β ⍰ 0.1–0.3 is a range where the plasma is more dynamic, since it is influenced by both the magnetic field and temperature fluctuations, which suggests that the transition between magnetically and kinetically dominated plasmas occurs at these values of β. For β > 1, both A and γ take nearly constant values, a feature that is especially notable for the electrons and might be related to their demagnetization. The relation between β, κ, and Ec that we present is an important result that can be used by theoretical models in the future.

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