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Correlations between Kappa distributions and collision parameter in space plasmas at 1 AU

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Abstract

Particle collisions play an important role in establishing thermal equilibrium in a fluid. In fact, the non-thermal characteristics observed in solar wind plasma, such as temperature anisotropy and beam velocity, appear to be regulated by collisions. In works like Kasper et al. [1], a new parameter of study is introduced: collisional age, which estimates the collision frequency compared to plasma packet flight times. Kasper et al. [1] concludes that while non-thermal solar wind is generally associated with high velocities, these distributions suggest that the occurrence frequency is actually determined by the collisional age. On the other hand, Bale et al. [2] demonstrated that the temperature relationship has a stronger correlation with the number of Coulomb collisions than other parameters like solar wind velocity. It is expected that low-collision plasma can exhibit other non-thermal characteristics, such as distributions with high-energy tails that exceed a Maxwellian distribution.
Kappa distributions are considered a suitable approach for studying particle distributions in astrophysical plasmas, particularly due to the supra-thermal energy tails found in plasmas outside classical thermal equilibrium. In Eyelade et al. [3], these Kappa distributions are studied in the Earth's magnetosphere, revealing direct correlations between the Kappa index, energy, and plasma beta parameter.
Our work focuses on studying correlations between the collision parameter and Kappa distributions at 1 AU using data provided by the freely accessible THEMIS satellite.

References

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[2] S. Bale y col., Physical review letters, 2009, 103, 211101
[3] A. Eyelade y col., The Astrophysical Journal, 2021, 253, 34