THEORY OF KAPPA DISTRIBUTIONS AND NONEXTENSIVE STATISTICAL MECHANICS: APPLICATIONS IN ASTROPHYSICAL PLASMAS

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ABSTRACT

Classical collisional particle systems residing in thermal equilibrium have their particle velocity/energy distribution function stabilized into a Maxwell-Boltzmann distribution. On the contrary, space and astrophysical plasmas are exotic collisionless particle systems residing in stationary states characterized by the so-called kappa distributions [1-3]. A breakthrough in the field came with the connection of kappa distributions with statistical mechanics and thermodynamics, accomplished by the following two findings: (i) kappa distributions maximize the entropy of nonextensive statistical mechanics [4] under the constraints of canonical ensemble [5-8], and (ii) particle systems exchanging heat with each other reaching thermodynamic equilibrium are stabilized always into a kappa distribution [9,10]. Thereafter, kappa distributions became increasingly widespread across the physics of astrophysical plasma processes, describing particles in the heliosphere, from the solar wind and planetary magnetospheres to the heliosheath and beyond, the interstellar and intergalactic plasmas [1]. The lecture will review the physical foundations and recent developments of kappa distributions in space and astrophysical plasmas.

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