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Origin and Role of kappa distributions in space and astrophysical plasmas

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Abstract

Classical collisional particle systems reside in thermal equilibrium and have their particle velocity/energy distribution function stabilized into a Maxwell-Boltzmann distribution. On the contrary, collisionless particle systems such as space plasmas, reside in a generalized thermal equilibrium, where the stationary states are characterized by the so-called kappa distribution function. A breakthrough in the field of statistical mechanics of plasmas came with the connection of kappa distributions with thermodynamics, accomplished by the following two findings: (1) kappa distributions maximize the entropy of nonextensive statistical mechanics under the constraints of canonical ensemble, and (2) particle systems that exchange heat with each other and reaching thermal equilibrium are stabilized always into a kappa distribution. Thereafter, kappa distributions have become increasingly widespread across space and plasma physics, describing particles in the heliosphere, from the solar wind and planetary magnetospheres to the heliosheath and beyond, the interstellar and intergalactic plasmas. The talk will review the physical foundations and recent developments of kappa distributions.

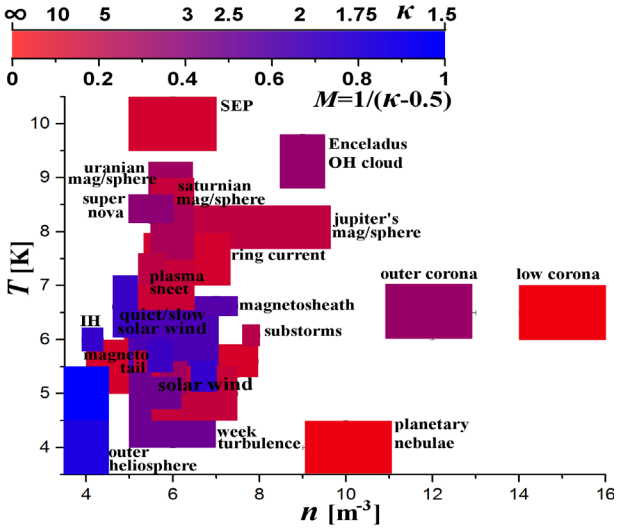

Figure: Examples of space plasmas with their representative values of density n, temperature T, kappa κ. The color-map is based on the measure M=1/(κ-½) in the n-T plane.

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