The nonextensive parameter for the rotating astrophysical systems with power-law distributions

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We study the nonextensive parameter for the rotating astrophysical systems with power-law distributions, including both the rotating self-gravitating system and the rotating space plasmas. We extend the equation of nonextensive parameter to a complex system with arbitrary force field $F(r, v)$, and then derive a general equation of the q-parameter, most generally including both the rotating self-gravitating systems and the rotating space plasmas. This equation presents clear physical meanings of the q-parameter different from one, showing the nonequilibrium properties of the power-law distributions in the complex systems under external force fields.

When we apply the equation of the q-parameter to the rotating astrophysical systems and the rotating space plasmas, respectively, we show that the q-parameter is related not only to the temperature gradient, the gravitational force and the electromagnetic force (Coulomb force and magnetic induction intensity) in the systems, but also to the inertial centrifugal force and Coriolis force if the systems are rotating. These forces all introduce significant effects on nonextensivity of the astrophysical systems. We have given the expressions of the q-parameter for the rotating self-gravitating systems, which may be suitable for describing the distributions of self-gravitating gases, galaxies and dark matter haloes.

At the same time, we have also given the expressions of the q-parameter for the rotating space plasmas. By defining the physical temperature in the space plasmas and making parameter replacements, we can reproduce the famous kappa-distribution in space plasmas, obtain the expressions of the kappa-parameter, and thus present clear physical meaning of the kappa-parameter. It is shown that the kappa-parameter can be quantificationally determined by the temperature gradient, the electromagnetic forces (Coulomb force and magnetic induction intensity), the inertial centrifugal force and the Coriolis force in the rotating space plasmas.

We also list several examples to illustrate the nonextensivities introduced by the rotation effects.

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