Possible explanation for power law tails of the solar wind ion distribution function: Study of the Liouville-Coulomb system

Brent Randol
NASA's Goddard Space Flight Center, Greenbelt (MD), United States

Velocity distribution functions (VDFs) of solar wind particles are often seen to exhibit non-thermal features: a "kappa"-distributed core (a statistical distribution that has a Gaussian-like peak which transitions smoothly to a power-law tail), as well as an additional tail that does not connect smoothly to this core (see, e.g., Chotoo et al., 2000). Here, we present an explanation as to how these features come about based on a self-consistent theory of suprathermal particle acceleration from mutual Coulomb interactions. For the results presented here, we employ the simulations described in Randol & Christian (2014, 2016) and discussed further in Randol (2019, 2021), except with higher accuracy. The main result is that for a plasma that has just undergone ionization (for moderate Coulombic energy density), a "sharp" tail (that is, one that does not connect smoothly to the Gaussian core) is formed quickly, and over time, this tail rises in intensity while the Gaussian core simultaneously forms a kappa distribution. Results at longer times as well as dependence on initial Coulombic energy density are also discussed.