Characteristics of electron velocity distributions in space plasmas

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Space plasmas are essentially collisionless systems out of thermal equilibrium, where enhanced populations of suprathermal particles are observed. The typical distributions are generally better described by kappa distributions than by Maxwellians, especially for electrons [Pierrard and Lazar, 2010]. This has large consequences since the small electron mass makes them major agents for plasma energy transport. More than 120 000 velocity distributions measured by Helios, Cluster and Ulysses in the ecliptic have been analyzed within an extended range of heliocentric distances from 0.3 to over 4 AU [Pierrard et al., 2016]. The velocity distribution of electrons reveal a dual structure with a thermal (Maxwellian) core and a suprathermal (Kappa) halo. A detailed observational analysis of these two components provides estimations of their temperatures and temperature anisotropies. For low values of the power-index kappa, these two components manifest a clear tendency to deviate from isotropy in the same direction. The existence of plasma states with anti-correlated anisotropies of the core and halo populations and the increase of their number for high values of the power-index Kappa suggest a dynamic interplay of these components, mediated most probably by anisotropy-driven instabilities. Estimating the temperature of the solar wind particles and their anisotropies is important for understanding the origin of these deviations from thermal equilibrium.

Kappa-distributed populations of electrons were used to develop a kinetic solar wind model. Low values of the parameter kappa are associated to an enhanced population of suprathermal electrons leading to higher velocities at large radial distances [Pierrard and Pieters, 2014]. Boundary conditions are based on observational input photospheric magnetograms. The model provides an extended radial profile of the velocity distribution functions of the particles from the corona to the whole heliosphere. The results are compared with solar wind observations at 1AU to obtain the best prediction of solar wind characteristics.

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[2] V. Pierrard, et al., Solar Phys. **291**, 2165 (2016).

[3] V. Pierrard, M. Pieters, J. Geophys. Res. Space Phys. **119**, 9441 (2014).