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Suprathermal particle distributions in space physics: Kappa distributions and entropy

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The energization of a charged test-particle of mass m in contact with a large ensemble of charged particles of mass M at equilibrium is studied with the Fokker-Planck equation for Coulomb collisions and a quasi-linear diffusion operator for wave-particle interactions. The features of the nonequilibrium steady state velocity distribution of the test-particle system is studied as a function of the mass ratio m/M, and the relative strengths of the wave-particle interactions and Coulomb collisions. It is shown that the steady distribution function is not necessarily a Kappa distribution. The temperature of heavy minor ions given by the model is shown to vary linearly with the mass ratio as observed in the solar wind. The time evolution of the distribution function with and without the energization by wave-particle interactions is calculated and it is demonstrated that the Kullback relative entropy rather than the Tsallis nonextensive entropy rationalizes the results obtained.