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Probabilistic model of beam-plasma interaction in the randomly inhomogeneous solar wind

Vladimir Krasnoselskikh and Andrii Voshchepynets
CNRS-University of Orleans, LP2CE, Orleans CEDEX 2, France (vkrasnos@cnrs-orleans.fr)

We apply the probabilistic model of beam plasma interaction proposed before to electron beams propagating in the interplanetary plasma taking into account known properties of the density fluctuations in the solar wind measured aboard ISEE. The new element here with respect to previous work consists in the calculation of the probability density for density fluctuations having power law spectra, while previously we used Gaussian probability distribution. We use the property that for the given frequency the probability distribution of density fluctuations uniquely determines the probability distribution of phase velocity of wave. We present the system as discrete consisting of small equal spatial intervals and the density profile on each small interval is linear. The model is based on general description of the wave particle interaction on any of these small spatial intervals with linear profile. We solve equations of motion of a particle under the action of the wave with the given amplitude and phase in the beginning of the interval. This approach allows one to estimate variations of the wave's energy density and particle's velocity, depending on the density gradient. The presence of the plasma inhomogeneity results in the variation of the phase velocity of the wave having known frequency and causes a spreading of the width of the resonance in the velocity space. Since the characteristic time of the evolution of the electron distribution function and wave energy is much longer than the time of the single wave-particle resonant interaction on a given small interval, we can proceed to the description of the relaxation process in terms of averaged quantities. We derive a system of equations, similar to the quasi-linear approximation, but conventional velocity diffusion coefficient $D$and the wave's growth rate γ are replaced by averaged in phase space making use the probability distribution of phase velocities and assuming that the interaction on each interval is independent upon previous interactions. The dependencies of functions $D$and γ are completely determined by the statistical properties of the distribution function of the amplitudes of the fluctuations. We show, that in the case of solar wind the relaxation process is determined similarly to Gaussian case by four major parameters, the beam velocity ratio to thermal velocity of plasma, the dispersion and amplitude of the fluctuations, and, the width of the beam in the velocity space. We show that the length of relaxation of the beams can be sufficiently larger than 1AU.