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Electron beam-plasma instability in the randomly inhomogeneous solar wind

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We propose a new model that describes effects of plasma density fluctuations in the solar wind on the relaxation of the electron beams ejected from the Sun during the solar flares. The density fluctuations are supposed to be responsible for the changes in the local phase velocity of the Langmuir waves generated by the beam instability. We use the property that for the wave with a given frequency the probability distribution of density fluctuations uniquely determines the probability distribution of phase velocity of wave. We replace the continuous spatial interval by a discrete one, consisting of small equal spatial subintervals with linear density profile. This approach allows us to describe the changes in the wave phase velocity during the wave propagation in terms of probability distribution function. Using this probability distribution, we describe resonant wave particle interactions by a system of equations, similar to a well-known quasi-linear approximation, where the conventional velocity diffusion coefficient and the wave growth rate are replaced by the averaged in the velocity space. The averaged diffusion coefficient and wave growth rate depend on a form of the probability distribution function for the density fluctuations. This last distribution is obtained from the spectrum of the density fluctuations measured aboard ISEE satellites when they were in the solar wind. It was shown that the process of relaxation of electron beam is accompanied by transformation of significant part of the beam kinetic energy to energy of the accelerated particles via generation and absorption of the Langmuir waves. We discovered that for the very rapid beams with beam velocity vb>15vt, where vt is a thermal velocity of background plasma, the relaxation process consists of two well-separated steps. On first step the major relaxation process occurs and the wave growth rate almost everywhere in the velocity space becomes close to zero or negative. At the second stage the system remains close to the state of marginal stability long enough to explain how the beam may be preserved traveling distances over 1 AU while still being able to generate the Langmuir waves.