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ORIGINAL ARTICLE

Small-scale Langmuir wave instability in preflare chromosphere of solar active region

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Abstract Necessary conditions have been investigated for the appearance of instability of high-frequency electron Langmuir waves in plasma of solar chromosphere near the foot-point of loop structure. We have considered the earliest stage of a flare process in solar active region.

At the chromospheric part of current circuit of a flare loop such instability can appear and develop as the result of combined action of large-scale electric field, Landau damping and collisional processes in preflare plasma. We have investigated the process of instability development for two possible scenarios: (a) when preflare loop plasma has a classical Coulomb conductivity and (b) when anomalous resistance appears due to saturation of Bernstein turbulence. The growth rates of instability have been obtained and analyzed in detail. It has been assumed in the process of calculation that preflare plasma can be described by the FAL model of the solar atmosphere, which takes into account the process of helium diffusion. It has been shown that Langmuir wave instability can appear in its marginal form in the area under investigation either in the presence of Coulomb conductivity or in the presence of saturated Bernstein turbulence. Existence of instability with the growth rate, which changes its sign, proves the principal possibility of generation of non-damping Langmuir waves with small amplitudes.

Keywords Magnetic field · Sun activity · Flare loop · Plasma instabilities

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1 Introduction

Langmuir turbulence is often considered as possible driver of the process of particle acceleration in the flares (Altyntsev et al. 1982; Kingsep and Iankov 1975; Pikelner and Tsytovich 1975). When this turbulence is developed, it consists of the waves of different scales and it means that process of particle acceleration has diffusive form. High-frequency Langmuir turbulence can actually accelerate only the relatively fast particles namely due to the fact that plasmon phase velocity (w/k) (here w is the wave frequency, k is the wave vector) exceeds thermal velocity of electron V_{T_e} (Alexandrov et al. 1988):

$$\frac{\omega}{k} > V_{T_e} \tag{1}$$

When turbulence is "weak" and wave energy accumulates in the area of plasma's "condensate", the particle acceleration is relatively small, but it becomes much more effective when plasma turbulence becomes "strong". In accordance with some estimates (Altyntsev et al. 1982) approximately 90 % of turbulence energy transform into the energy of the fast particles. Well known "tails" of energetic particles can rise in this way (Ibid.). Anyway, at the early beginning of this process of transformations of small initial perturbations in plasma we always find the corresponding instability. Thus the "earliest origin" of it—the linear stage of instability can be considered (in a sense) as necessary condition of turbulence rise and development (Alexandrov et al. 1988). Strictly speaking, in the only one situation we can trace the way from the linear stage of instability up to the appearance of weak turbulence. This is "history" of quasilinear relaxation of spatially restricted beam of energetic particles in plasma (Alexandrov et al. 1988). Such beams can exist in the loop structures after the "flash" phase of a flare in solar active region (De Jager 1959; McClements 1989;

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