Generation of Solitonlike Structures of Electromagnetic Wave Field During Transillumination of Inhomogeneous Plasmas

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By usage of exact solution for Helmholtz equation it is investigated the reflectionless propagation of electromagnetic wave through the thick inhomogeneous plasma layer (so called the wave barrier transillumination). On the basis of numerical calculations it has been shown that in the inhomogeneous plasma layer under the reflectionless propagation the wave amplitude spatial profile may has the solitonlike structure. Moreover for the case of relatively small variations of local effective plasma permettivity the large modulations both wave amplitude and wave vector may be observed in this system. It is important to note here that the transilluminated plasma layer may contains wide enough wave opacity zones and the plasma inhomogeneity may includes the large number of plasma density subwave structures.

It is revealed that by the change of physico-mathematical model incoming parameters it is possible to vary significantly the plasma inhomogeneity characteristics including the plasma layer thickness, the number of small-scale structures and nevertheless the full transillumination of gradient barriers by electromagnetic wave will take place. It is very important also that due to the plasma dielectric permettivity gradients the specific wave cuttoff frequency determined by the inhomogeneity profile may appears.

It is analized the possible spatial profiles of electromagnetic wave amplitude, the plasma effective dielectric permettivity, the wave vector and the plasma density spatial distribution in the inhomogeneous layer under the incoming parameters variations. Sometimes the wave dynamics is very sensitive to small changes of incoming parameters. It is considered the influence of cubic nonlinearity of plasma on wave barriers transillumination. It is shown that this influence promotes to the wave barriers transillumination.

The exactly solvable physico-mathematical models for electromagnetic waves interaction with the inhomogeneous plasma are of the greate interest to numerical applications, for example, to study the features of electromagnetic radiation interactions with inhomogeneous dielectrics including plasmas. In particular, it is important to realize the electromagnetic radiation tunneling through gradient wave barriers in the problem of dense plasma heating up to very high temperatures, to transilluminate opaque plasma layers in the communication tasks and for the development of new methods of dense plasma diagnostics.

It is interesting also for the understanding of physical mechanism realizing the radiation escape from the sources placed deeply in the overdense plasma in the astrophysics. This task is important for the elaborations of absorbing coverings and transillumination ones in the radiophysics, to elaborate the thin radiotransparent fairings for antennas and so (see, for example, papers [1-7]).

Such models are interesting also for investigations the new features of wave amplification in inhomogeneous plasma, the plasma instabilities dynamics including waves generation and their nonlinear interactions in the plasma flows presence. New features may appear in the interaction of electromagnetic waves with charged particles under the plasma inhomogeneities presence and for the very short wave impulse evolution in inhomogeneous plasmas. Additional features may appear for electromagnetic waves interaction with the inhomogeneous chiral plasmas.

References

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