PENETRATION OF AN ELECTROMAGNETIC PULSE INTO A CURRENT-CARRYING PLASMA

Ovchinnikov K.N. and Uryupin S.A.

Lebedev Physical Institute, Russian Academy of Sciences, Moscow, Russia, [uryupin@sci.lebedev.ru](mailto:uryupin@sci.lebedev.ru)

In this report the penetration of weak pulse into current-carrying plasma with time-varying temperatures of the particles has been studied. Explicit time, plasma and pulse parameters dependencies of the effective depth of field penetration are established for a fully ionized and weakly ionized plasmas. It is shown that in the case of a fully ionized plasma penetration of long pulse field occurs in the subdiffusion regime when the effective penetration depth depends on the time as *t*1/5. In a weakly ionized plasma, when elastic scattering of electrons by neutral particles is dominant, the penetration depth is proportional to *t*, that allows to speak about the field superdiffusion. We note that revealed penetration patterns are different from the law which was established previously for a turbulent plasma where the penetration depth increases with time as *t*1/4 [1]. In [2] represented the experimental data obtained at TUMAN-3, among which there are those when the electron drift velocity is less than or comparable to the ion-acoustic velocity. In the same paper the experimental data for tokamaks with significantly different sizes and plasma concentrations are compared. It is marked that some discharges on the reviewed facilities are situated in the "subsonic" regime. "Subsonic" regime was created by increasing of the particles density by pellet injection (Alcator, ASDEX) or gas injection (ASDEX, TFTR). The relationship between the current and the plasma density at DITE facility for discharges in deuterium and hydrogen is shown in [2]. It was noted, in both cases obtaining maximum density corresponds to a phase with decreasing current and in the same phase the transition in the "subsonic" regime realized. The developed theory can be used to analyze the penetration of electromagnetic pulse in the "subsonic" discharges at these facilities if the pulse duration is greater than characteristic time of plasma particles heating. For estimates, we use the following set of parameters: ne ~ 6 × 1013 cm–3, Te ~ 50 eV, I ~ 100 kA and plasma pinch radius r = 15 cm. At such values of the parameters the electron drift velocity is less than the ion-acoustic veloсity. Under these conditions the proposed theory is needed if the probe pulse duration for these facilities will exceed the value ~0.3 ms. As a physical object to illustrate the penetration of electromagnetic pulse in a weakly ionized plasma, we consider the lightning discharge. For estimates we accept ne ~ 1016 cm–3, Te ~ 1 eV, the radius of the lightning channel ~10 cm, and the value of current as I ~ 100 kA. We accept also the cross section for elastic scattering of electrons by neutrals is ~10–15 cm2 and neutral density is ~1019 cm–3. With these parameters for electron heating time we obtain an estimate ~0.1 μs, that is, the pulse duration must be greater than 0.1 μs.

References

1. Ovchinnikov K N and Uryupin S A 2013 Plasma Physics Reports 39 745
2. Vinogradov N I, Izvozchikov A B and Shakhovets K G 1987 Preprint No. 1177 FTI im. A.F. Ioffe, Academy of Sciences of USSR, Leningrad