Electromagnetic Resonances of Plasma Column between Two Metallic Plates

S.A. Dvinin1, V.A. Dovzhenko2, and O.A. Sinkevich3

1Lomonosov Moscow State university, Moscow, Russia, [s\_dvinin@mail.ru](mailto:s_dvinin@mail.ru)  
2Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences, Moscow, Russia  
3Moscow Power Engineering Institute, Moscow, Russia, [oleg.sinkevich@itf.mpei.ac.ru](mailto:oleg.sinkevich@itf.mpei.ac.ru)

It is known that there are two types of electrodynamic resonances of bounded supercritical plasma, placed between the two metal planes are possible. The first type is associated with the excitation of surface waves propagating along the lateral surface [1]. The second one is caused by standing surface waves in the sheath at plasma-metal boundary [2–4]. This paper discusses both types of resonances together.

Electromagnetic field in the area, containing the plasma and sheathes (*r* < *R*), is represented by the sum of eigenwaves of three-layer structure plasma-sheath-metallic wall. Eigenwaves calculations prove the existence of three types of space field distributions: propagating surface waves (\*), waves with complex propagation constants (\*\*), radially damped waves (\*\*\*).The latter type gives a decisive contribution to the resonances associated with the surface waves propagating along the lateral surface. Setting the boundary conditions at the surface *r* = *R* makes it possible to calculate the resonances associated with the excitation of both types of waves together. The dispersion relations were obtained using equations for electromagnetic field [5, 6].

Electrodynamic resonances of bounded supercritical plasma, placed between the two metal planes were investigated. Modification of resonance electromagnetic field and frequencies when their frequencies are close are discussed. The plasma column brings inductive impedance of the evanescent modes if the electron density lower than the density corresponding to the geometric plasma-sheath resonance [7] *n*e/*n*C < *L*pl/(*d*1 + *d*2). This resonance is converted into a resonance standing surface waves when *d*1 = *d*2 = 0. In opposite case energy transfer to surface wave on plasma-sheath interface prevails. Being compensated by capacitive current of waveguide higher modes this field can be resonantly enhanced. Another possibility is associated with a change in the impedance introduced by the radial surface waves at large radii of the plasma *hR*1 > *π*/2. Discharge properties in both cases including joint excitation are calculated.

References

1. Dvinin S.A, Dovzhenko V.A., Solntzev G.S. Sov. Phys.: Fizika Plazmy, 1983, 9, 1297. 7.
2. Lieberman M.A., Booth J.P., Chabert P. et al: Plasma Sources Sci. technol. 2002, 11, 283.
3. Двинин С.А., Вологиров А.Г., Михеев В.В., Свиридкина В.С. Физика плазмы, 2008, 34, 688.
4. Gekelman W., Barnes M., Vincena S, Pribyl P. Phys. Rev. Lett. 2009, 103, 045003.
5. Никольский В.В. Вариационные методы для внутренних задач электродинамики. М.: Наука, 1968.
6. Felsen L.B., Marcuvitz N. 1973 Radiation and scattering of waves (Prentice-Hall, Inc., Englewood Cliffs, New Jersey).
7. Taillet J. American Journal of Physics, 1969, 37, 423.