§34. Large Amplitude Langmuir Waves in a Relativistic Plasma with Negative Ions

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Observations confirm the facts that stationary nonlinear Langmuir waves are usually formed in a plasma with negative ions[1]. When negative ions are introduced in the plasma the response of the plasma to disturbances is found to be drastically modified. We consider large amplitude Langmuir waves involving high-speed electrons, non-relativistic positive ions and negative ions.

We apply the fluid equations for positive ions, electrons, negative ions and use the Poisson's equation, and thereby the pseudopotential is derived. The oscillatory solution of large amplitude Langmuir waves exist when the following conditions are satisfied: (i) The pseudopotential has a minimum value at the origin. (ii) Nonlinear ion-acoustic waves exist only if the pseudopotential >0 at the maximum electrostatic potential. We consider the pseudopotential for the three cases of the positive and negative ion species: (H^+, O^-), (H^+, NO_2^-) and (He^+, NO_2^-). We show a bird's eye view of the pseudopotential, as an example, in the case where the positive ions is H^+ and the negative ions is O^- in Fig.1.

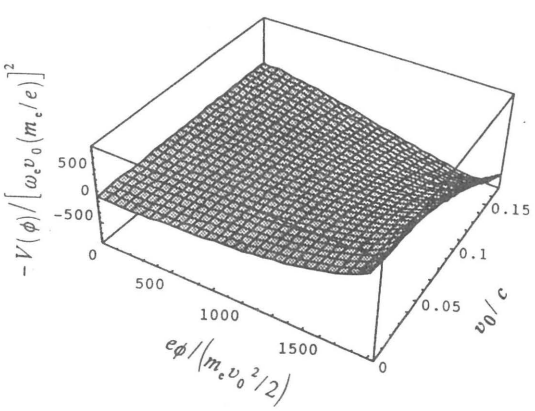

Fig.1.

We illustrate the existence region of large amplitudeLangmuir waves depending on the relativistic effect v_0/c in Fig.2-(a), (b) and (c), for the case of (H^+, O^-), (H^+, NO_2^-) and (He^+, NO_2^-), respectively. Large amplitude Langmuir waves propagate in the lower region of the curves but do not exist in the other region.

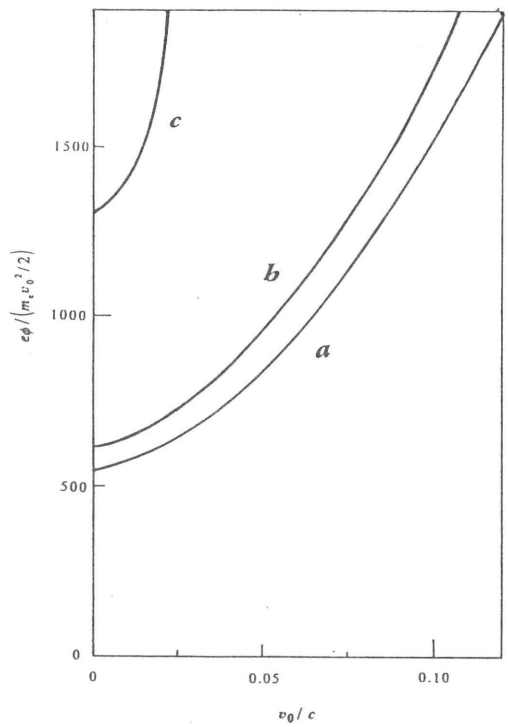

Fig.2

The results are summarized as follows: The existence conditions for large amplitude Langmuir waves sensitively depend on the ratio of the positive ion mass to electron mass, the electrostatic potential and the relativistic effect. The existence region of large amplitude Langmuir waves spreads as the relativistic effect increases. This region is differ considerably from each other, the widest range of the existence region is the case (H^+, O^-), whereas the existence region of the case of (He^+, NO_2^-) is fairly narrow. The present study predicts new findings on large amplitude Langmuir waves in plasmas with negative ions.

References

1)Hargreaves,J.K., The Solar-Terrestrial Environment, (Cambridge Univ. Press) (1992), p.229.