SHORT COMMUNICATIONS

NOTE ON PLASMA-ELECTRON OSCILLATIONS*

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Wild, Murray, and Rowe (1954) have recently presented strong evidence that coronal plasma oscillations are responsible for certain forms of solar radio noise. It may be of interest in this connexion to mention briefly some results, partly new, which we have obtained in a laboratory study of plasma oscillations. The interpretation of the experiments is not in all respects unambiguous, and we have not attempted any quantitative scaling from discharge tube to solar conditions—nor to the apparently allied problem of colliding nebulae—but there is at least some parallelism between the phenomena probably occurring in the different sources. The experiments have been done with hot-cathode discharges in mercury vapour or argon, at pressures of order of 10^{-3} mm Hg, with cathode falls of potential between the ionization potential and a little over 100 V, i.e. with primary electrons moving with velocities rather greater than 10^8 cm/sec. The oscillations have been mainly studied with a probe inserted into the discharge and coupled to an external variable-frequency resonator. So far as the detecting system does not produce distortion, the spectrum obtained is thus comparable with Wild, Murray, and Rowe's " natural spectrum ".

It has been found that :

(1) There is no strong coherent oscillation of any large volume of plasma, with frequency near the Langmuir plasma-electron frequency (f), in the tubes we have used.

(2) Oscillations with frequency close to f occur very commonly in limited regions where the plasma is traversed by one or more beams of primary electrons.

(3) The conditions under which they are produced are consistent with their maintenance through some type of slipping stream interaction, growing in amplitude along one of the beams, and rapidly becoming catastrophic through the operation of Bohm and Gross's (1949) process of electron trapping.

(4) Contrary to what was thought earlier (Emeleus and Neill 1951), harmonics can be generated, i.e. frequencies $2f$ and $3f$ picked up in addition to the fundamental frequency f. The conditions for their production are not entirely understood, but generally speaking, they have been found where there is other reason to believe that the plasma or beam oscillations are non-linear. There is some evidence, which needs confirmation, for the occasional occurrence of a subharmonic with frequency $\frac{1}{2}f$.

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(5) Oscillating beams not only acquire a longitudinal distribution of energy (Dittmer's (1926) " scattering "), but have a strong tendency to be deviated laterally. The resulting transverse motion could provide the basis of a mechanism for generating electromagnetic radiation with field components perpendicular to the original direction of the beam.

(6) Under certain conditions plasma ion oscillations, or relaxation oscillations, with frequency less than 1 Mc/s are produced as a secondary consequency of the higher frequency (plasma electron) oscillations. Their spectrum has the characteristics of low frequency " noise " (Martin and Woods 1952). If the low frequency oscillations react on the high frequency oscillations in the plasma, the frequency of the latter will become spread. Wild, Murray, and Rowe (1954) have found it necessary to postulate a spread round f in the coronal oscillations, which might conceivably receive a contribution from a comparable mechanism.

We have not actually been able to detect electromagnetic radiation with the Langmuir frequency, or its harmonics, coming direct from a plasma in which high frequency oscillations are taking place. If present, its energy outside the tube is much less than that of the corresponding oscillatory currents which can be withdrawn by an internal probe.

References

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