Jones potential. The agreement is also quite good [except for the height of the first peak of $S(k)$] with the neutron-scattering experiment of Henshaw[9] (argon in the vicinity of the triple point). There, a comparison can be made also with the x-ray scattering experiment of Gingrich and Thomson.[10] The difference is quite serious, more than 5 %. It should be noted that, there also, the x-ray scattering intensity shows a rather irregular behavior for large k's.

The question can then be raised of the precision of the x-ray scattering experiment and of the possibility of obtaining, from their use, quantitative information on the interaction. We suggest that a more systematic comparison is made with neutron experiments, which may lead to a reinvestigation of the various correction errors and to a better determination of the form factors that are necessary to extract the structure factor from the measured x-ray intensities.

*Postal address: Laboratoire de Physique Théorique et Hautes Energies, Faculté des Sciences, Orsay, France.

†Laboratoire associé au Centre National de la Recherche Scientifique.

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PLASMA RESPONSE TO THE SUDDEN APPLICATION OF AN ELECTRIC FIELD*

John S. DeGroot and Kenneth R. MacKenzie
Department of Physics, University of California, Los Angeles, California

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Dreicer[1] used the rapid decrease of the Coulomb cross section with energy to show that there is a critical runaway field E_r. Buneman[2] showed qualitatively that instabilities will grow and stop the runaway process. Field and Fried (FF),[3] using a three-dimensional quasilinear theory for wave particle interactions, studied the sudden application of electric fields (10 and 50 times E_r) to a fully ionized collisionless hydrogen plasma with $T_e/T_i \gg 1$ (and Debye numbers $N_\mathrm{D} = 2\times10^5$ and $N_\mathrm{D} = 10^6$, respectively). Due to the growth of ion-acoustic waves they found that the electron drift velocity (which initially increased as $|v_d| = eEt/m$) reached a maximum and then decreased to about $\frac{1}{4}$ the peak value, at which point the approximations become invalid.

In our experiment a pulsed, azimuthally uniform, 1% ionized plasma is produced by photoionization.[4] The photons are generated over a 3-μsec period at the center of a 60-cm-diam chamber by discharging 10 μF at 10 kV through a spark of the type used by Ballofet.[5] Subsequently the density decays about 1.0 %/μsec. In spite of the high xenon mass, this plasma can be matched to the FF theory better than a hydrogen plasma which contains molecular ions by simply scaling v_d as (at. wt)$^{1/4}$. Also, the photoionization cross section is a factor of 9 lower than xenon. Densities of 5×10^{11} and values of $N_\mathrm{D} = 10^6$ could be produced by raising the pressure to 10^{-3} Torr; but collisions entered within the times of interest, so measurements were typically made at 5×10^{-5} Torr with densities of 10^9 and $N_\mathrm{D} \simeq 10^5$. The FF value of $E/E_r = 10$ was extrapolated to values above 40 to make the growth of waves occur within the electron-neutral collision time.

The E field is induced by a transformer shown in Fig. 1, consisting of punched laminations (of Mumetal—to ensure essentially zero magnetic field in the plasma). The ionizing photons pass between them and enter a plastic torus through a nylon screen with Debye-length apertures. The plasma immediately loses fast electrons and forms a potential well which contains the plasma electrons as v_d increases. A one-turn primary and auxiliary secondary are shown above a slotted metal support ring (forming a closed circuit outside the laminations) which shields the plasma from the primary and secondary electrostatic fields, leaving only the uniform induced step-function E field in the plasma secondary ($\simeq 5$

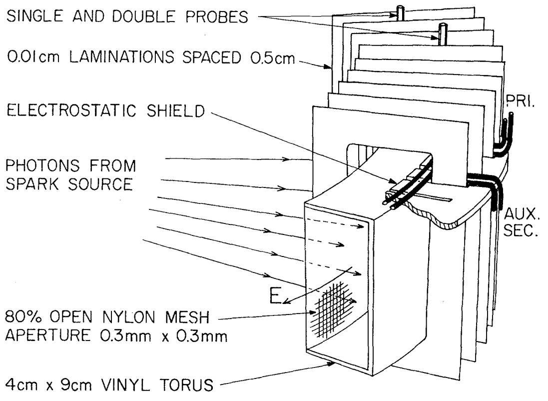

FIG. 1. A section of the toroidal transformer consisting of 300 Mumetal laminations lined up to intercept minimum photon flux.

$\times 10^{-2}$ V/cm).

The total current in the plasma (≃0.8 A, shown in Fig. 2 with a correction for decay) is found by taking the difference in the primary current with and without plasma. A maximum is seen which agrees with FF, but the decrease is less marked. This was expected, since waves within 1 cm of the wall should be lost before they can grow appreciably. However, the presence of a decelerating mechanism is clearly shown by an induced voltage on the auxiliary secondary at the time of maximum negative slope (like the induced voltage when a transformer secondary is opened). Any other resistive process exists at $t=0$.

The behavior of the current at the center of the torus was measured with a double probe consisting of two flat plates (each 14 mm^2 in area) separated by a thin insulator. When oriented perpendicular to the current flow, the difference in electron collection is, to lowest order, proportional to v_d. A typical result is compared with calculations in Fig. 2. The theory has been extrapolated by multiplying the calculated v_d and t by $(M^{1/4}/a_e)(E_r N_D/E)^{1/2}$ and $M^{1/4}\omega_{pe}(E/E_r N_D)^{1/2}$, respectively ($a_e$ is thermal speed; M is at. wt). Figure 2 also shows qualitatively what happens when collisions are made to predominate by raising the pressure and admitting helium. In our device, helium, with its 24-eV potential, has an ionization efficiency some two orders of magnitude lower than xenon.

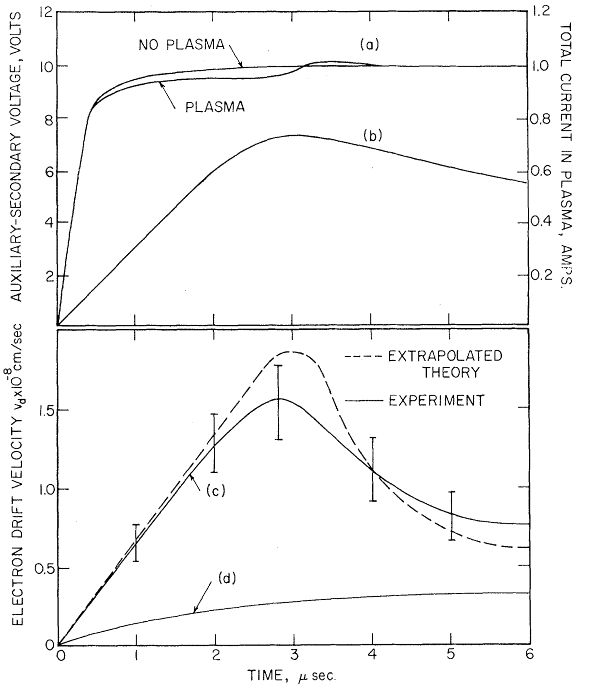

FIG. 2. (a) Auxiliary secondary voltage corresponding to $E=6.8\times10^{-2}$ V/cm and $n=5\times10^9$, showing the induced emf. (b) Total current in the plasma secondary. (c) Double probe display of the center drift velocity with $E=4\times10^{-2}$ V/cm and $n=1\times10^9$. (d) Collisions eliminate these effects—obtained by admitting helium, with $E=3.4\times10^{-2}$ V/cm and $n=11\times10^9$. (c) is compared with theory with no adjustable parameters. The error bars show variations obtained under nearly identical conditions (±10 % in density). $\theta_e=1.5$ eV and $\theta_i=1/40$ eV for all curves.

Although the expected fluctuations near the ion plasma frequency have been observed, the attempts to examine the details of growth and the spatial nature of the waves (predicted $\lambda\simeq0.04$ cm) have so far been unsuccessful.

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