field for $\omega_{ce} < \omega_{pe}$. This mode of transport is inoperative for $\omega_{ce} > \omega_{pe}$, but these treatments do not necessarily predict the existence of the observed stable nonpenetrating state.

The limited diagnostics permit only gross observations of the interaction characteristics. Detailed measurements of the electron temperature, particle trajectories, potential distributions, the dependence of the phenomena on electron temperature and ion energy remain to be done.

We wish to thank B. D. Fried, W. B. Thompson, C. F. Kennel, and A. V. Haeff for many stimulating discussions. We are indebted to E. Ashwell for maintenance of the experimental apparatus and assistance in the conduct of the experiments.

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NOTE ON X-RAY SCATTERING BY ARGON

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The structure factor measured by x-ray scattering experiments on argon is compared with the same quantities calculated with two different intermolecular potentials. We show that it is not possible to get, from the scattering data, quantitative information concerning the interaction and that the discrepancy between theory and experiment is probably due to a systematic error in the latter.

Mikolaj and Pings have recently studied x-ray scattering by dense argon gas in the vicinity of the critical point.[1] Using those experiments, they have drawn conclusions regarding the interatomic interaction. In particular, assuming that the Percus-Yevick equation can be used in order to obtain a two-body interaction from the experimental structure factor, they show that the effective two-body interaction so derived depends very strongly on the density.[2] The depth of the potential is found to be -120°K when the density is as low as 0.280 g/cm^3. It rises to -90°K when a density of 0.780 g/cm^3 is reached (the critical density of argon is 0.536 g/cm^3).

It may be thought, at first sight, that this apparent variation of the depth of the potential is due to the failure of the Percus-Yevick equation at those densities. It has been shown elsewhere[3] that this explanation is not tenable: It is possible using molecular dynamics computation to obtain the structure factor of the Lennard-Jones fluid, and to process this structure factor as if it were experimental, using the Percus-Yevick equation. The potential so obtained differs but little from the original Lennard-Jones potential in the density range we are interested in; for the density 0.780 g/cm^3, the bowl of the potential differs from the exact one by less than 1%.

It is therefore tempting to ascribe the apparent change of depth of the potential to the presence of many-body forces. It is generally believed that the "bare" two-body potential, as determined by low-density experiments, resembles a Kihara potential: A depth as large as 163 °K may be necessary[4] in order to explain the behavior of the second virial coefficient at very low temperatures. A Kihara potential with a depth of 143°K fitting rather well the low-density data has been determined by Baker, Fock, and Smith.[5] It leads[6] to a critical temperature which is too large by a factor 1.13. The choice of a deeper potential still increases the discrepancies at the critical point. A Lennard-Jones potential of a depth of 120°K, fitting the second virial coefficient except at very low temperatures, yields critical constants[7] that are clearly better than those obtained from the Kihara potential. In particular, the critical temperature is too high again, but by a factor 1.07 only.

In view of the great success of the Lennard-Jones potential at higher densities, it is tempting to consider it as a good effect interaction

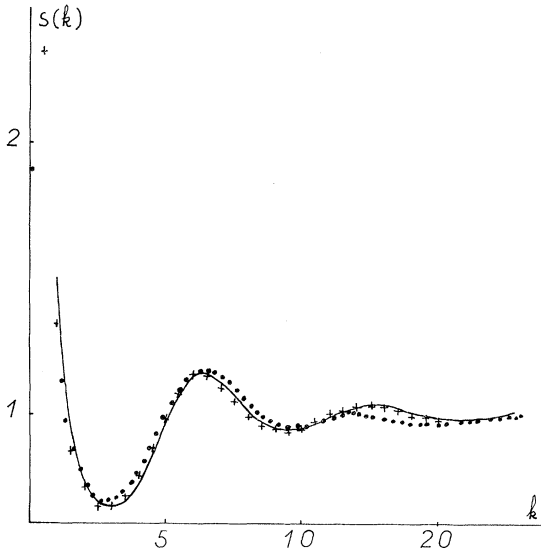

FIG. 1. The structure factor $S(k)$ for argon at the density $\rho = 0.2899$ g/cm^3 and at the temperature $T = -110$°C as calculated with the Kihara potential (solid line) and with the Lennard-Jones potential (crosses). The dots correspond to the experimental data of Ref. 1.

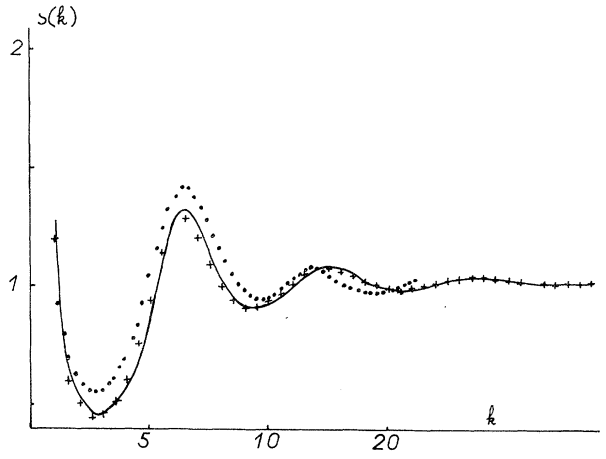

FIG. 2. Same as Fig. 1 with $\rho = 0.536$ g/cm^3 and $T = -110$°C.

that includes most of the many-body effects despite the very bad fit it gives for the second virial coefficient at low temperatures.

We have computed the structure factor $S(k)$ both with the Kihara and the Lennard-Jones potential mentioned above. We think it reasonable to consider that the effect arising from the difference between these two potentials gives the order of magnitude of that due to the many-body forces. The PY II equation was used for convenience as it was amply demonstrated[3,6,7] that it yields negligible errors at densities not far from critical. Results are shown on Figs. 1-3, corresponding to a temperature of -110°C and to densities of 0.289, 0.536, and 0.780 g/cm^3, respectively. It is seen that the difference between the Lennard-Jones and Kihara results is small, 2% at most for those values of k accessible to x-ray scattering experiments. This shows that if one wants, using those experiments, to obtain quantitative information on the potential with a precision of 10%, it seems necessary to determine the structure factor with an error smaller than 1%.

Comparison with the experimental data of Pings is also shown in Figs. 1-3. It is seen that the discrepancy between the theoretical results and experiment is not small. It is an order of magnitude larger than the difference due to the uncertainty on the interaction. The experimental structure factor seems too high for low and intermediate k's. In the high-k region the oscillations of the experimental structure factor are not regular. This contrasts with the regular behavior of the theoretical structure factor. Those regular oscillations were shown to be due to the sharp repulsion of the interaction, and it is difficult to imagine that this feature does not remain in the presence of many-body forces.

It seems appropriate to add the following remarks: Those regular oscillations at high k's are displayed by the neutron-scattering experiment of Clayton and Heaton[8] on liquid krypton, which, by the way, agrees very well with the molecular dynamics results which use the Lennard-

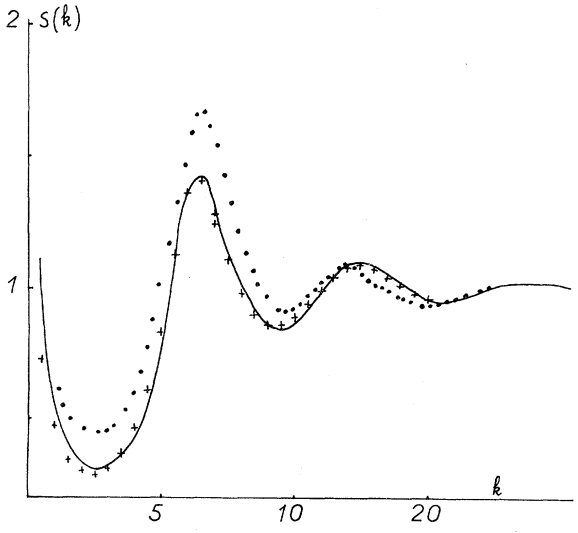

FIG. 3. Same as Fig. 1 with $\rho = 0.780$ g/cm^3 and $T = -110$°C.

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.

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PLASMA RESPONSE TO THE SUDDEN APPLICATION OF AN ELECTRIC FIELD*

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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 $N_D = 2\times10^5$ and $N_D = 10^6$, 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 $N_D = 10^6$ 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 $N_D \simeq 10^5$. 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