Laboratori Nazionali di Frascati

LNF-67/79

I. Modena and F. P. Ricci : MOBILITY OF ELECTRONS IN DENSE ^{4}He FLUID.

Estratto da : Phys. Letters 25A, 213 (1967)

MOBILITY OF ELECTRONS IN DENSE ^{4}He FLUID

I. MODENA
Laboratori Nazionali del CNEN, Frascati (Roma) Italy
and

F. P. RICCI
Istituto di Fisica dell'Università, Roma, Italy

Received 12 July 1967

Experimental results of mobility of electrons in ^{4}He, at constant density for $2.6 \leqslant T \leqslant 10.6^{\circ}$K and at constant temperature for $0.026 \leqslant \rho \leqslant 0.144$ g/cm are reported and discussed.

Although highly useful, from a theoretical point of view, very few experimental results are available in the literature concerning transport porperties in very dense fluids at constant density ranging from well below the critical temperature up to a temperature two times higher than the critical one. Moreover, as far as transport of mass, no experimental results of this kind are available in the literature. For this reason we have measured the mobility μ of electrons in ^{4}He both at constant density (0.144 ± 0.003 g/cm^3) in the temperature range $2.6 \leqslant T \leqslant 10.6^{\circ}$K, and at constant temperature ($T = 10.5^{\circ}$K), varying the density ($0.026 \leqslant \rho \leqslant 0.144$ g/cm^3).

The aim of the measurements was twofold: first, to discriminate the contributions of hard-core collisions and soft interactions in the diffusion process [1, 2]; second to examine the mobility up to a temperature twice the critical temperature, searching whether it is not possible to distinguish between gaseous and liquid phase when crossing the critical temperature at a pressure higher than the critical pressure [3].

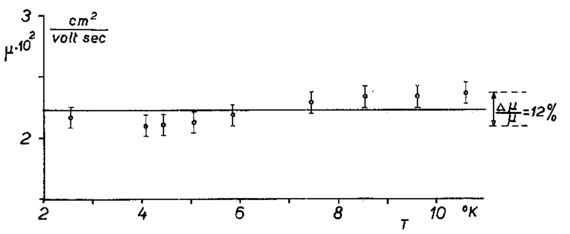

Fig. 1. Plot of the mobility μ versus temperature T at constant density ($\rho = 0.144 \pm 0003$ g/cm^3). The horizontal line represents the average value of the experimental points.

Electrons in dense ^{4}He are very suitable probes for hydrodynamics, since they behave like a rigid bubble [4] of radius ~ 10 Å in our range of pressures.

The mobility measurements were performed by a time-of-flight technique [5] already used in this laboratory [6]. Measuring temperature and pressure gave the ^{4}He density through *PVT* data [7].

Fig. 1 shows a very small increase of μ with temperature $[(\partial\mu/\mu\partial T)_{\rho} = 1.1 \times 10^{-2}{}^{\circ}\mathrm{K}^{-1}]$. However using the Stoke-Einstein relationship and introducing the weak pressure dependence of the bubble radius R, following Kuper [4], such an increase is completely eliminated.

From this result it seems reasonable to argue

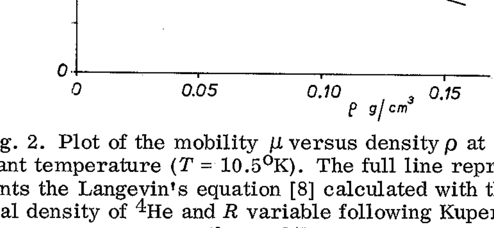

Fig. 2. Plot of the mobility μ versus density ρ at constant temperature ($T = 10.5^{\circ}$K). The full line represents the Langevin's equation [8] calculated with the real density of ^{4}He and R variable following Kuper's theory [4].

that the hard core collisions do not play an important role in the diffusion mechanism at this value of density.

Fig. 2 shows the μ versus density at $T = 10 \cdot 5^{\circ}K$, and a strong dependence can be noticed. It can also be proved from fig. 2 that the Langevin's formula [8] is well verified up to a density $\rho \sim 0.06\ g/cm^3$ if the real density of ^4He is used [9] and the bubble radius R is calculated as above. Therefore in the behaviour of the mobility process does not appear any significant change when crossing the density range in which there is a maximum in the comprensibility [7]. This would indicate that it is meaningless as far as transport properties is concerned to extend the liquid-vapour transition above the critical temperature as suggested before [3].

The authors wish to thank Dr. A. Savoia for helpful discussion about the Kuper model of electrons [4] in dense ^4He.

1. S.A.Rice and A.R.Allnat, J. Chem. Phys. 34 (1961) 2144.
2. A.G.Gibbs and J.H.Ferziger, Phys. Rev. 138A (1965) 701.
3. D.H.Douglass Jr., Physics 1 (1965) 329.
4. C.G.Kuper, Phys. Rev. 122 (1961) 1007.
5. S.Cunsolo, Nuovo Cimento 21 (1961) 76.
6. I.Modena, Proc. of LT8 Conf. Butterworths, London (1963) p. 51.
7. Porperties of materials at low temperatures (Phase I) ed. V.J.Johnson (Pergamon Press, 1961).
8. L.B.Loeb, The kinetic theory of gases, (Dover Publ. New York, 1961) p. 576.
9. J.Levine and T.M.Sanders, Phys. Rev. Letters 8 (1962) 159.

* * * * *