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*The photographs referred to here (Figs. 2a and b) were left out of the original Russian issue. They may be included as errata in a future issue. - Transl.

INFLUENCE OF He³ ON THE MOBILITY OF POSITIVE IONS IN LIQUID HELIUM

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A study of the mobilities of the positive and negative ions in liquid helium has established the fact that the ion scattering is closely connected with the superfluid character of the liquid [1-5]. The moving ion interacts with the gas of phonons and rotons, and this interaction determines the features of the mobilities of the charged particles in HeII.

In He³-He⁴ solutions it is necessary to add to this mechanism the interaction with the impurity excitations, which is connected with the presence of He³. This is evidenced by the data of [6], where the mobility was investigated in solutions with very low He³ concentrations (1.3 x 10⁻³ and 5.1 x 10⁻³ %), and it was observed that the presence of He³ has no effect on the ion mobility down to 0.8°K, but at lower temperatures the mobilities of both the positive and negative ions become lower than in pure He⁴.

The present investigation was undertaken to obtain more detailed information on the character of ion scattering by He³ atoms. We measured the mobility of the positive ions in an He³-He⁴ solution containing 3.9% He³, in the temperature interval from T_λ to 1.4°K.

The ions were produced in the liquid helium under the influence of electrons emitted from a layer of titanium tritide deposited on a molybdenum disc placed in a measuring cell.* The ion mobility was measured by a method similar to that used in [3]. Electric pulses were applied in synchronism to two pairs of grids placed in the measuring cell, in such a way that the grids allowed the ions to pass at one pulse polarity and retained the ions at the opposite polarity. Each pair of grids thus served as a shutter that could be either opened or closed in synchronism. When the ion travel time between the shutters in a given electric field was equal to the period of the pulse or to a multiple of it, the frequency dependence of the ion current was a maximum. From the position of these maxima it was possible to calculate the time necessary for the ion to cover the given distance, and the ion velocity.

The distance between shutters was 3.00 ± 0.05 mm, and the volume of the measuring cell was about 3 cm³. The temperature in the cryostat was maintained constant by an electric stabilizer accurate to 10⁻⁵°. The mobility-measurement accuracy was not worse than 4%, and the absolute error was apparently somewhat higher.

The figure shows the mobility μ of the positive ions against the reciprocal temperature in pure He⁴ (curve 1) and in an He³-He⁴ solution (curve 2) in the temperature interval from T_λ

to 1.4°K. It follows from the plot that the dependence of μ on $1/T$ for He^4 agrees well with the data of [2,3,7], which are represented by the solid lines (our results are represented by the circles). The curve 2 for solutions lies below curve 1 for He^4 in the entire temperature interval. Whereas for the solution investigated in [6], with a concentration $5.1 \times 10^{-3}\%$, the difference between the ion mobility in He^4 and in the solution shows up only at 0.8°K, in the case of a solution with 4% concentration, as seen from the figure, such a difference can be seen starting with practically the λ -transition temperature. At 2.1°K, the decrease of the mobility in the solution is about 15% compared with He^4 , reaching 45% at 1.4°K, it being clear that with further lowering of the temperature this difference will continue to increase. The temperature dependence of the mobility becomes steeper above 2.1°K, for both pure He^4 and the solution, owing to the proximity of the λ -point.

In the case of pure He^4 , Arkhipov [5] calculated the decelerating force acting on the ion, under the assumption that only phonons and rotons are present. It is easy to perform a similar calculation for He^3 - He^4 solutions, with allowance for the impurity excitations connected with the presence of the He^3 . This makes it possible to calculate the ratio of the ion mobility μ in the solution to the mobility μ_0 in pure He^4 . For sufficiently high temperatures, where scattering by phonons can be neglected, calculations yield:

$$\frac{\mu}{\mu_0} = \frac{p_0 N_r}{p_0 N_r + ((2N_{\text{He}^3}/\sqrt{m})(2m_{\text{ef}} kT)^{1/2})},$$

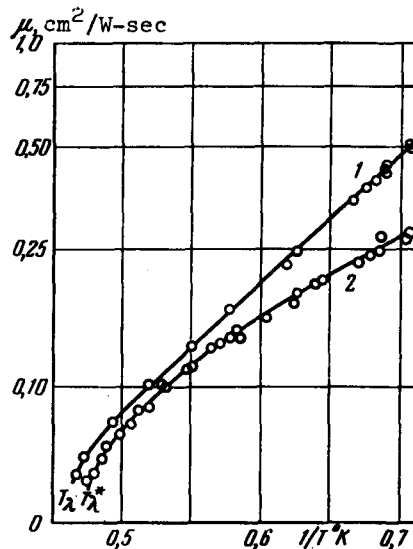
where p_0 is the roton momentum, N_r and N_{He^3} are respectively the numbers of rotons He^3 atoms per unit volume, and m_{ef} is the effective mass of the He^3 atoms in the solution.

Calculation of μ/μ_0 by means of the foregoing formula and its comparison with the experimental results show that the calculated values are about 15% lower than the experimental values in the region of 2°K, and 80% lower near 1.4°K.

An analysis of the foregoing results probably calls for allowance for the fact that the de Broglie wavelength of the impurity excitation connected with the He^3 is comparable with the dimensions of the positive ion.

The experiments with the He^3 - He^4 are presently continuing.

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Positive-ion mobility in liquid helium vs. the reciprocal temperature. Curve 1: solid - data of [2,3,7], o - present work. Curve 2: He^3 - He^4 solution. T_λ and T_λ^* pertain to He^4 and the solution, respectively.

discussions.

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CONCERNING THE SUPERCONDUCTIVITY OF V_3In

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A recent communication reports observation of superconductivity in the compound V_3In [1]. The critical temperature of this compound, as indicated by the authors, was $13.9^\circ K$. It is also reported there that the authors were able to synthesize, besides V_3In , a number of other vanadium compounds having the Cr_3Si lattice, namely V_3Cd , V_3Pb , V_3Tl , and V_3Bi . The last four compounds exhibited no superconductivity at $T > 4.2^\circ K$.

As indicated in [1], the samples of all the compounds were prepared by diffusion annealing vanadium wire in the vapor of the corresponding metal in a sealed quartz-glass ampoule, at a temperature $1000 - 1200^\circ C$, for twenty hours.

A few years ago we attempted to synthesize V_3In and V_3Al and to investigate the superconducting properties of these compounds. The samples were prepared in the following manner: Powders of the initial metals were mixed in the required ratios and pressed with a hydraulic press into cylinders of 5 mm diameter and 8 - 10 mm length. The samples were suspended on a vanadium wire or foil in a quartz-glass ampoule, which was evacuated, sealed, and placed in the loop of a high-frequency oven to sinter the samples.

The so-prepared samples of V with In and V with Al became superconducting at critical temperatures $\sim 10^\circ K$ and $\sim 15^\circ K$, respectively.

Further investigations have revealed that if the walls of the quartz ampoule are covered on the inside with a vanadium foil, then the critical temperature of the samples is greatly lowered, to $2^\circ K$ in some cases. The samples underwent a spectral analysis, which showed that the spectra of all the samples that became superconducting at high temperatures contained rather intense silicon lines, whereas in samples so prepared that they became superconducting at temperatures below $4.2^\circ K$, no silicon was observed.

Introduction of small amounts of powdered quartz glass into the sample caused superconductivity to set in at high temperatures ($\sim 10^\circ K$) even when the ampoule walls were covered with vanadium foil.

The foregoing facts give grounds for assuming that sintering of samples of vanadium-containing systems in quartz ampoules may be accompanied by de-oxidation of the ampoule walls by the metal vapor and the formation of the ternary compounds $V_3Si_xM_{1-x}$ on the surface of the sample, and these cause lines of the Cr_3Si lattice to appear in the x-ray spectrum. Our