

FIG. 1. Schematic diagram of NMR cell and form of the NMR signal upon crystallization of a laminated solution. The dashed curves show the signal wave form when the ampule is filled with a homogeneous mixture.

cell was uniformly filled, but it was constant and could be used for normalization. We used the lowest possible radio-frequency field amplitudes, so as to stay far away from saturation and make the signal amplitude proportional to the volume concentration of the He^3 at the given point and also proportional to the amplitude of the radio frequency field and independent of the time of passage through resonance (25–250 sec). The described method has made it possible to determine the ratio of the volume concentrations of the phases in equilibrium. For the two liquid phases at the start of the crystallization (Fig. 1), this ratio agreed with the data on lamination in the liquid.¹⁵ Therefore, using these data and taking into account the small corrections ($\sim 6\%$) entailed in the conversion of the volume concentration into molar concentration, we obtain the concentration of the crystal growing from the laminated mixture.

The results of the experiments are shown in Fig. 2(a).

In addition, an experiment was performed in which part of the crystal was grown at 0.65°K , and then after cooling part was grown as 0.4°K . No jump in

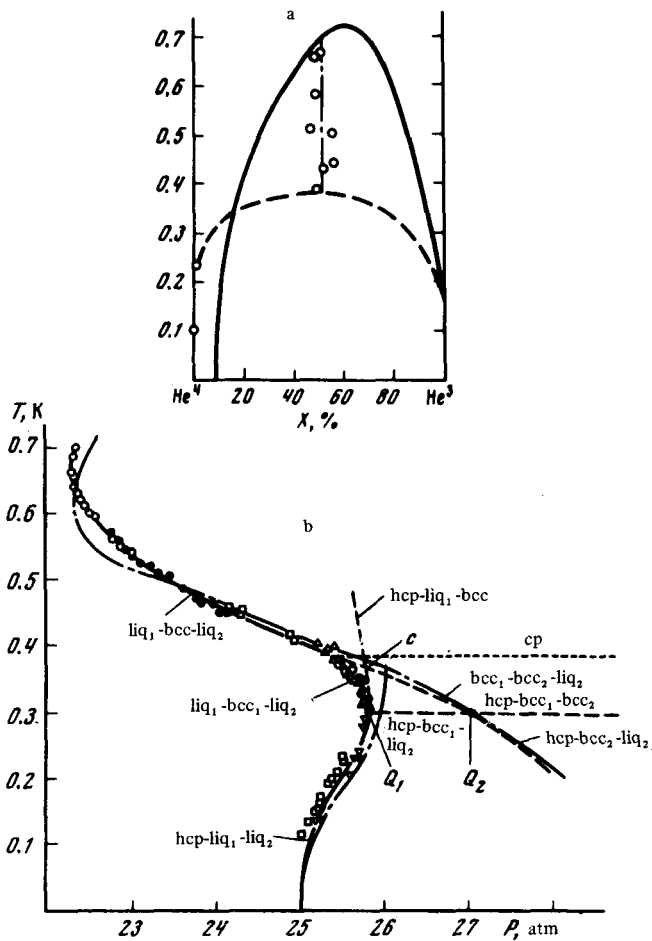


FIG. 2. a) Concentration of crystal grown from a laminated He³-He⁴ solution; solid curve—concentration of laminated liquid phases, [5] dashed—lamination in solid He³-He⁴ solutions [7]; b) pressure and temperature along the three-phase liquid-liquid-crystal equilibrium line, the different symbols are results of different experiments. Dashed lines—other three-phase lines, dash-dot—data of [6], dotted—critical lamination point of He³-He⁴ solid solutions. [7]

the signal amplitude was observed between these parts (accurate to ~ 3%). This allows us to conclude that above 0.38 °K the grown crystal has always one concentration, ~ 52% He³, a fact that influences strongly the form of the phase diagram of He³-He⁴ below 0.38 °K. At the same time, measurements were made of the pressure and temperature along the three-phase equilibrium line; the results of these measurements are shown in Fig. 2(b). Different symbols pertain to different experiments. The points in the region 0.25–0.38 °K were plotted only during the course of melting, for then, in contrast to the higher and lower crystallization was slowed down and it was necessary to overcome the mixture strongly (~ 0.7 atm) to make the process proceed at a

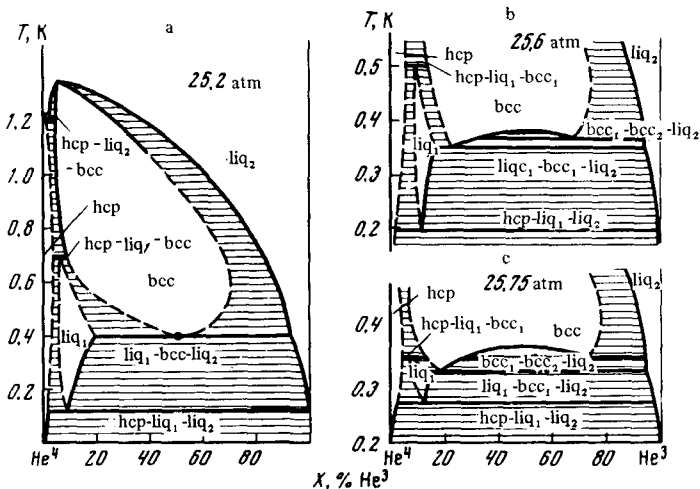


FIG. 3. He^3 - He^4 crystal-liquid phase diagrams at different pressures. The solid curves are those for which experimental data are available,^[1-7] and the dashed curves show the assumed course of the equilibrium curves. The two-phase regions are shown shaded.

noticeable rate even in the presence of a crystal primer. For this reason it was also impossible to grow the crystal accurately at these temperatures.

The results change significantly our ideas concerning the phase diagram of He^3 - He^4 mixtures in the region 25-28 atm and 0.25-0.38°K, as compared with the phase diagram proposed in^[6]. This is the most complicated section of the diagram and is possible the cause of the difficulty in the crystallization of solutions. The solid lines in Fig. 2(b), show the measured three-phase equilibrium lines and indicate the phases that are in equilibrium in this case: Liq_1 -liquid with lower He^3 concentration, Liq_2 -liquid with higher He^3 concentration, BCC-body-centered-cubic phase, BCC_1 -with lower He^3 concentration, BCC_2 -with higher He^3 concentration, HCP-hexagonal close packing. The dashed lines show other three-phase equilibrium lines constructed on the basis of data of^[6], and the dotted line is the line of the critical points of stratification of solid solutions.^[7]

An important consequence is the establishment of the fact that at 0.38°K the three-phase line Liq_1 -BCC- Liq_2 arrives at the critical point of the stratification of the solid solution^[7] and splits at this point into Liq_2 - BCC_1 - BCC_2 and Liq_1 - BCC_2 - Liq_2 .

Figure 3 shows the ensuing variation of the phase diagram plotted with the temperature and concentration as coordinates. The kink on the three-phase equilibrium line at 0.30°K corresponds apparently to a fourth point Q_1 , in agreement with the statement made in^[8] that at the pressures under consideration solid solutions with more than 4% He^3 have a BCC structure up to the lamination curve (i.e., the BCC-HCP transition on the lamination curve occurs at a temperature ~ 0.30°K). On the other hand, the intersection of the

HCP—Liq₁—BCC₁ and BCC₁—BCC₂—Liq₂ lines (the point *C*) is not a quaternary point at 0.37°K, as stated in^[6], while Fig. 3(c) shows the form of the phase diagram corresponding to the equality of the pressures and temperatures for two different three-phase equilibria. A set of diagrams describing the behavior of the liquid and solid He³—He⁴ mixtures in other regions can be found in^[1,6].

The author is grateful to V. P. Peshkov for a discussion of the results.

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