$$kT_\lambda \Delta\left(\frac{d}{dT}\ln P_3\right) = (1 - x_{liq})\,\Delta\frac{\partial^2\varphi}{\partial T \partial x_{liq}}$$

$$+\left\{\frac{\partial\varphi}{\partial P}\Delta\left(\frac{dP}{dT}\right) + (1 - x_{liq})\left[\Delta\frac{\partial^2\varphi}{\partial P \partial x_{liq}}\frac{dP}{dT}\right]\right\} \qquad (4')$$

and so on. The authors of reference 1 have incorrectly discarded the additional terms within the curly brackets in Eq. (4') and thus obtained some agreement of the theory with experiment. However, an analysis of the complete Eq. (4') for phase transitions does not confirm those conclusions which were made by the authors on the basis of the incorrect Eqs. (3) and (4). In that case any assertions about the character of the lambda transition in solutions of helium isotopes remain unproved assumptions.

[1] Esel'son, Kaganov, and Lifshitz, J. Exptl. Theoret. Phys. (U.S.S.R.) **33**, 936 (1957), Soviet Phys. JETP **6**, 719 (1958).

[2] Esel'son, Bereznyak, and Kaganov, Dokl. Akad. Nauk SSSR **111**, 568 (1956), Soviet Phys. "Doklady" **1**, 683 (1956).

Translated by D. ter Haar
191

REPLY TO THE LETTER BY M. P. MOKHNATKIN

B. N. ESEL' SON, M. I. KAGANOV, and I. M. LIFSHITZ

Submitted to JETP editor November 25, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) **36**, 964 (March, 1959)

As was shown at the beginning of our paper, the character of the lambda transition in solutions of helium isotopes follows from a large number of experimental data, in particular from the fact that the elasticity of the vapor over the solution depends essentially on the lighter isotope concentration over a large range of temperatures (absence of a plateau in the P-x diagram).

The proof of the fact that the lambda transition is of the second order was therefore not the object of our paper. The object of the paper was the analysis of different thermodynamic consequences from the fact that a lambda transition (a transition of the second order) existed in solutions and a comparison of these consequences with experimental data. In particular the character of the singularity in the P-T curve at the lambda point was elucidated in the paper. The conclusions of that consideration were in accordance with experiment and corroborated the conclusion about the second order transition.

M. P. Mokhnatkin asserts that this conclusion is illegitimate. An error was discovered in the fact that we neglected in a number of formulae derivatives of the pressure with respect to the chemical potential of the condensed phase. This neglect was, to be sure, made deliberately and was justified by the smallness of the specific volume of the liquid (v_{liq}) as compared with the specific volume of the vapor (v_{vap}). We remark that in those cases where this was necessary we took the derivative of the pressure with respect to the chemical potential of the liquid into account [see Eq. (19) and following].

Even if we retain the terms which M. P. Mokhnatkin writes down [see his Eqs. (3') and (4')] which, of course, leads to needlessly complicated equations, the conclusions obtained on the basis of Eq. (10) remain completely the same. Indeed, when the derivatives of the pressure with respect to the chemical potential of the liquid are taken into account, the equation analogous to Eq. (10) has the form

$$\frac{kT_\lambda}{P}\left\{1 - \frac{v_{liq} + (x_{liq} - x_{vap})(\partial v_{liq}/\partial x_{liq})_\lambda}{v_{vap}}\right\}\Delta\frac{dP}{dT},$$

$$= (x_{vap} - x_{liq})\frac{\Delta C_p}{T_\lambda}\frac{\partial T_\lambda}{\partial x_{liq}}\left\{1 - \left(\frac{\partial P}{\partial T}\right)_\lambda\left(\frac{\partial T_\lambda}{\partial P}\right)\right\}.$$

We have used here the notation of our paper and the index λ at the derivatives indicates that one must take half of the sum of the values for the two phases at $T = T_\lambda$. The expressions within curly brackets differ quite insignificantly from unity: on the left hand side the difference is about 10^{-2} and on the right hand side about 10^{-3}, which also confirms the legitimacy of the omissions made.

Translated by D. ter Haar
192