Macroscopic Density Fluctuations and Metastable States of ^{3}He-^{4}He Solid Solutions in Pre-separation Region

K. A. Chishko, T. N. Antsygina, A. A. Lisunov, V. A. Maidanov, V. Y. Rubanskyi, S. P. Rubets, and E. Ya. Rudavskii

B.Verkin Institute for Low Temperature Physics and Engineering, Kharkov, Ukraine

A rigorous thermodynamic theory is applied to interpret the experimentally observed behavior of bulk ^{3}He-^{4}He mixed crystals at arbitrary concentrations $x_3 = 1 - x_4$ of the components. The experiments were performed using the precision barometry method on the solutions with $0.01 \leq x_3 \leq 0.9$. Temperature dependences of the pressure $P(T)$ in homogeneous solid mixtures have been studied both above and below the equilibrium phase separation temperature T_s. With decreasing temperature, as T_s is approached, the pressure increases instead of expected reduction due to decrease in the phonon contribution ($P_{ph} \sim T^4$). Such an increase in pressure continues in the metastable region below T_s until the spinodal temperature where the mixture separates inevitably. Theoretical interpretation of the observed effects shows that the found pressure behavior can be described only with the consistent account for fluctuations in the impurity subsystem which near T_s dominates over phonon contribution into the pressure. The obtained theoretical results are in good quantitative agreement with the experimental data. Density fluctuations give rise to a spontaneous formation of impuriton nano-clusters containing several hundreds of atoms. This estimated size of the fluctuating nano-clusters agrees quantitatively with the corresponding value obtained from the Lifshis-Slesov phenomenological theory of homogeneous nucleation.

1. T.N. Antsygina, A.A. Lisunov, V.A. Maidanov, V.Y. Rubanskyi, S.P.Rubets, E.Ya. Rudavskii, and K.A.Chishko, Physica B: Condensed Matter, **406**, 3870 (2011).

Section: QS - Quantum solids

Keywords: ^{3}He-^{4}He solid solutions, phase separation, impuriton density fluctuations, metastable states