Thermodynamic Grounds for the bcc-hcp Transition in Solid Helium Isotopes

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The analytic approach to the destabilization mechanisms of the hcp and bcc phases is applied to both solid helium isotopes, ^{3}He and ^{4}He. Three different types of excitations, zero-point and thermal phonons and thermal vacancies, are analyzed from this point of view. Thermal phonons are considered within the classical Debye theory, contribution of zero-point phonons to thermodynamics is taken according to strong molar volume dependence (see Ref. [1]), and vacancies are treated as wide-band quasi-particles according to Hetherington's model.[2] For the bcc-hcp pressure-temperature line we estimate vacancy concentration, x_V, using molar volume dependence of the vacancy activation energy, Q_V, obtained in Ref. [3]. Based on similarity of x_V vs V_m dependences along the bcc-hcp equilibrium lines for both helium isotopes and on huge x_V values near the melting curve, we suppose that in high temperature range the hcp lattice is destabilized by high values of x_V and the transition to the bcc phase. The second reason for hcp phase destabilization in a case of ^{3}He is zero-point phonons which become a main factor in low temperature region.

1. S. Trickey, W. Kirk, and E. Adams, Rev. Mod. Phys., **44**, 668 (1972).
2. I.H. Hetherington, JLTP, **32**, 173 (1978).
3. V.N. Grigorev and Ye.O. Vekhov, JLTP, **149**, 41 (2007).