Torsional oscillators and the entropy dilemma of solid $^4$He

M.J. GRAF, A.V. BALATSKY, I. GRIGORENKO, S.A. TRUGMAN, (LANL), Z. NUSSINOV, (WUSTL) — Solid $^4$He is viewed as a nearly perfect Debye solid. Yet, recent calorimetry measurements by Chan’s group (JLTP 138 (2005) 853 and Nature 449 (2007) 1025) indicate that at low temperatures the specific heat has both cubic and linear contributions. These features appear in the same temperature range where measurements of the torsional oscillator period suggest a supersolid transition. We analyze (Phys. Rev. B 75 (2007) 094201) the specific heat and compare the measured with the estimated entropy for a proposed supersolid transition with 1% superfluid fraction and find that the observed entropy is too small. We suggest that the low-temperature linear term in the specific heat is due to a glassy state that develops at low temperatures and is caused by a distribution of tunneling systems in the crystal. We propose that dislocation related defects produce those tunneling systems. Further, we argue (Phys. Rev. B 76 (2007) 014530) that the reported mass decoupling is consistent with an increase in the oscillator frequency as expected for a glass-like transition. The glass model offers an alternate interpretation of the torsional oscillator experiments in contrast to the supersolid nonclassical rotational inertia (NCRI) scenario.

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