A New Heat-Capacity Anomaly at the Melting Transition in the Second Layer of ^{3}He on Graphite

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The second layer of helium on graphite at high densities forms a compressible two-dimensional (2D) solid with a triangular lattice which is incommensurate (IC) to the first layer. For films of three or more layers thick, rounded heat capacity (C) peaks were observed in the previous experiments using a Grafoil substrate at $T \geq 0.5$ K both for ^{3}He [1] and ^{4}He [2]. The peak temperature increases with increasing density until it is finally saturated. Although the peaks are likely associated with melting transitions of the 2D solids, the nature of the transition is not known in detail until now. Here we report a new feature of the melting C anomaly observed for the second layer IC solid of ^{3}He, but not for ^{4}He. In this experiment, a ZYX exfoliated graphite was used instead of Grafoil as it has a surface coherence length ten times larger than Grafoil. The feature involves the sharpness of the peak as well as a strong asymmetry in T, *e.g.*, a λ-shaped or BCS type anomaly, at three densities between 19.7 and 21.4 nm^{-2} where a part of ^{3}He atoms are promoted to the third layer as a liquid phase. On the other hand, similar C peaks observed for ^{4}He films are always broad regardless of substrate and density, and so far not been observed to be asymmetric. The strong contrast between ^{3}He and ^{4}He is probably related to the difference in stiffness of the first layer, in exchanging atoms with adjacent layers, or, more interestingly, in the universality class of the melting transition.

[1] S. W. Van Sciver, Phys. Rev. B **18**, 277 (1978).
[2] D. S. Greywall, Phys. Rev. B **43**, 309 (1993).

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