Spinodal decomposition of two-dimensional ^{3}He at low densities

F. M. Gasparini[a], R. Holler[b], and E. Krotscheck[a,b]

[a]Department of Physics, University at Buffalo, SUNY, Buffalo, New York 14260, USA
[b]Institute for Thoretical Physics, Johannes Kepler University, Linz, Austria

Recent experiments[1] on quasi-two-dimensional ^{3}He absorbed on graphite and on graphite pre-plated with ^{4}He, as well as earlier experiments[2] with ^{3}He on a non-crystalline substrate suggest that there is a liquid-gas phase transition at low densities[3]. The result has received wide attention[4] since it is counter-intuitive because two-dimensional ^{3}He is generally believed to be a gas. Effects like the enhancement of two-particle binding due to the finite width of the ^{3}He holding potential[5] and phonon-exchange are not strong enough to produce sufficient binding which would lead to a condensed phase.
However, in the presence of a substrate, the ^{3}He acquires an effective mass, either from the band structure of the underlying substrate, or from hydrodynamic backflow of ^{4}He. We show that even a small effective mass of $m^* = 1.06 m_{\mathrm{He_3}}$ is, at $T = 0$, sufficient to produce a spinodal instability of the ^{3}He which leads to a condensed phase.

1. D. Sato, K. Naruse, T. Matsui, and Hiroshi Fukuyama, Phys. Rev. Lett. **109**, 235306 (2012).
2. B. Bhattacharyya and F. M. Gasparini, Phys. Rev. Lett. **49**, 919 (1982).
3. A. D. Smart, Physics Today **66**, 15 (2013).
4. V. Grau, J. Boronat and J. Casulleras, Phys. Rev. Lett. **89**, 045301 (2002).
5. S. Kilić, E. Krotscheck, and L. Vranješ, J. Low Temp. Phys. **119** 715 (2000).

Section: QF - Quantum Fluids

Keywords: Low-density ^{3}He, phase transition