Quantum Phase Diagram of a Strongly Correlated Two-Dimensional ^{3}He

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^{3}He monolayers adsorbed on a graphite surface are the simplest and ideal model systems for studying strongly correlated two dimensional (2D) Fermions where we can tune the correlation precisely by filling control. Our recent heat capacity (C) and continuous-wave NMR measurements down to $T \approx$ 0.3 mK show that ^{3}He monolayer (the second layer) adsorbed on graphite preplated with ^{4}He monolayer (the first layer) has a surprisingly rich phase diagram with four distinct quantum regions (states) depending on particle density near the Mott localization. The localized state here is the 4/7 registered phase with a commensurate density ($\rho_{4/7}$) against the first layer density.

Some years ago, Casey *et al*. [1] claimed that the transition from the 2D normal Fermi fluid (region I) to the 4/7 phase is the Mott-Hubbard type and that they are phase-separated in the vicinity of $\rho_{4/7}$. Our data clearly indicate that the nature of this previously believed two-phase region is not a conventional phase separation but a new kind of instability, for example, in momentum space [2] (region II). This new claim is based on our measured isothermal density dependences of C, magnetization (M), the NMR line width and the resonance field shift in NMR.

Furthermore, we found many interesting new magnetic and thermodynamic properties when density exceeds $\rho_{4/7}$ (regions III and IV). The NMR line width suddenly decreases here from the value at $\rho_{4/7}$ suggesting promotion of the excess ^{3}He atoms to the third layer. The third layer is considered as a heavy 2D Fermi fluid with a large effective mass judging from our C data [3]. This is an interesting bilayer system where the exchanges between the second and third layer atoms are important. One most exciting observation is an anomalous kink in the temperature dependence of the excess magnetization (M_{ex}) below 1 mK. This could be a finite-T phase transition either of the spin-singlet or antiferromagnetic type in the third layer.

[1] A. Casey, H. Patel, J. Nyéki, B. P. Cowan, and J. Saunders, Phys. Rev. Lett. **90**, 115301 (2003).
[2] M. Imada, J. Phys. Soc. Jpn. **73**, 1851 (2004).
[3] D. Tsuji *et al*., this workshop.