Commensurate-Incommensurate Transition in ^{4}He Monolayer Adsorbed on a C_{60} Fullerene

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Path-integral Monte Carlo calculations have been performed to study adsorption of ^{4}He on a single C_{60} fullerene molecule. In order to account for helium corrugations on the molecular surface, the sum of all interatomic pair potentials between a carbon atom and a ^{4}He atom is used for the ^{4}He-C_{60} interaction. The radial density distributions reveal a layer-by-layer growth of ^{4}He with the first adlayer being located at a distance of $\sim$ 6.2 Å from the center of a C_{60} molecule. This first layer is found to exhibit various quantum states as the number of adsorbed ^{4}He atoms N varies. For N=32 the helium layer shows a commensurate solid structure with twenty helium atoms being localized on the tops of the hexagon centers of the C_{60} surface and the other twelve atoms above the pentagon centers. As more ^{4}He atoms are added, a commensurate-incommensurate transition is observed. After going through various domain wall states the first layer is crystallized into an incommensurate solid for $N \sim 52$. We find that solid states observed for N=32,44, and 48 do not show any superfluid response even below 0.2 K while domain-wall fluids formed with 45 to 47 ^{4}He atoms show significant superfluid fractions below 0.6 K. Finally different quantum states observed in the first ^{4}He layer around a C_{60} are compared with phase diagrams determined for the helium monolayer on a graphite surface.