Test of ϕ^4 Model Predictions near the ^{3}He Liquid-Gas Critical Point

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NASA is supporting the development of an experiment called MISTE (Microgravity Scaling Theory Experiment) for a future International Space Station mission. The main objective of this flight experiment is to perform in-situ *PVT*, heat capacity at constant volume, C_V, and isothermal susceptibility, χ_T, measurements in the asymptotic region near the ^{3}He liquid-gas critical point. On the ground, gravity induces a measurable density gradient for reduced temperatures $|T/T_c-1|<10^{-4}$. An accurate test of theoretical predictions within the asymptotic region close to the critical point is limited because of this gravity effect. Precision ground-based measurements are now being performed in the crossover region away from the critical point in preparation for this flight experiment. The ϕ^4 model, applied to the $O(1)$ universality class, was tested using recently obtained C_V and χ_T data in the crossover region of ^{3}He. The heat capacity and susceptibility measurements were performed in the same 0.05 cm high sample cell along the critical isochore over the range $10^{-5}<|T/T_c-1|<10^{-1}$. This RG-based ϕ^4 model with a minimal set of *three* adjustable parameters provided an excellent fit to the C_V and χ_T data both above and below the critical point in the gravity free crossover region. The temperature dependence of the correlation length, ξ, calculated from the best-fit parameters, will be compared with previous experimental measurements in the crossover region. The good agreement between the ϕ^4 model calculations and the experimental C_V and χ_T measurements unexpectedly extended beyond the theoretically predicted crossover range. [This work was supported by NASA.]