Neutron transparency measurements in cryogenic ^{3}He vapour

N.D. Vasilev[a], O. Kirichek[b], T.R. Charlton[b], C.J. Kinane[b], R.M. Dagliesh[b], A. Ganshin[c], S. Langridge[b], and P.V.E. McClintock[a]

[a]Department of Physics, Lancaster University, Lancaster, UK
[b]ISIS, STFC Rutherford Appleton Laboratory, Harwell Science and Innovation Campus, Didcot, UK
[c]Laboratory for Elementary Particle Physics, Cornell University, Ithaca, NY, USA

We present a new experimental method for the investigation of critical collective excitations based on the use of neutrons to probe critical opalescence. We collected transmission data through ^{3}He vapour within the temperature range (1.4 K - 50 K) and use the information obtained to infer the apparent ^{3}He vapour density. Our preliminary data demonstrate unexpected behavior. In particular, near the critical temperature ($\sim$3.32 K) the neutron transmission is significantly higher than would be expected, just based on the average density of ^{3}He atoms. We compare our data with the results obtained earlier using conventional methods (based on the measurement of refractive index and permittivity). Away from the critical point all methods yield similar results but, in the critical regime, our results are lower than previously reported. This is where critical opalescence effects are expected to become significant and where any microscopic thermal fluctuations become strongly correlated, leading to large-scale density fluctuations. This new experimental approach opens opportunities for the use of neutrons to probe opalescence near the critical point. We believe it represents the first time that neutrons have been applied to the study of quantum fluids under critical conditions.