MAR15-2014-020159

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Probing the A-B interface of superfluid helium-3

RICHARD HALEY, Lancaster University

At temperatures around 1 mK helium-3 forms a BCS spin triplet condensate. The order parameter is sufficiently complex that more than one superfluid phase exists, each exhibiting a different broken symmetry, and there is a model first order transition between the two most stable phases, labeled A and B. The Lancaster Ultra-Low Temperature Group has developed techniques to probe the properties of the A-B interface in the deep sub-mK regime where the superfluid is in the pure condensate limit. Shaped and controllable magnetic fields are used to induce the transition, and to stabilize and move the A-B phase boundary inside the experimental volume. The latent heat of the transition has been measured, and the nucleation behavior shown to be incompatible with conventional thermodynamic models. Since superfluid helium-3 is inherently pure, and the order parameter transforms continuously across the A-B interface, it is the most coherent two-dimensional structure to which we have experimental access. It has been proposed that this 2D surface in the surrounding 3D bulk volume is a good analog of a cosmological brane separating two distinct quantum vacuum states; experiments that simulate brane annihilation and the creation of topological defects have been carried out at Lancaster. Other investigations have included measurements of the surface tension and wetting behavior of the interface. During these studies it was discovered that a large, unpredicted frictional force was acting on the interface even though it is moving through a pure superfluid. Recent breakthrough work on the dynamics of the A-B interface has finally solved this puzzle. Current experiments include a setup where the interface region is probed directly using quartz tuning fork resonators that couple to the local density of broken Cooper pair quasiparticle excitations and thus give insight into the order parameter energy gap structure as A transforms to B.