Superfluid Phases of ^{3}He Confined in a Single 0.6 Micron Slab

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We present our NMR study of p-wave superfluid ^{3}He confined in a well-characterised restricted geometry. The confinement is provided by a nanofabricated cell with a 0.6 micron thick cavity. NMR is used both to identify the phases and make quantitative measurements of the suppression and distortion of the order parameter. The degree of confinement is continuously tuned with pressure and surface quasiparticle scattering is modified by preplating the walls of the cell with ^{4}He.

Confinement on a length scale comparable to the superfluid coherence length suppresses the order parameter and alters the relative stability of different superfluid phases. We observe a profound effect of confinement on the phase diagram. The A phase $\big(\mathbf{\Delta}(\mathbf{p}) = \Delta[\hat{p}_x + i\hat{p}_y][\uparrow\uparrow + \downarrow\downarrow]\big)$ stabilises in a wide range of the phase diagram below the superfluid transition, even at low pressure, and the B phase with a planar distortion $\big(\mathbf{\Delta}(\mathbf{p}) = \Delta_\parallel[-\hat{p}_x + i\hat{p}_y][\uparrow\uparrow] + \Delta_\parallel[\hat{p}_x + i\hat{p}_y][\downarrow\downarrow] + \Delta_\perp\hat{p}_z[\uparrow\downarrow + \downarrow\uparrow], \Delta_\perp < \Delta_\parallel\big)$ is observed at low temperature and higher pressure where the coherence length is shorter. We find evidence for spatial variations of the order parameter across the slab in the B phase.

These experiments open the way for studies of many surface and size phenomena in superfluid ^{3}He.