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Observation of the Polar Phase of ^{3}He[1]

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Exotic pairing of Fermions into a condensed bound state is now well established in many systems. In superfluid 3He it is becoming evident that the nature and stability of the emergent order parameter can be altered radically by confinement in regular geometries or by providing anisotropic disorder realized in materials whose nanoscale structure is smaller than the coherence length. The temperature dependent coherence length diverges as the superfluid transition is approached from below and sets the characteristic length scale for confinement. Thus, the degree of confinement can be varied as the temperature is varied below Tc. Additionally, unlike most superconductors, the 3He liquid's properties can be pressure-tuned over a large range. In bulk liquid, (in zero magnetic field) there are two equilibrium phases of 3He: at high pressure, as the temperature is lowered there is a transition from the chiral A phase to the isotropic B phase. In bulk liquid, the relative stability of the two phases is controlled not by confinement but by strong-coupling interactions. In our highly confined system, both factors (confinement and strong coupling) come into play and depending on pressure we see a succession of two transitions (three phases) within the superfluid as the sample is cooled from the normal state. Drawing on theoretical work we identify the phases as the Polar phase near Tc, followed by a polar distorted A or B phase (depending on pressure) with the low temperature phase being the B phase at all pressures. These observations are made with a torsional pendulum that was used to assay the superfluid fraction and the disordered medium is the so-called "Obninsk" alumina aerogel that has highly oriented strands aligned with the torsional axis.

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