MAR15-2014-008735

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

Evidence for intertwined superfluid and density wave order in two dimensional ^{4}He[1]

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We report the identification of a new state of quantum matter with intertwined superfluid and density wave order in a system of two dimensional bosons subject to a triangular lattice potential. Using a torsional oscillator we have measured the response of the second atomic layer of ^{4}He adsorbed on the surface of graphite over a wide temperature range down to 2 mK. Superfluidity is observed over a narrow range of film densities, emerging suddenly and collapsing towards a quantum critical point, near to layer completion where a Mott insulating phase is predicted to form. The unusual temperature dependence of the superfluid density in the $T \rightarrow 0$ limit and the absence of a clear superfluid onset temperature are explained, self-consistently, by an ansatz for the excitation spectrum, reflecting density wave order, and a quasi-condensate wavefunction breaking both gauge and translational symmetry.

In collaboration with Jan Nyeki, Anastasia Phillis, Andrew Ho, Derek Lee, Piers Coleman, Jeevak Parpia, Brian Cowan.

[1]Supported by EPSRC (U.K) EP/H048375/1