Quantum Criticality Found in a Simple Liquid

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The 3He layer L1 solidifies into a two dimensional quantum solid on a triangular lattice. The atoms move in this solid even at absolute zero, due to quantum exchange. Shown is the ring exchange of three atoms. The solid is a two dimensional frustrated magnet. Credit: University of London

A team from the Low Temperature Laboratory, Royal Holloway, University of London, has discovered a breakdown of the standard theoretical model of strongly interacting fermions in liquid 3He films.

The findings, which are published in *Science* on 7 September 2007, have implications for the understanding of metallic systems near so called ‘quantum critical points’. In these ‘strange’ metals, electric currents no longer seem to be carried by electrons, but rather by some more complex excitations, the nature of which are not fully understood.

Metals have been important materials to humankind for millennia, yet it seems that we still do not have a complete understanding of the full richness of the metallic state. In this sense the implications of these new phenomena are potentially far-reaching.

Professor Saunders explains: 'Heavy fermion behaviour and quantum criticality are usually associated with rather complex materials, and have defied definitive explanation. Our observation of the breakdown of Fermi liquid behaviour in a two dimensional variant of bulk liquid 3He, the Fermi liquid paradigm, is unexpected and exciting'.

He adds: 'Helium has always been a fertile playground for fundamental condensed matter physics. Liquid 4He was the first Bose-Einstein Condensate and superfluid 3He the first p-wave superfluid. There is even the suggestion that solid 4He may be a supersolid. We need simple systems to test candidate theories for explaining complex systems.'

This fundamental research at Royal Holloway underpins the huge international programme of 'materials discovery' which is currently underway. New materials with new properties drive important new device applications.

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Source: by Alison Denyer, University of London