Superfluid ^{3}He in Aerogel: Ordering and Disorder

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In contrast to anisotropic superconducting states occurring in strongly correlated electron systems, the superfluid ^{3}He occurs from an isotropic Fermi surface, and hence, candidates of pairing states are close to one another in energy. This implies that even a weak perturbation, such as an introduced *uniform* anisotropy or a quenched *random* anisotropy, may lead to a change of pairing states or a destruction of superfluid long range order.

From this point of view, it is an interesting subject to examine possible anisotropic pairing states of the superfluid ^{3}He in aerogel. Among them, the familiar ABM (axial) pairing state, characterized by the **l** and **d** vectors, is the best candidate of the A-like phase appearing near $T_c(P)$ of superfluid ^{3}He in aerogel and, actually, is favored by both a random [1] and (possible) uniform [2] anisotropies inherent in the aerogel structure. By combining this consequence of anisotropies with an impurity-induced reduction [3] of the strong coupling effect stabilizing the ABM pairing in the bulk liquid, the strange phase diagram of ^{3}He in aerogel, with a remarkable lowering of PCP and a positive slope of the A-B transition curve $T_{AB}(P)$, can be understood if the A-like phase is in the ABM pairing state.

On the other hand, the random anisotropy destroys [4] the conventional ODLRO of the ABM state instead of stabilizing this *pairing state* and makes the A-like state a glass phase. Although the possibility of the loss of superfluidity in the A-like phase *in equilibrium* is under debate [1,4], the ABM state under a weak applied flow or field, i.e., seen in NMR or flow measurements, is a genuine superfluid phase in spite of the loss of ODLRO.

When a *fixed* anisotropy can be defined in aerogel over a much longer distance than the coherence length, the A-like phase occurs over a wider region in the phase diagram. In particular, in aerogels with a uniaxially stretched deformation, the polar pairing state is expected to occur close to $T_c(P)$ at any pressure [2]. In aerogels with a uniform stretch or compression, the direction of gap nodes is properly controlled. In this respect, examining possibilities of exotic vortices such as a vortex with polar core in the stretched case and half quantum vortices in the compressed case might become a new direction of researches onsuperfluid ^{3}He in aerogel.

[1] K. Aoyama and R. Ikeda, Phys. Rev. B **72**, 012515 (2005).
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[3] K. Aoyama and R. Ikeda, submitted to Phy. Rev. B (cond-mat/0706xxxx).
[4] G. E. Volovik, cond-mat/07042484 and references therein.