MAR08-2007-000226

Abstract for an Invited Paper
for the MAR08 Meeting of
the American Physical Society

Superfluid defects in solid Helium-4: grain boundaries, dislocations, superglass[1]

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First principle quantum Monte Carlo simulations and recent experiments all point out that ideal, defect free, crystals of Helium-4 are not supersolid. Contrary to naive expectation that disorder inhibits superfluidity and suppresses superfluid response due to localization effects, disorder in quantum solids works in the opposite direction: if particles in the ideal crystal are already localized then defects can help to make the sample superfluid. The theory of superfluidity in lower dimensional defective structures embedded in a higher dimensional bulk has its own twists since such phenomena as superfluidity, roughening and defect mobility may be strongly linked. An unusual behavior is expected in the 3D network of 1D liquid channels when normal state at temperatures orders of magnitude above T_c is indistinguishable from that of a superfluid. The possibilities for "designing" crystallographic defects are countless, and in the strongly correlated system each case (superfluid or not) has to be considered separately. We find that generic grain boundaries and the screw dislocation along the z-axis are superfluid, while special types of boundaries and edge dislocations are insulating [1,2]. We also find that Helium-4 can form a metastable superfluid glass [3]. Whether these findings are relevant for the explanation of supersolid and other experiments remains an open question.

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2. M. Boninsegni, A.B. Kuklov, L. Pollet, N.V. Prokof'ev, B.V. Svistunov, and M. Troyer, Phys. Rev. Lett. **99**, 035301 (2007).

3. M. Boninsegni, N. Prokof'ev, and B. Svistunov, Phys. Rev. Lett. **96**, 105301 (2006).

[1]NSF support