Abstract for an Invited Paper
for the MAR10 Meeting of
The American Physical Society

Historically related puzzles in ^{3}He: spin fluctuations, the specific heat, and the superfluid phase diagram

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By 1965 theorists agreed that the repulsive core of He-He interactions implied that BCS pairing in ^{3}He could only occur with pair angular momentum l$>$ 0, and they had constructed the appropriate generalization of the BCS mean-field theory, including frameworks for including the quasiparticle interactions described by Landau's Fermi liquid theory. Between 1966 and the discovery of superfluid ^{3}He in 1972, dramatic improvements in experimental technique revealed surprising non-analytic finite-temperature corrections to the Landau-theory specific heat. Another surprise appeared with the discovery of the superfluid phases, whose phase diagram was inconsistent with any plausible mean-field theory. Simple RPA-based spin-fluctuation models played a central historical role in the solution of both of these puzzles and in explaining the occurrence of spin-triplet l= 1 pairing, but the corrections to the Landau and BCS molecular field theories first identified in paramagnon models have turned out to be general properties of Fermi liquids, and the Landau and BCS molecular fields now appear not to be dominated by spin fluctuations.