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Critical Current, Vortices and Fermionic Bound States in the BEC to BCS Crossover RAJDEEP SENSARMA, MOHIT RANDERIA, TIN LUN HO, Physics Department, The Ohio State University — We have analyzed a single vortex at $T = 0$ in a 3D superfluid atomic Fermi gas across a Feshbach resonance[1] using a fully self-consistent Bogoliubov-deGennes approach. From the current flow around a vortex we conclude that unitarity ($a_s = \infty$) is the most robust superfluid state in the entire BCS-BEC crossover, with the highest critical velocity v_c of about $0.1v_F$. On either side of unitarity, v_c decreases. It is determined by pair breaking on the BCS side and by collective excitations in the BEC regime. In the BCS limit, the order parameter near the vortex core shows a variation on both the scale of k_F^{-1} and of the coherence length ξ, while away from the BCS limit only a variation on the scale of ξ is seen. The density in the core rises quadratically with radial distance and is progressively depleted as one moves from BCS to BEC. The number of fermionic bound states in the core decreases as we move from the BCS to BEC regime. Remarkably, a bound state branch persists even on the BEC side reflecting the composite nature of bosonic molecules.
[1] R. Sensarma, M. Randeria and T.L. Ho, cond-mat/0510761

Rajdeep Sensarma
Physics Department, The Ohio State University

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