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Vortex Matter in Multicomponent Superfluid Fermi Gases

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Vortices, and solitons as their one-dimensional counterpart, arise as topological excitations related to the phase texture of the order parameter. In a single-component superfluid there is only one phase angle, but in multicomponent systems the presence of different phase angles results in a much richer phase diagram. In this contribution we first review how the order parameter (the macroscopic wave function) and the equation that it must obey can be obtained for fermionic superfluids in the BEC-BCS crossover. In the BEC limit, the physics of the Gross-Pitaevskii equation for tightly bound molecules is obtained, but as the pairs evolve towards the BCS superfluid, the coefficients of the effective field equation for the macroscopic wave function must be adapted. We derive expressions for these coefficients from a gradient expansion of the action functional of the underlying Fermi gas. Next, we use this description to investigate vortex matter in multicomponent superfluids, revealing the phase diagram of this system. Finally, we describe how topological excitations can be used to obtain information on the elementary excitations and their dispersion relation. This dispersion relation remains a topic of theoretical disagreement in the BEC/BCS crossover, and using our description we discuss how experiments could distinguish between concave and convex dispersions.