The Evolution from BCS to BEC Superfluidity: 
A Functional Integral Approach

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In these three lectures, I will review the evolution from BCS to BEC superfluidity for spin-1/2 fermions in three dimensions using the functional integral approach. In the first lecture, I will discuss the BCS-BEC evolution for s-wave interactions and show that there is just a crossover between the two limits, where an indirect gapped superfluid in the BCS side evolves smoothly into a direct gapped superfluid in the BEC regime [1, 2]. In the second lecture, I will analyze the same problem for p-wave interactions and demonstrate that a topological quantum phase transition takes place between the gapless BCS phase and the fully gapped BEC limit [3, 4]. Finally, in the third lecture, I will add spin-orbit and Zeeman fields to the s-wave problem and show that it induces a p-wave triplet component in the order parameter, thus producing a rich phase diagram containing gapless and fully gapped phases as interactions, spin-orbit and Zeeman fields are tuned [5, 6, 7].


