Exact Self-Consistent Condensates in (Imbalanced) quasi-1D Superfluid Fermi Gases

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Borrowing some techniques from high-energy physics, and in particular from the study of Nambu-Jona-Lasinio model in 1+1 dimensions, we present an analytic method to approach Eilenberger equation and the associated Bogoliubov-de Gennes equation for quasi-1D fermionic gases. The problem of finding self-consistent inhomogeneous condensates is reduced to solving a certain class of nonlinear Schrödinger equations, whose most general solitonic solution is indeed available. Previously known solutions can be retrieved by taking appropriate limits in the parameters. The applicability of the method extends to ring geometry and to population imbalanced Fermi gases. In particular we show exactly that fermionic zero-modes are robust against imbalance.

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