Supersymmetric BCS superconductivity

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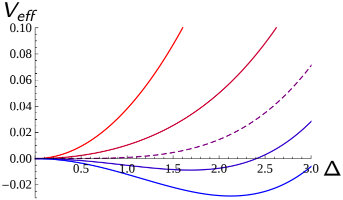
Motivation

- Condensed matter systems with quasi-supersymmetry
- Some exact non-perturbative results can be computed within supersymmetric theories
- supersymmetric field theories are more stable under radiative corrections, the theory is less sensitive to the UV cutoff
- Holographic superconductors

Bardeen-Cooper-Schrieffer: $\mathcal{L} = i\psi^\dagger \bar{\sigma}^\mu \partial_\mu \psi + g^2(\psi\psi)(\psi^\dagger\psi^\dagger)$

- Temperature
- Chemical potential
- Hubbard-Stratonovich:
  $\Delta \sim (\psi\psi)$



Landau-Ginzburg: $V_{eff} = a(T - T_c)\Delta^2 + b\Delta^4 + \dots$

- We want a simple ($\mathcal{N} = 1$) SUSY theory (at $T, \mu = 0$)
- $U(1)$ SSB at low T and symmetry restored at high T.
- μ leads to a Fermi surface.

relativistic BCS theory	SUSY BCS theory
$\mathcal{L} = i\psi^\dagger\bar{\sigma}^\mu\partial_\mu\psi + g^2(\psi\psi)(\psi^\dagger\psi^\dagger)$	$\mathcal{K} = \Phi\Phi^\dagger + g^2(\Phi\Phi^\dagger)^2$
	μ for $U(1)_R$ ($R_\varphi{=}0$, $R_\psi = -1$)

$$V_{eff} = g^2|\Delta|^2 \quad \begin{array}{l} -\dfrac{1}{2}\displaystyle\int^\Lambda \frac{d^3p}{(2\pi)^3}(\omega_\pm) \\ -\dfrac{1}{\beta}\displaystyle\int \frac{d^3p}{(2\pi)^3}\log(1+e^{-\beta\omega_\pm}) \end{array} \qquad \begin{array}{l} +\dfrac{1}{2}\displaystyle\int^\Lambda \frac{d^3p}{(2\pi)^3}(2\omega_S) \\ +\dfrac{1}{\beta}\displaystyle\int \frac{d^3p}{(2\pi)^3}2\log(1-e^{-\beta\omega_S}) \end{array}$$

$$\omega_\pm = \sqrt{(p\pm\mu)^2 + 4g^2\Delta^2} \qquad \omega_S = \sqrt{p^2 + 4g^2\Delta^2}$$