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High-order diagrammatic expansion around BCS: polarized superfluid phase of the attractive Hubbard model (ONSITE presentation)

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In contrast to conventional QMC methods, expansions of intensive quantities in series of connected Feynman diagrams can be formulated directly in the thermodynamic limit. Over the last decade, diagrammatic Monte Carlo algorithms made it possible to reach large expansion orders and to obtain state-of-the-art results for various models of interacting fermions in 2 and 3 dimensions, mostly in the normal phase.

We obtained first results inside a superconducting phase, for the 3D attractive Hubbard model [1]. Spontaneous symmetry breaking is implemented by expanding around a BCS Hamiltonian. All diagrams up to 12 loops are summed thanks to the connected determinant algorithm [2] with anomalous propagators. Working on the BCS side of the strongly correlated regime, we observe convergence of the expansion, and benchmark the results against determinant diagrammatic Monte Carlo [3]. In presence of a polarizing Zeeman field (where unbiased benchmarks are unavailable due to the fermion sign problem) we observe a first-order superconducting-to-normal phase transition, and a thermally activated polarization of the superconducting phase well described by a dilute gas of quasiparticles. We also discuss the large-order behavior of the expansion and its relation to Goldstone and instanton singularities.

[1] G. Spada, R. Rossi, F. Simkovic, R. Garioud, M. Ferrero, K. Van Houcke, F. Werner, arXiv:2103.12038
[2] R. Rossi, PRL 119, 045701 (2017)
[3] E. Burovski, N. Prokof'ev, B. Svistunov, M. Troyer, PRL 96, 160402 (2006)

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