**Free Energy**

**Free Energy a couple ways**

Since we have all the excitations of our BCS model, at least within the mean field approximation, and in field-free environment, we can construct the Landau potential, L. Going back to our result for K in a previous file (say Excitations/MFT file).



where in the MFT excitations file, we found, for instance,



With K we can solve for the grand partition function,



and then the Landau potential,



So,



Another option is to continue with our construction of the grand partition function via functional integral from the Excitations/GL Free Energy file. We left off with:



And we did a saddle point analysis to conclude that the Δ’s satisfied the gap equation,



Then if we plug this back into our integrand, we get the saddle point/mean field approximation to Ξ.



where Δ is the one satisfying the highlighted equation. And so,



And this is equivalent to:



These two L’s seem to differ from each other. In fact we’d get *another* different expression for L if we used the result for K found in the Excitations/Single Particle GF file Appendix. But I’m hoping that that they are all in fact the same. In *at least* in the important term, i.e., the ln term, they are all identical.