The weakly coupled Pfaffian as a type I quantum Hall liquid

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There is a deep and precise relation between superconductivity and the quantum Hall effect, which can be formally implemented by replacing the physical Maxwell gauge field by the statistical Chern-Simons gauge field. Here, there is a correspondence between the perfect conductivity of the superconductor and the quantization of the Hall conductance, the Meissner effect and incompressibility, and quantized vortices and fractionally charged quasiparticles. In some cases, this relation goes even further, in that the Hall fluid is a condensate of electron pairs. Specifically, the quantized Hall phase seen in the proximity of the half-filled second Landau level, *í* = 5/2, is likely associated with the Pfaffian or Moore-Read state. The ideal Pfaffian state has a natural interpretation as a weakly-paired state of composite fermions with $p + ip$ symmetry, *i.e.* it bears an analogous relationship to the metallic "composite Fermi liquid" state of the half-filled Landau level as the corresponding BCS state does to an ordinary metal.

I will discuss an important aspect of the quantum-Hall/superconductor relationship, particularly relevant to the Pfaffian phase. Specifically, the relationship implies that quantum Hall states will, like superconductors, generically exhibit two length scales: a screening length λ that characterizes the decay of density deviations and a coherence length ξ that characterizes variations of the superfluid order. Further, the ratio of these scales should crucially influence the structure of vortices. Accordingly we propose that quantum Hall fluids should come in two classes: a) type II quantum Hall fluids where (roughly) $\lambda \geq \xi$ and density deviations are accommodated by the introduction of single quasiparticles/vortices and b) type I quantum Hall fluids where $\lambda < \xi$ and quasiparticles are unstable to agglomeration and form multi-particle bound states or, if the interactions are sufficiently short-ranged, phase-separate entirely. I will show that the Pfaffian state is a type I superconductor of composite fermions. There is a proposal to use properties of vortices in Pfaffian state to realize a quantum computation scheme. I will discuss whether this proposal is realistic.