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Off-Diagonal Long-Range Order and Collective Excitations in the Fractional Quantum Hall Effect[1]

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The experimental discovery of the fractional quantum Hall effect was a stunning surprise which came to be understood in terms of a novel state of matter in which strongly correlated electrons acquire a new and unprecedented type of collective quantum order. The mystery of superconductivity was first understood macroscopically in terms of Ginsburg-Landau effective theory before the microscopic BCS theory was developed. Here the historical order was reversed. Laughlin discovered his essentially exact microscopic wave function and only subsequently did we begin to understand its implications in terms of a new type of off-diagonal long-range order and an effective Chern-Simons field theory for composite particles carrying magnetic flux. In this gauge theory, the fact that Laughlin's quasi-particle excitations carry sharply quantized fractional charge could be understood as analogous to sharp flux quantization in a superconductor. The fact these vortex excitations have finite energy could be understood as the result of magnetic screening by the gauge field. In addition to discussing this macroscopic picture of the FQHE, I will also discuss the microscopic wave function that Allan MacDonald and I developed in collaboration with Phil Platzman which accurately describes the gapped magneto-phonon and magneto-roton collective excitations of the system.

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