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Intrinsic Gap of the $5/2$ Fractional Quantum Hall State and Tilted Field Experiments

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Nearly twenty years since the first discovery of an even denominator fractional quantum Hall state (FQHE), a complete understanding of the $5/2$ -state continues to be among the most important questions in semiconductor physics. It is widely believed that this unique state of matter is theoretically best described by the Moore-Read Pfaffian wavefunction, resulting from a BCS-like pairing of composite fermions [1]. In recent years this wavefunction has received special interest owing to its non-abelian quantum statistics which underlies a new paradigm for topological (fault tolerant) quantum computation. However, in spite of several important theoretical advancements, an unequivocal experimental verification of the Moore-Read description is still missing. We present results from a study of the $5/2$ state in a sample with the lowest electron density reported to date (by nearly a factor of two) [2]. This allows for the observation of the $5/2$ in a regime where the cyclotron energy is smaller than the Coulomb interaction energy. We discuss our results in the context of previous work, and we examine the role of disorder on the activation energy gap. Measurements of the energy gap for the $5/2$ and the $7/3$ FQH states in a tilted field geometry also reveals an unexpected and contrasting dichotomy between the two. Whereas the $7/3$ FQH gap is observed to be enhanced by an applied parallel magnetic field, the $5/2$ gap is strongly suppressed, in spite of the two gaps being energetically comparable at zero parallel fields in our sample. This calls into question the prevailing theoretical belief that they should behave similarly if both are spin-polarized, and raises doubt as to whether or not the $5/2$ state is indeed described by a spin-polarized Pfaffian Moore-Read wavefunction.

[1] G. Moore and N. Read, Nucl. Phys. B 360, 362 (1991).

[2] C.R. Dean, B.A. Piot, P. Hayden, S. Das Sarma, G. Gervais, L.N. Pfeiffer, K.W. West, Phys. Rev. Lett. 100, 146803 (2008).

[3] C.R. Dean, B.A. Piot, P. Hayden, S. Das Sarma, G. Gervais, L.N. Pfeiffer, K.W. West, Phys. Rev. Lett. 101, 186806 (2008).