Fractional quantum Hall effect: What's new

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After a brief review of the current status of the fractional quantum Hall effect (FQHE) and open problems, I will report on recent progress on the following topics [1, 2, 3, 4]:

Anti-Pfaffian pairing at 3/8: (In collaboration with S. Mukherjee, S.S. Mandal and A. Wójs [1].) We predict [1] that an incompressible fractional quantum Hall state is likely to form at $\nu = 3/8$ as a result of a chiral p-wave pairing of fully spin polarized composite fermions carrying four quantized vortices, and that the pairing is of the anti-Pfaffian kind. Experimental ramifications include quasiparticles with non-Abelian braid statistics and upstream neutral edge modes.

Phase diagram of two-component FQHE: (In collaboration with A.C. Archer [2].) Because of FQHE in graphene and AlAs quantum wells, there is renewed interest in the physics of FQHE for multi-component systems, where the components can be spin and/or valley/subband indices. We calculate the phase diagram of two component fractional quantum Hall effect as a function of the spin/valley Zeeman energy and *continuous* filling factor, which reveals new phase transitions and phase boundaries spanning many fractional plateaus. This phase diagram is relevant to fractional quantum Hall effect in graphene and in GaAs and AlAs quantum wells, when either the spin or the valley degree of freedom is active. Good agreement is found with experiment in AlAs and graphene.

Unconventional mechanism for FQHE at 4/11, 5/13: (In collaboration with S. Mukherjee, S.S. Mandal and A. Wójs [3].) The origin of the FQHE states at 4/11 and 5/13, evidence for which was seen a decade ago by Pan *et al.* (Phys. Rev. Lett. **90**, 016801, 2003), has remained controversial. We show [3] that these represent a new class of FQHE states, originating because of a peculiar interaction between composite fermions that suppresses occupation of pairs with relative angular momentum *three* rather than one. This confirms the mechanism proposed by Wójs, Yi and Quinn (Phys. Rev. B **69**, 205322, 2004). We make quantitative predictions for experiments, including a spin transition as a function of the Zeeman energy.

Composite fermion crystals: (In collaboration with A.C. Archer and K. Park [4].) We determine quantitatively the phase diagram of the crystal phase at low fillings, and find a rich variety of crystals of composite fermions. In particular, we convincingly show that the crystal between 1/5 and 2/9 is a "type-I crystal" of composite fermions carrying two vortices. We evaluate the dispersions of the magnetophonons and magnetoplasmons of the crystals, as well as their shear modulus, which shows discontinuity at the phase boundaries. Possible experimental signatures of the phase diagram are considered.

[1] S. Mukherjee, S. S. Mandal, A. Wójs, and J. K. Jain, Phys. Rev. Lett. **109**, 256801 (2012).
[2] A. C. Archer and J. K. Jain, Phys. Rev. Lett., in press.
[3] S. Mukherjee, S. S. Mandal, A. Wójs, and J. K. Jain, unpublished.
[4] A. C. Archer, K. Park and J. K. Jain, unpublished.