

Das et al. Reply: In Ref. [1] (Comment), Simon has raised an objection that the proposed wave function [Eq. (2)] (WF-I) in Ref. [2], which is antisymmetrization of so-called Halperin 113 wave function (WF-II) [3], does not describe a fractional quantum Hall (FQH) state. Simon conjectures that antisymmetrization will have a minor effect on a phase separated state. However, the indistinguishability of particles cannot be treated naively as antisymmetrization often makes a drastic change in the characteristic of a quantum state. For example, antisymmetrization of Abelian Halperin 331 wave function [3] transforms it into a wave function for non-Abelian state [4].

It is natural that two species in WF-II will avoid each other as they feel more repulsion than the particles between same species. In WF-I, however, being all the particles indistinguishable in nature, any $N/2$ particles in an N particle system can form a group. Therefore, formation of two distinct physically separated groups is not obvious. Instead, all the particles are expected to optimize their positions for forming a uniform liquid as in any of the known FQH states. To this end, let us consider 1 through $N/2$ particles in the first group and the remaining particles in the second group. Both homogeneous, g_{11} , and heterogeneous, g_{12} , pair correlation functions [Fig. 1(a)] hover around 1.0, as in any other FQH liquid. In contrast, as shown in Ref. [5], the behaviors of g_{11} and g_{12} indicate phase separation [inset of Fig. 1(a)] between two groups or species.

The entanglement spectra (ES) for a toy-model numerical wave function (WF-III) is shown [1] as identical to the same for the \mathcal{A} phase in Ref. [2] for anti-Pfaffian flux, $N_\Phi = 2N + 1$. However, for the particle-hole symmetric Pfaffian (PH-PF) flux $N_\Phi = 2N - 1$ (same for the WF-I), the ES does not match, because the \mathcal{A} phase has a high degree of particle-hole asymmetry. Nonetheless, WF-III reproduces almost identical g_{11} and g_{12} to the same for WF-I [see Fig. 1(b)]. Therefore, WF-III also describes a liquid state, and may also be topologically identical to the ground state wave function of the \mathcal{A} phase. It is, however, not surprising that an $L = 0$ wave function, which is *not* the global ground state of a toy-model Hamiltonian, can be representative of the *global* ground state of a realistic

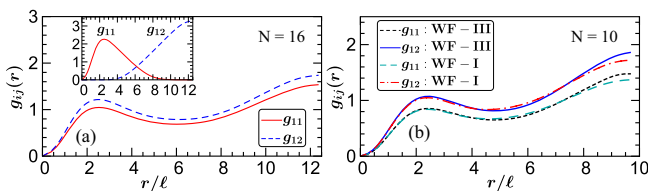


FIG. 1. (a) g_{11} and g_{12} for WF-I. Inset: same for WF-II. (b) g_{11} and g_{12} for WF-I and WF-III are compared.

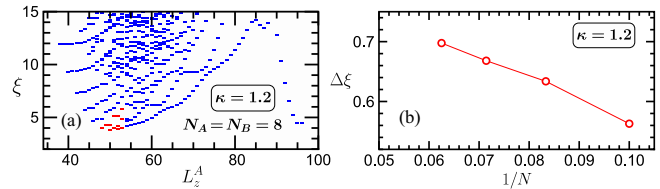




FIG. 2. (a) ES in the \mathcal{A} phase at PH-PF flux. (b) Scaling of $\Delta\xi$ at PH-PF flux shift with $1/N$ in the \mathcal{A} phase.

Hamiltonian because such a wave function does not necessarily reflect the nature of the toy model considered.

As far as the ES with an equal number of particles in two parts is concerned, the Hilbert space of the \mathcal{A} phase or WF-I allows all the particles to occupy up to the highest possible $N/2$ orbitals. We thus have the ES up to the highest possible L_z^A . While the number of states at higher possible L_z^A is always finite in number, the number of states grows exponentially with N for the medium range of L_z^A for which the particles mostly occupy mid-level orbitals in the sphere. Therefore, the latter kind of states are more entangled and hence lower their lowest energies with the increase of N . On the other hand, the former kind of states, being least entangled, either increase their entangled energies or their separation with respect to the lowest entangled energy grows with N . In view of this, we show the ES for $N = 16$ and $N_\Phi = 31$ in Fig. 2(a) where the low energy branch at higher L_z^A is much reduced, while universal low-lying edge state counting 1-1-2-2... remains unaltered. Further, the entangled energy difference ($\Delta\xi$) between the lowest energy and the energy at the highest L_z^A increases with N [see Fig. 2(b)].

To summarize, the proposed wave function and also the \mathcal{A} phase in Ref. [2] describe the FQH liquid state rather than a phase separated or stripe or bubble state.

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