Comment on "Conductance and Shot Noise for Particles with Exclusion Statistics"

The interplay of high magnetic fields and many-body interactions in a two-dimensional electron gas produces the fractional quantum-Hall effect (FQHE) at low temperatures. At filling factor $\nu = 1/m$ (m is an odd integer) the Hall resistivity reaches a plateau, showing that the correlated quasiparticles carry fractional charge νe. The fractionally charged quasiparticles (FCQPs) *may* obey fractional exclusion statistics (FES) [1].

Recent shot-noise and Coulomb-blockade experiments confirm that one-dimensional FCQPs carry the edge-state currents in the FQHE but cannot establish FES unambiguously. Isakov *et al.* [2] consider a novel theoretical possibility. They generalize the Landauer-Büttiker first-quantized method for one-dimensional conductance and shot noise to noninteracting particles with FES, thought to be relevant to the edge-state FQHE. The explicit formula obtained for the crossover of shot noise to thermal noise stretches its normal interpretation in terms of the noninteracting Schottky and Johnson-Nyquist formulas.

The results of Ref. [2] may be of experimental interest. Despite this, we note some potentially troublesome issues of principle. These warrant closer examination.

(1) To obtain a FES noise spectral density strictly by first quantization, one must first have a counting method going beyond the normal occupancies for fermions and bosons. The proposal of Isakov *et al.* [2] fails to recover standard results for normal fluctuations, as required by second quantization [3]. To redeem their argument they must add an *ad hoc* term to their Eq. (3), maintaining presumed conformity with the fluctuation-dissipation theorem (FDT). Note that they are forced to appeal to the FDT with no knowledge at all of the microscopic structure of its proof. The FDT is an absolutely basic structural link between equilibrium fluctuations and dissipative response in a many-body system. Its *ad hoc* treatment severely undermines the microscopic credibility of the state-counting argument.

(2) FCQPs carry the FQHE edge-state current in *one dimension* and thus represent the excitations of a correlated Luttinger fluid. This is totally unlike a fluid of "independent" quasiparticles. There are no grounds, in second quantization, to describe exclusion statistics by an ansatz that interpolates intuitively between the limiting occupancies for *free* bosons and fermions. Not surprisingly, the oversimplified counting leads again to a familiar difficulty: a term must be added *ad hoc* to keep faith with the FDT. For bosons a further unphysical feature appears, in that the zero-frequency spectral density for shot noise diverges. This dilemma is avoidable—in second quantization—via the generalized commutation relations introduced long ago by Green [4].

(3) The crossover of the spectral density from thermal to shot noise is derived by assuming $\exp(\beta\mu) \gg 1$. This occurs when either the thermal energy (temperature) β^{-1} is very small or the chemical potential μ is very large. The latter corresponds to a high-density system. If the FCQPs are truly independent, the system will be ballistic. In the quantum ballistic limit there is no shot noise.

Shot noise is inherently a nonequilibrium phenomenon; any *correlations* in it must involve nonlinearity in the applied field. For normal fermions, linear theories based on quantum-coherent (or on semiclassical) diffusion imply a smooth crossover from low temperatures and high fields to high temperatures and low fields. While this has strong appeal in making sense of experiments, a first-principles nonequilibrium theory is not in sight.

The Landauer-Büttiker approach is akin to Kubo linear response. For shot noise in correlated systems, a major question should be how its suppression is modified by many-body interactions. In a strictly single-particle, linear-transport picture, suppression enters via the factor $T(1 - T)$, where T is the one-particle transmission probability through the system. In both limits $T \to 0$ and $T \to 1$, shot noise tends to zero. For $T \to 0$ the system is nonconducting; trivially, there is no shot noise. When $T \to 1$, the system is ballistic; again, within strictly first-quantized treatments of fluctuations, there is no shot noise. However, as the quasiparticles of a normal Fermi system are correlated, it is fair to wonder whether their shot noise is indeed so comprehensively suppressed.

One is now asked to go beyond the normal and to postulate fractional statistics for (nearly free) quasiparticles in the Luttinger liquid, an utterly correlation-dominated system. The paper of Isakov *et al.* [2] raises many more open problems than have been answered satisfactorily, even in the Landau model of normal quasiparticles.

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