Comment on "Quantum Suppression of Shot Noise in Atom-Size Metallic Contacts"

In a recent Letter [1], van den Brom and van Ruitenbeek found a pronounced suppression of the shot noise in atom-size gold contacts with conductances near integer multiples of $G_0 = 2e^2/h$, revealing unambiguously the quantized nature of the electronic transport. However, the *ad hoc* model they introduced to describe the contribution of partially open conductance channels to the shot noise is unable to fit either the maxima or minima of their shot-noise data. Here we point out that a model of quantum-confined electrons with disorder [2] quantitatively reproduces the measurements of Ref. [1].

We model a nanocontact in a monovalent metal as a deformable constriction in an electron gas, with disorder included via randomly distributed delta-function potentials [2]. For convenience, the system is taken to be two dimensional. The transmission probabilities T_n of the conducting channels are obtained via a modified recursive Green's function algorithm [2]. The dimensionless shot noise s_I at zero temperature is [3]

$$s_I \equiv \frac{P_I}{2eI} = \frac{\sum_n T_n(1 - T_n)}{\sum_n T_n}, \tag{1}$$

where P_I is the shot-noise spectral density and I is the time-average current. Plotting s_I versus the conductance $G = G_0 \sum_n T_n$ eliminates the dependence on dimensionality for an ideal contact, provided no special symmetries are present.

Starting from the numerical data that were used to generate the conductance histogram in Ref. [2], we compute the mean and standard deviation of s_I and T_n as functions of G. The averages are taken over an ensemble of impurity configurations and contact shapes. The agreement of the experimental results for particular contacts and the calculated distribution of s_I shown in Fig. 1(b) are extremely good: 67% of the experimental points lie within 1 standard deviation of $\langle s_I \rangle$ and 89% lie within 2 standard deviations [4]. It should be emphasized that no attempt has been made to fit the shot-noise data; the numerical data of Ref. [2], where the length of the contact and the strength of the disorder (mean-free path $k_F \ell = 70$) were chosen to give qualitative agreement with experimental conductance histograms for gold [5], have simply been reanalyzed to calculate $\langle s_I \rangle$.

Contrary to the model of Ref. [1], the minima of $\langle s_I \rangle$ do not occur at integer multiples of G_0, but are shifted to lower values, which correspond *not* to the maxima of the conductance histogram, but rather to the maxima of $\langle T_n \rangle$.

Figure 1(c) shows that the number of partially open channels increases in proportion to G. For comparison, the shot noise for a contact with only one partially open channel, which sets a lower bound, is shown as a dashed curve in Fig. 1(b). The presence of several partially open channels for $G > G_0$ increases $\langle s_I \rangle$ above this lower bound, leading to an apparent saturation at $\langle s_I \rangle \approx 0.18$ for larger contacts. Neither the maxima nor the minima of the experimental data can be fit by the model of Ref. [1], which includes only two partially open conductance channels.

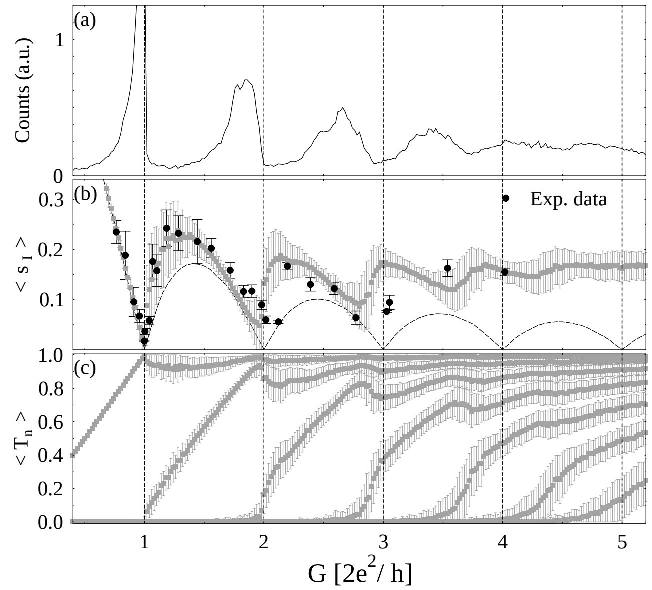

FIG. 1. (a) Conductance histogram reproduced from Ref. [2]; (b) calculated mean shot noise $\langle s_I \rangle$ (grey squares), together with experimental data from Ref. [1] (black circles); (c) mean transmission probabilities $\langle T_n \rangle$. The error bars indicate the standard deviations of the numerical results over the ensemble and the experimental errors, respectively.

The excellent agreement between the shot-noise data of Ref. [1] and our model calculation suggests that quantum transport in gold nanocontacts can be well described by a model which includes only two essential features, quantum confinement and coherent backscattering from imperfections in the contact.

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[4] A finite temperature slightly lowers s_I for larger G, but does not significantly change the quality of the fit.
[5] Not all features of all conductance histograms for gold are well described by Fig. 1(a). See, e.g., B. Ludolph *et al.*, Phys. Rev. Lett. **82**, 1530 (1999).

