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Comment on “Conductance Fluctuations in Mesoscopic Normal-Metal/Superconductor Samples”

Recently, Hecker *et al.* [1] experimentally studied magnetoconductance fluctuations in a mesoscopic Au wire connected to a superconducting Nb contact. They compared the rms magnitude of these conductance fluctuations in the superconducting state [$\text{rms}(G_{\text{NS}})$] to that in the normal state [$\text{rms}(G_{\text{N}})$] by increasing the magnetic field above the critical field of 2.5 T. It was reported that $\text{rms}(G_{\text{NS}})$ was about 2.8 ± 0.4 times larger than $\text{rms}(G_{\text{N}})$, which should confirm the theoretical predicted enhancement factor of $2\sqrt{2} \approx 2.8$.

In this Comment, we show that their claim is not justified. Although not explicitly mentioned in Ref. [1], we have to assume that the $\text{rms}(G)$ was calculated according to $\text{rms}(G) = \text{rms}(R)/R^2$, where $\text{rms}(R)$ denotes the rms magnitude of the measured resistance fluctuations and R the total measured resistance. The point we want to make is that the authors did not take into account the presence of an incoherent series resistance R_{series} from the contacts, which is different when the Nb is in the superconducting or normal state. Since the measured $\text{rms}(R)$ originates only from the phase-coherent part of the disordered conductor, with resistance R_{φ} , the correct procedure is to calculate $\text{rms}(G)$ according to $\text{rms}(G) = \text{rms}(R)/R_{\varphi}^2 = \text{rms}(R)/(R - R_{\text{series}})^2$. As shown below, when we correct for the presence of this series resistance, we find that $\text{rms}(G_{\text{NS}})$ is *not* significantly larger than $\text{rms}(G_{\text{N}})$.

Their device consists of a narrow Au wire (Au^w , length $L = 1.0 \mu\text{m}$, width $W = 0.13 \mu\text{m}$) connected at its ends to a macroscopic Nb and Au contact (Nb^c or Au^c) via a rectangular shaped contact (Nb^r or Au^r , $L = 0.8 \mu\text{m}$, $W = 1.6 \mu\text{m}$). The total resistance is the sum of these five contributions: $R = R_{\text{Nb}}^c + R_{\text{Nb}}^r + R_{\text{Au}}^w + R_{\text{Au}}^r + R_{\text{Au}}^c$, where $R_{\text{Nb}}^c + R_{\text{Nb}}^r$ are zero in the superconducting state.

Since the series resistances of the Au contact ($R_{\text{Au}}^c + R_{\text{Au}}^r \approx 1.2R_{\square}^{\text{Au}} \approx 1.1 \Omega$) are small compared to phase-coherent resistance of the Au wire (10.5Ω), we will correct only for the series resistances of the Nb contact ($R_{\text{Nb}}^c + R_{\text{Nb}}^r \approx 1.2R_{\square}^{\text{Nb}} \approx 4.8 \Omega$). This series resistance is present only in the normal state and is exactly equal to the increase in resistance when the magnetic field exceeds B_c (see Fig. 1(a), in Ref. [1]). We note that not only the macroscopic Nb contact is regarded to be incoherent but the rectangular shaped Nb contact as well. Namely, the phase-breaking length $L_{\varphi} \equiv \sqrt{D\tau_{\varphi}}$ for Nb is expected to be reduced compared to $L_{\varphi} \approx 0.6 \mu\text{m}$

TABLE I. The measured resistance R_{NS} and uncorrected conductance fluctuations $\text{rms}(G_{\text{NS}})$ in the superconducting state at $T = 50 \text{ mK}$ and $B = 1 \text{ T}$, and the measured resistance R_{N} and the *corrected* conductance fluctuations $\text{rms}(G_{\text{N}})$ in the normal state at $T = 50 \text{ mK}$ and $B = 4 \text{ T}$.

	Sample 1	Sample 2
$R_{\text{NS}} (\Omega)$	11.60	9.72
$R_{\text{N}} (\Omega)$	15.87	14.34
$\text{rms}(G_{\text{NS}}) (e^2/h)$	0.16 ± 0.02	0.14 ± 0.02
$\text{rms}(G_{\text{N}}) (e^2/h)$	0.109 ± 0.006	0.109 ± 0.009
$\text{rms}(G_{\text{NS}})/\text{rms}(G_{\text{N}})$	1.5 ± 0.2	1.3 ± 0.2

for Au by $\sqrt{D_{\text{Au}}/D_{\text{Nb}}} \approx 2.5$, which implies that the resistance fluctuations from this Nb rectangle are strongly suppressed due to ensemble averaging as well.

In Table I we have reproduced the measured (average) resistance of the two studied samples in the normal state and in the superconducting state. We did not correct $\text{rms}(G_{\text{NS}})$ [2]. The $\text{rms}(G_{\text{N}})$ has been corrected as described above. As a result, the $\text{rms}(G_{\text{N}})$ are a factor of $(R_{\text{N}}/R_{\text{NS}})^2 \approx 2$ larger than reported in Ref. [1] and, consequently, the ratio $\text{rms}(G_{\text{NS}})/\text{rms}(G_{\text{N}})$ becomes about 1.4 ± 0.2 . We doubt, however, that the remaining difference from 1 is significant, since the statistical error could well be larger than 0.2 due to the fact that only a few large fluctuations determine $\text{rms}(G_{\text{NS}})$ (see Figs. (1b) and 2, in Ref. [1]).

In conclusion, we have argued that the measured $\text{rms}(G_{\text{NS}})$ is not significantly enhanced compared to $\text{rms}(G_{\text{N}})$, and it remains an experimental challenge to observe the predicted enhancement factor of $2\sqrt{2}$.

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- [1] K. Hecker, H. Hegger, A. Altland, and K. Fiegle, *Phys. Rev. Lett.* **79**, 1547 (1997).
- [2] The reported values for $\text{rms}(G_{\text{NS}})$ are considerably smaller than the rms magnitude of the sample-specific conductance fluctuations of about $\text{rms}(G_{\text{NS}}) \approx 1.0e^2/h$ observed in both a cross-shaped and a T-shaped two-dimensional electron gas coupled to superconductors. S. G. den Hartog *et al.*, *Phys. Rev. Lett.* **77**, 4954 (1996); S. G. den Hartog *et al.*, *ibid.* **76**, 4592 (1996). A comparison with the normal state values was not made in these experiments.