Comment on "Ensemble-Average Spectrum of Aharonov-Bohm Conductance Oscillations: Evidence for Spin-Orbit-Induced Berry's Phase"

In their recent Letter, Morpurgo *et al.* [1] present experimental results for the magnetoresistance of mesoscopic, ring-shaped conductors. The magnetoresistance data have been analyzed in terms of an ensemble-averaged Fourier spectrum defined by [1]

$$F_S(\omega) \equiv \frac{1}{S} \sum_{s=1}^{S} |f(\omega, s)|, \quad (1)$$

where the sum over s runs over the S different traces of the measured resistance of the same sample and $f(\omega, s) = \sum_{n=1}^{N} e^{i\omega B_n} R(B_n, s)$ denotes the (discrete) Fourier transform of the resistance $R(B, s)$ with respect to the applied magnetic field B. In the experiments each trace consists of $N = 8192$ data points and the increment of the field $B_{n+1} - B_n$ is kept fixed [1]. It is obvious that definition (1) is substantially different from

$$P_S(\omega) \equiv \left| \frac{1}{S} \sum_{s=1}^{S} f(\omega, s) \right|, \quad (2)$$

i.e., the square root of the power spectrum [2] of the ensemble-averaged conductance. In Ref. [1] it is argued that the use of (1) is instrumental for the observation of the splitting in the h/e peak which the authors ascribe to a spin-orbit-induced Berry phase.

The aim of this Comment is threefold. First, we argue that their data do not support one of their conclusions, viz. that the use of (1) provides information that is otherwise not easily accessible. Second, it will be demonstrated that a more detailed analysis of the same experimental data reveals that the internal structure of the peak due to the h/e oscillations is richer than anticipated in [1]. Finally, and completely independent of the foregoing, their data does not support their hypothesis, viz. that the statistical properties of the sample(s) used are such that the h/e peak will disappear (if $S \to \infty$) [3].

In Fig. 1 we show $F_S(\omega)$ and $P_S(\omega)$, as obtained from the experimental data used for Fig. 5 of [1] for $S = 5$ and $S = 65$. The first four sets of data have been smoothed, using the same procedure as in [1]. The difference in scale between $F_S(\omega)$ and $P_S(\omega)$ has no physical significance [2]. From Fig. 1 it is clear that using (2) instead of (1) brings out the internal structure of the h/e peak much more clearly. Hence the use of (1) is not essential for the detection of the h/e peak.

A more detailed analysis of the experimental data shows that the relative intensities of the subpeaks depend sensitively on the data processing procedure used [4], as illustrated in Fig. 1. In previous work [5] the presence

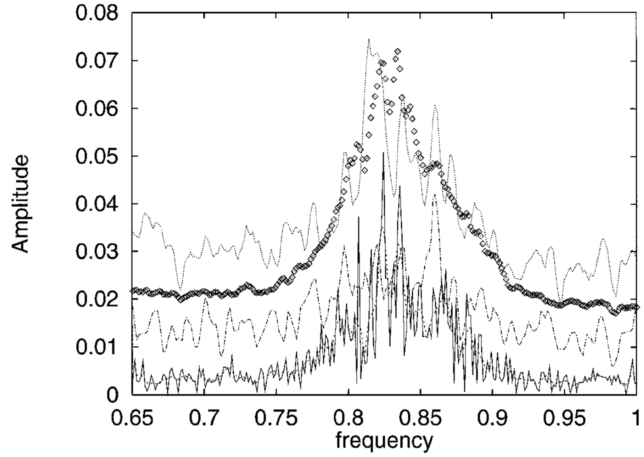

FIG. 1. Fourier amplitude of the h/e peak in the magnetoresistance of a mesoscopic ring as a function on the frequency ω. Diamonds: $F_{65}(\omega)$ (see also Fig. 5 of [1]). Dotted line: $F_5(\omega)$; dashed line: $P_{65}(\omega)$; dash-dotted line: $P_5(\omega)$; solid line: $P_{65}(\omega)$ without smoothing.

of substructure in $P_S(\omega)$ was attributed to slowly varying random fluctuations (see, e.g., Fig. 13b of [5]) and this physical picture explains the presence of substructure in $P_S(\omega)$ as well. Hence the interpretation in terms of a spin-orbit-induced Berry phase [1] does not seem to be unique.

Comparing $P_5(\omega)$ and $P_{65}(\omega)$ it is clear that as S *increases*, the noise is suppressed and the relative weight of the h/e peak increases. This finding is incompatible with the hypothesis of [1], namely, that the h/e peaks will disappear with increasing S.

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[1] A. F. Morpurgo, J. P. Heida, T. M. Klapwijk, B. J. van Wees, and G. Borghs, Phys. Rev. Lett. **80**, 1050 (1998).
[2] W. H. Press *et al.*, *Numerical Recipes* (Cambridge University Press, Cambridge, England, 1989), p. 420.
[3] R. Washburn and R. Webb, Rep. Prog. Phys. **55**, 1311 (1992).
[4] We have used the Hanning and Welsh window [2] and various degrees of smoothing.
[5] R. Washburn and R. Webb, Adv. Phys. **35**, 375 (1986).

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