## Comment on "Spectroscopic Evidence for Multiple Order Parameter Components in the Heavy Fermion Superconductor $CeCoIn_5$"

Recently, Rourke *et al.* reported point-contact spectroscopy (PCS) results on the heavy-fermion superconductor $CeCoIn_5$ [1]. They obtained conductance spectra on the *c*-axis surfaces of $CeCoIn_5$ single crystals. Their major claims are twofold: $CeCoIn_5$ has (i) *d*-wave pairing symmetry and (ii) two coexisting order parameter components. In this Comment, we show that these claims are not warranted by the data presented.

First, do their data represent spectroscopic properties of $CeCoIn_5$? Rourke *et al.* claim that their estimated contact *radius* satisfies the ballistic criterion [2] at $T_c$ and even further at lower temperatures [1]. Our estimation using more rigorous formulas [3–5] shows that their contact *diameter* ($d$) is larger than the mean free path ($l$) at $T_c$ by a factor of 1.2–2.3, although $l/d \gg 1$ at lower temperatures. Since such an estimation (albeit a convention in the literature) gives just an indirect measure based on *bulk* parameters, it does not necessarily corroborate that a point contact formed on the *surface* is ballistic. The actual physical properties at the contact region can be much different from those in bulk, depending on the surface cleanness, roughness, contact pressure, etc. Therefore, whether atypical PCS data such as in Ref. [1] contain intrinsic spectroscopic information or not should be checked more carefully beyond such simple estimations.

Second, we point out that the zero-bias conductance peak (ZBCP) and subsequent dip-hump structure seen in Fig. 1(a) of Ref. [1], which is the main feature they attribute to *d*-wave symmetry, has also been frequently observed in *s*-wave superconductors [6]. In Fig. 1(a), we show our own data obtained from epitaxial $MgB_2$ thin films. While other possibilities are open, including multiple contacts, a well-known origin for the dip structure near the gap edge is local heating due to the nonballistic nature of the contact [6].

Third, we have obtained PCS data from $CeCoIn_5$ single crystals along both (001) and (110) directions over wide temperature ranges [7,8]. These data were taken reproducibly, well within the Sharvin limit, without showing any significant heating effects. They are consistent with each other and can be analyzed with a single order parameter. It is important to sample more than one crystallographic orientation to conclude the order parameter symmetry and if multiple order parameters exist.

Finally, Rourke *et al.* base their claims of the *d*-wave symmetry on the ZBCP, which they attribute to Andreev bound states (ABS). It is well known that there are several origins for ZBCPs in tunneling conductance measurements [9], and proper diagnostics must be performed to determine if a ZBCP actually arises from ABS, particularly tracking the evolution of the size and shape of the ZBCP with the magnitude and direction of an applied magnetic field [9].

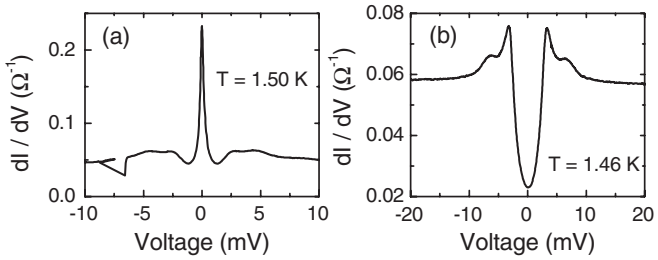


FIG. 1. Conductance spectra of point contacts on $MgB_2$ thin films using Au tips. (a) Reproducing the features in Refs. [1,6]. (b) Reproducible data taken in the ballistic limit.

Measurements along different crystallographic orientations would also provide such information [7,8]. Without such diagnostics, the origin of the ZBCP remains unknown. We also point out that other measurements classify $CeCoIn_5$ as either $d_{x^2-y^2}$ or $d_{xy}$, so ABS should not be observed on the *c*-axis surface of a single crystal. Rourke *et al.* compare their data with calculations using an extended Blonder-Tinkham-Klapwijk model, assuming parallel and serial combinations of conductance channels via surface ABS and bulk Andreev reflection. However, no materials microanalysis is provided to justify their modeling and such a claim supports only the argument that the contacts are large and, thus, nonballistic.

While we do not exclude the possibility of coexisting multiple order parameters in $CeCoIn_5$, we claim that Rourke *et al.*'s interpretation of their PCS results [1] as such evidence should be viewed critically.

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