Comment on "Spectroscopic Evidence for Multiple Order Parameters in the Heavy Fermion Superconductor $CeCoIn_5$"

In a recent Letter [1], Rourke *et al.* report point contact (PC) spectroscopic studies on the heavy Fermion superconductor $CeCoIn_5$. They have reported two types of spectra [Figs. 1(a) and 1(b) of Ref. [1]] obtained using a Pt-Ir tip. Figure 1(a) shows a zero bias conductance peak followed by two dips appearing symmetrically about the central peak. Figure 1(b) shows an asymmetric hump structure. They attribute these features to the presence of Andreev surface states and Andreev bulk states. They have taken the central peak as the signature of existence of nodes in the order parameter. They attempted to analyze the spectra using *d*-wave Blonder-Tinkham-Klapwijk (BTK) formalism and obtained support for multiband superconductivity in superconducting $CeCoIn_5$.

In the past, several groups related many "*unnatural*" features in a PC spectrum between a normal metal (N) and a superconductor (S) with exotic phenomena such as the existence of Andreev bound states [2]. On such occasions, much simpler explanations [3] for the emergence of those features were also proposed.

In PC experiments, such spectral features are frequently observed in a variety of contacts between different combinations of an N and an S [4]. In Ref. [4], the origin of the dip structures has been extensively discussed when the contact is not in the ballistic limit. In Ref. [1], the authors have not measured the mean free path of their sample. Their estimate based on measurements by other groups in different samples is highly questionable, since the residual resistivity of crystals can be widely different even if the crystals are from the same batch. Therefore, the authors have not ruled out the possibility that the reported spectra were obtained with contacts in the thermal regime, where the shape of the conductance spectra will be determined by contact heating and voltage jumps associated with the current reaching the critical current of the superconductor, rather than an unconventional pairing symmetry.

The same combination of sample and tip can give rise to both a "*canonical*" spectrum as well as an unconventional spectrum, depending on the contact size as shown in Fig. 1. Figure 1 shows a spectrum for a Fe-foil–Nb-tip combination with the contact in the thermal regime, showing both the dip and hump features (marked by arrows), which the authors of Ref. [1] attribute to unconventional superconductivity. Sometimes, the contact can be made at multiple points, which is a possible reason for observing the hump structure emerged in the region between the two dips. The inset shows a canonical Andreev reflection spectrum using the same combination of sample and tip when the contact is in the ballistic regime. Why the dip structures evolve with junction impedance, as the authors of Ref. [1] observe, is discussed [5] in Ref. [4]; therefore, an N/S point contact spectrum should be chosen carefully before attempting to analyze it using BTK theory.

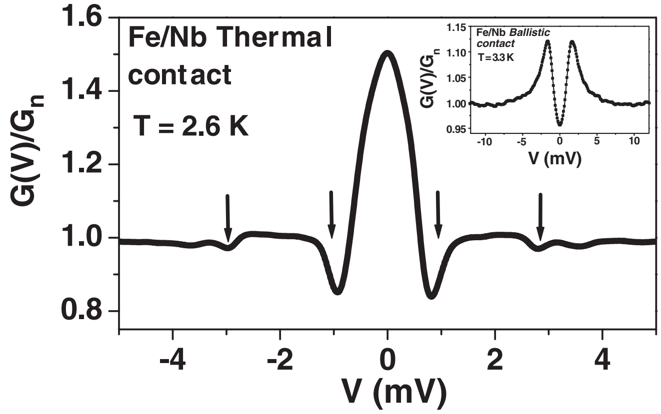

FIG. 1. A spectrum for a nonballistic point contact between a Fe foil and a Nb tip. The arrows show the position of the anomalous dips in the conductance spectrum. The inset shows a spectrum for the same combination of foil and tip in the ballistic limit.

In summary, the PC spectra shown in Ref. [1] are obtained with contacts close to the thermal regime. While one cannot rule out the possibility of an unconventional pairing symmetry in $CeCoIn_5$, the data presented in Ref. [1] cannot be taken as support for the unconventional superconductivity or multiple order parameters in $CeCoIn_5$.

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[5] In Ref. [4], it has been shown that the dip position varies with junction impedance, a feature that is not captured in the model described in the same paper. The reason for this discrepancy is that in the model the mean free path is implicitly tuned, keeping the contact diameter constant, whereas in the experiment the contact diameter is modified while the mean free path is a constant, characteristic of the sample.

