ELECTRON-SPECTROSCOPIC CHARACTERIZATION OF METAL INTERFACES

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The quality of metal interfaces can be investigated by observing how they scatter electrons or holes. Electron-phonon spectroscopy uses the spectral intensity of back-scattered electrons to estimate the amount of elastic scattering in the contact region. Andreev-reflection spectroscopy at superconductor - normal metal interfaces employs the Andreev reflected holes from inside the superconductor that are transmitted through or reflected at the contact interface to determine the reflection or transmission coefficient. The two methods yield contradictory results: Andreev reflection indicates that practically all metal interfaces are diffusive (that is they contain a certain amount of disorder or defects at which electrons or holes are scattered), independently of whether electron-phonon spectroscopy shows that the same interfaces are diffusive or ballistic [1].

Both methods have their drawbacks. The phonon density of states in the contact region can deviate from that of the bulk metal, blurring the spectral features and, thus, simulate more diffusion. On the other hand, one can under-estimate the Andreev-derived normal reflection by neglecting electronic, thermal, or lifetime broadening. Luckily these error mechanisms affect the true normal reflection oppositely and therefore do not diminish the above mentioned main result that ballistic contacts are at the same time diffusive.

How reliable is the value of the normal reflection as measured by Andreev reflection spectroscopy? In the ideal case the Andreev-reflection spectra are fitted with only three adjustable parameters: superconducting energy gap 2Δ, normal reflection parameter Z, and Dynes' lifetime parameter Γ. This allows to determine the normal reflection coefficient to within one percent. Since the contacts are - according to our interpretation - diffusive, we have to consider a distribution of transmission coefficients, that is each of the many conductance channels or modes i of an interface has its own coefficient $\tau_i = 1/(1+Z_i^2)$. The distribution itself is unknown except some ideal theoretical cases. Other parameters like an effective temperature might be taken into account, but all this leads to different parameter sets, including the reflection parameter, that describe almost equally well the experimental data. We discuss possible ways to reduce this ambiguity.

References

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