Phonon-drag induced suppression of the Andreev hole current in superconducting niobium contacts

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The Andreev reflection hole current at ballistic point contacts, which results from the conversion of single electrons into Cooper pairs, is suppressed at large bias voltages. Based on experiments with ultra-high purity Ta, Hahn *et al.*[1] have suggested that a huge *hot spot* or *normal bubble*, with diameter up to several times the superconducting coherence length, forms in the superconductor by trapping high-energy electrons between the contact and the normal-superconducting interface of the hot spot itself. We have investigated contacts with superconducting Nb ($T_c = 9.2\,\mathrm{K}$) and found a similar behaviour. The difference between the current in the superconducting (S) and the normal (N) state, called the excess current, drops nearly exponentially with increasing bias voltage like $I_{exc}(V) = I_S(V) - I_N(V) \sim \exp(-V/V_0)$. For contacts with normal resistances in the $1\,\Omega - 100\,\Omega$ range, the decay constant is $V_0 \approx 10\,\mathrm{mV}$. In contrast to the interpretation given by Hahn *et al.*, we attribute the suppression of the excess current to the phonon drag: Electrons accelerated across the contact generate non-equilibrium phonons which scatter not only at electrons, but also at holes that are retro-reflected from the superconductor. Since the hole-phonon scattering length is very short at large bias voltages, the probability that an Andreev-reflected hole returns through the contact to be recorded as excess current, is strongly reduced.

[1] A. Hahn, S. Hofmann, K. Hümpfner, and M. Schatz, Phys. Rev. B **65**, 224503 (2002).