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# Andreev reflection in s-type superconductor proximized 3D topological insulator. Supplemental Material.

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## DIFFERENTIAL RESISTANCE IN A WIDE BIAS RANGE

In all N-TI-S devices studied the differential resistance,  $R_{\text{diff}}$ , behaves similarly to the reference N-TI-N device and exhibits no AR related features. This is verified in Figs. 1a and 1b for two representative devices in a wide bias range. Just like in the reference N-TI-N device, see Fig. 1c, the small zero bias feature in  $B = 0$  develops into a pronounced resistance peak in a magnetic field  $B \sim 1$  T. This behavior is qualitatively consistent with a scenario of competing quantum corrections, weak anti-localization and Altshuler-Aronov, among which the former is suppressed by a perpendicular magnetic field and both are suppressed by a high bias owing to dephasing, see, e.g. Ref.<sup>1</sup>.

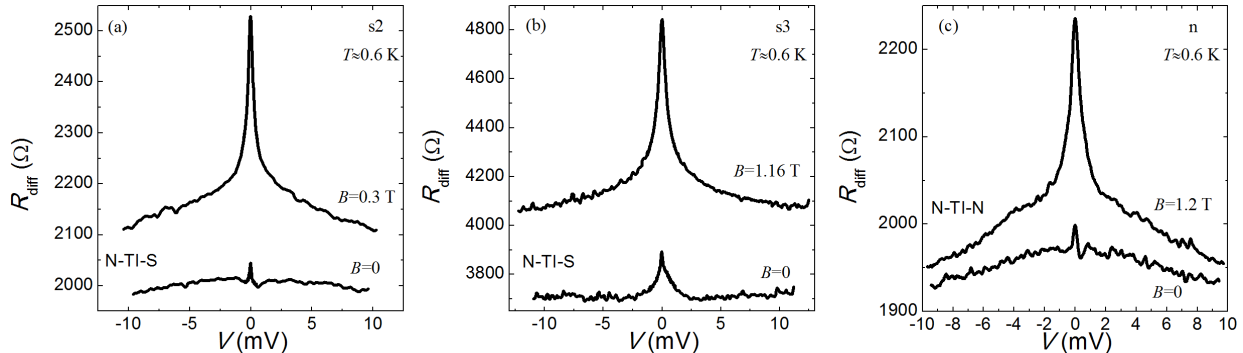


FIG. 1. Differential resistance in N-TI-S devices s2 (a) and s3 (b) and reference N-TI-N device n (c). The data is taken simultaneously with the main text noise data in Fig. 3 (s2), Fig. 4 (s3) and Fig. 2 (n).

## ELECTRON-PHONON ENERGY RELAXATION

As discussed in the main text, at large biases,  $|V| > 0.8$  mV, the data deviate below the  $q = e$  fit, both in zero and finite  $B$ -field, which is a result of shot noise suppression via electron-phonon ( $e$ - $ph$ ) energy relaxation<sup>2,3</sup>. We have checked that for  $T_N > 5$  K the  $e$ - $ph$  cooling dominates the noise response and is consistent with the linear dependence  $P_J \propto T_N^\alpha - T^\alpha$ , where  $P_J$  is the total dissipated Joule heat power and the exponent varies between  $\alpha \approx 3$  and  $\alpha \approx 4$  in different devices, see Fig. 2. A cooling rate of this type might

arise from the interaction with two-dimensional (e.g., surface) acoustic phonons<sup>4,5</sup>, similar to graphene<sup>6-8</sup>, or the interplay of *e-ph* and impurity scattering<sup>9</sup>. Note, that the doping dependence of the surface electrons' cooling rate in 3D TI<sup>10</sup> Bi<sub>2</sub>Se<sub>3</sub> at much higher *T* is consistent with the relaxation via surface acoustic phonons.

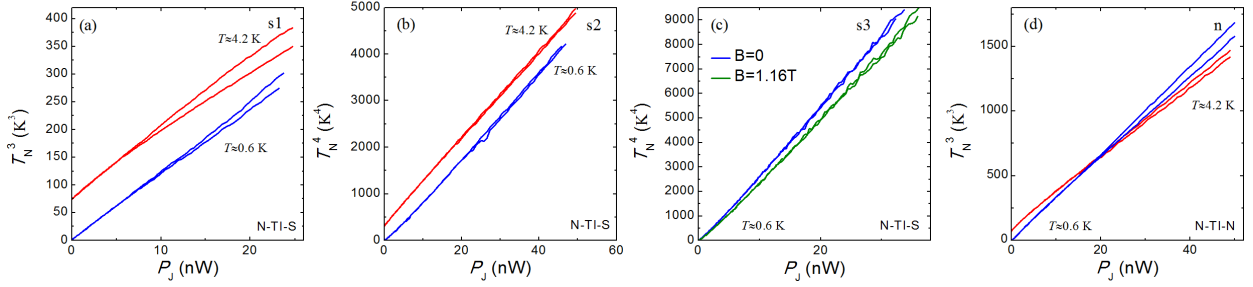


FIG. 2. E-ph energy relaxation in the strongly non-equilibrium transport regime. Close to linear dependence  $T_N^\alpha \propto P_J$  at bath temperatures of  $T = 0.6$  K (blue curves) and  $T = 4.2$  K (red curves) in devices s1(a), s2(b), n(d) and at bath temperature of  $T = 0.6$  K at zero (blue curve) and nonzero (green curve) magnetic field in device s3(c).

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