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DIFFERENTIAL RESISTANCE IN A WIDE BIAS RANGE

In all N-TI-S devices studied the differential resistance, R_{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 $B \sim 1\,\mathrm{T}$. 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.[1].

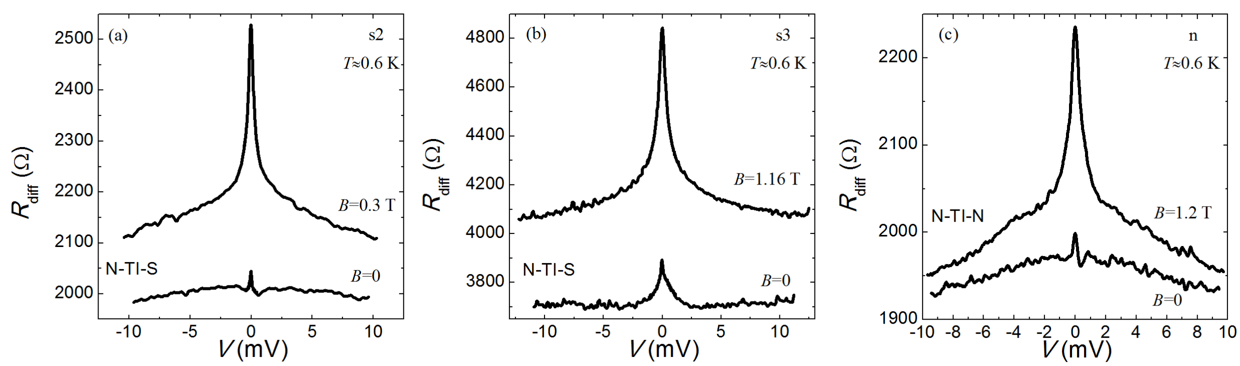

FIG. 1. Differential resistance in N-TI-S devices s2 (a) and s3 (b) and reference N-TI-N device n (c). The data is taken simultaneously with the main text noise data in Fig. 3 (s2), Fig. 4 (s3) and Fig. 2 (n).

ELECTRON-PHONON ENERGY RELAXATION

As discussed in the main text, at large biases, $|V| > 0.8\,\mathrm{mV}$, 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[2,3]. We have checked that for $T_N > 5\,\mathrm{K}$ 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[4,5], similar to graphene[6–8], or the interplay of *e-ph* and impurity scattering[9]. Note, that the doping dependence of the surface electrons' cooling rate in 3D TI[10] Bi_2Se_3 at much higher T is consistent with the relaxation via surface acoustic phonons.

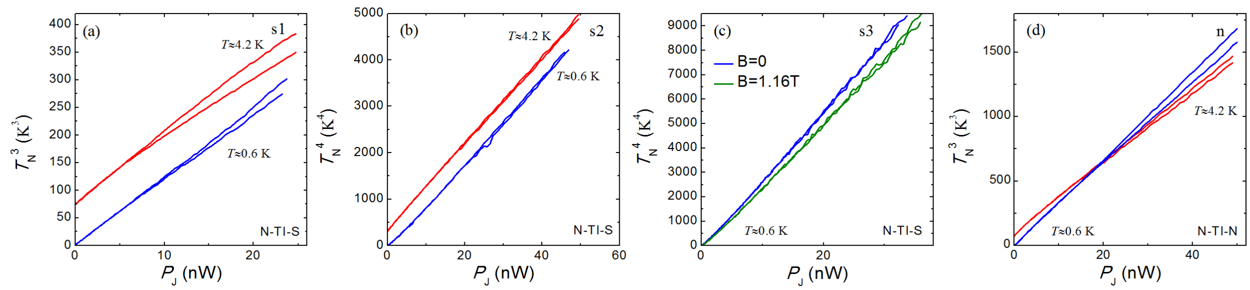

FIG. 2. E-ph energy relaxation in the strongly non-equilibrium transport regime. Close to linear dependence $T_N^\alpha \propto P_J$ at bath temperatures of $T = 0.6\,\mathrm{K}$ (blue curves) and $T = 4.2\,\mathrm{K}$ (red curves) in devices s1(a), s2(b), n(d) and at bath temperature of $T = 0.6\,\mathrm{K}$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

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