The emergence of the non-interacting channel in the strongly interacting 1D system

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We consider a strongly interacting one-dimensional (1D) system with two channels. When single-electron inter-channel backscattering processes $L_2^\dagger R_1$ (right-moving electron in the first channel backscatters into the left-moving state in the second channel) and $R_1^\dagger L_2$ (left-moving electron in the second channel backscatters into the right-moving state in the first channel) become relevant, we define two new fields. One field $\phi_g = \frac{1}{2}\left(\phi_1 + \phi_2 + \theta_1 - \theta_2\right)$ is frozen (gapped) by these relevant perturbations, whereas the second one $\phi_f = \frac{1}{2}\left(\phi_1 + \phi_2 - \theta_1 + \theta_2\right)$ remains free. We solve the problem exactly for arbitrary intra- and inter-channel interactions and find effective Luttinger parameter and velocity for the free field.

The free field contributes unity $\frac{e^2}{h}$ to the conductance of the system in agreement with previous studies [1,2], but in addition, it turns out that the parameters of the free field are independent of the interactions between right- and left-moving electrons in the same channel and between electrons moving in the same direction in different channels. Finally, if the inter-channel interactions are weak, the free field becomes non-interacting (effective Luttinger parameter $K = 1$) independently of how strong intra-channel interactions are!

[1] D. L. Maslov, M. Stone, *Phys. Rev. B* **52**, R5539 (1995).
[2] G. Shavit, Y. Oreg, *Phys. Rev. Lett.* **52**, 036803 (2019).