Supplementary Information accompanying paper "Excited state spectroscopy in carbon nanotube double quantum dots" by *Sami Sapmaz, Carola Meyer, Piotr Beliczynski, Pablo Jarillo-Herrero, and Leo P. Kouwenhoven.*

We provide additional measurements in the supplementary information. First we show in fig. 1 a measurement of the conductance as a function of the left side-gate for different central top-gate values. The peak position moves to lower gate voltage values, as expected, and also the first peak height decreases, which indicates that we influence the tunnel barrier.

In figure 2, we focus on a pair of triple points adjacent to the pair of fig. 6 of the accompanying paper. The total charge in this case N-1 holes in the left and M holes in right dot (the situation in the paper is N and M number of holes in the dots). In the subfigures different alignment of levels are shown for the situations indicated in the main figure. We find that the excited state of the right dot is practically the same as obtained from fig. 6 of the paper. This is as expected. For the excited states of the left we find different values for the different cases. Since the number of charges in the left dot is different for the two situations (fig. 6 in the main paper and fig. 2 here) it is expected to have a different excited state spectrum for both cases.

Finally, in fig. 3 we show measurements on a different nanotube double dot sample to demonstrate reproducibility. This sample is comparable to the one from the paper. In the different figures we show that we can operate the sample in different double dot regime: weak- and strong-tunnel coupled regime. Furthermore we present a zoom-in of a pair of triple points where the excited states are resolved.

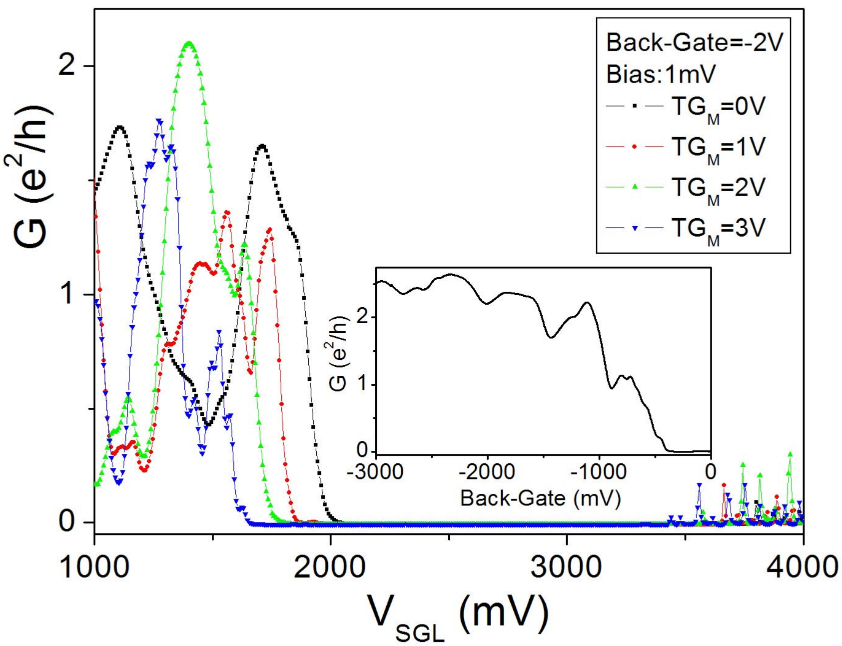

Figure 1. Conductance as a function of the left side-gate voltage (SG_L) at 4K is shown for different central top-gate values and with a fixed voltage of -2V on the back-gate showing p- and n-type behaviour. In the inset we show the conductance as a function of the back-gate voltage, while all other gates are grounded, in the p-region.

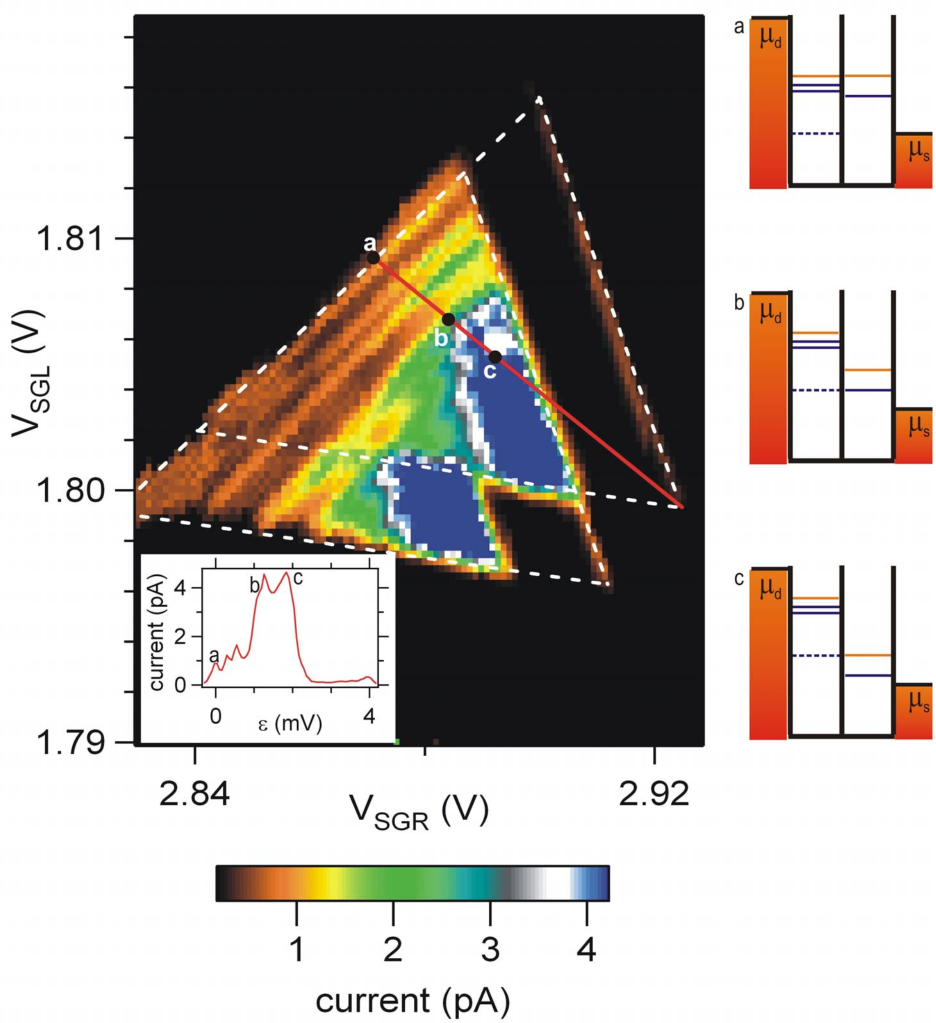

Figure 2. Triple point with (n-1) holes in left dot and same number of holes in right dot compared to the triple point in Figure 6 of the accompanying paper. A bias voltage of 4 mV is applied and the top-gates are grounded for this measurement. The inset shows the current as a function of the detuning ε between ground state levels (solid red line in triple point). Level schemes corresponding to three of the current peaks are shown on the right. We obtain a level splitting of 700 ± 60 μeV for the right dot from these data. There is one more excited state visible in the first orbital of the left dot. The first state is found at ~320 μeV, the second at ~580 μeV. The next peak corresponds to situation b: The next orbital excited state of the left dot is aligned with the excited state of the right dot. This leads again to an orbital splitting of ~ 1.9 meV.

The low energy excited states for the next orbital are not resolved due to the higher non-resonant current. The last peak corresponds more likely to situation c, as the splitting to b is ~ 650 μeV.

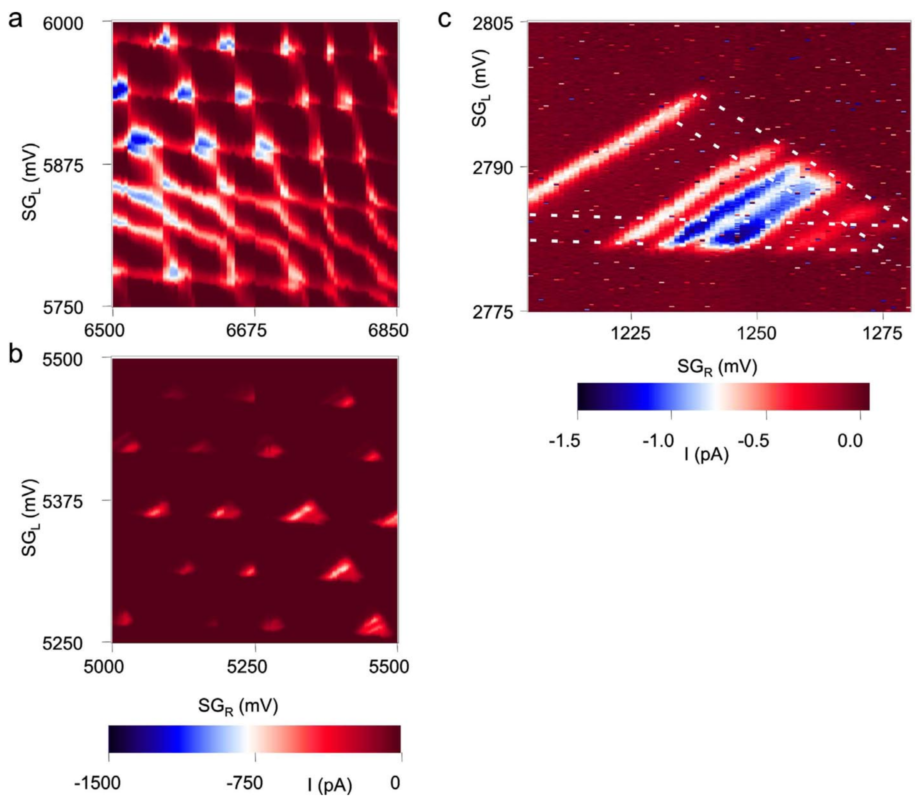

Figure 3. We show measurements on a different nanotube double quantum dot with a length of 500 nm for both the left and right dot. We apply a source drain bias voltage of -1mV for a), b) and a bias of -3 mV for c). The central top-gate is set to -1.5V. The current is plotted in color scale. In a) the double dot is in the strong tunnel-coupling regime and a clear honeycomb pattern is visible. In b) the triple points are clearly visible and the double dot is in the weak tunnel-coupling regime. In contrast to conventional GaAs quantum dots we do not have to retune the barriers to observe the double dot behaviour over a large side-gate voltage range. In c) we show a zoom-in of a pair of triple points where excited states are clearly resolved. Note that the current only flows when discrete levels are aligned.