Autocorrelation

Basics

For a given network of nanoparticles (NPs) with an evolving charge distribution $\vec{q}(t)$ and potential landscape $\vec{\phi}(t)$ at time t, we want to calculate the autocorrelation of the potential landscape or resulting electric currents $I(t)$. The electric current of the output electrode is given as

$$I(t) = e \cdot \frac{\Gamma_{+}(t) - \Gamma_{-}(t)}{t}$$

with t as the time passed during a **single** jump. The potential landscape is given as

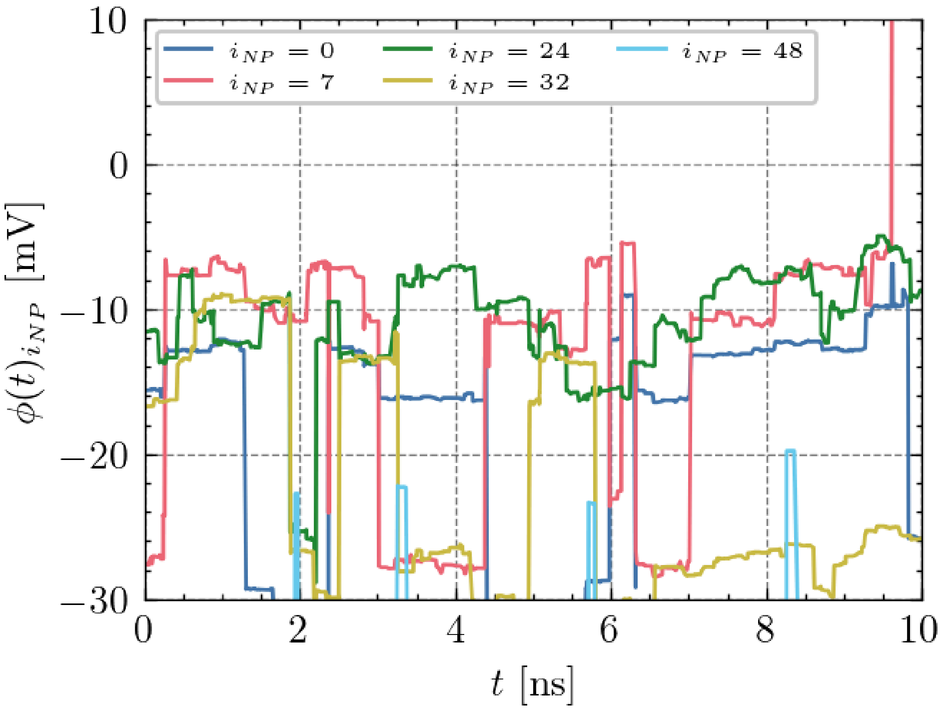
$$\vec{\phi}(t) = C^{-1} \cdot \vec{q}(t)$$

We calculate the autocorrelation $X \star X $of a random variable X at lag τ as

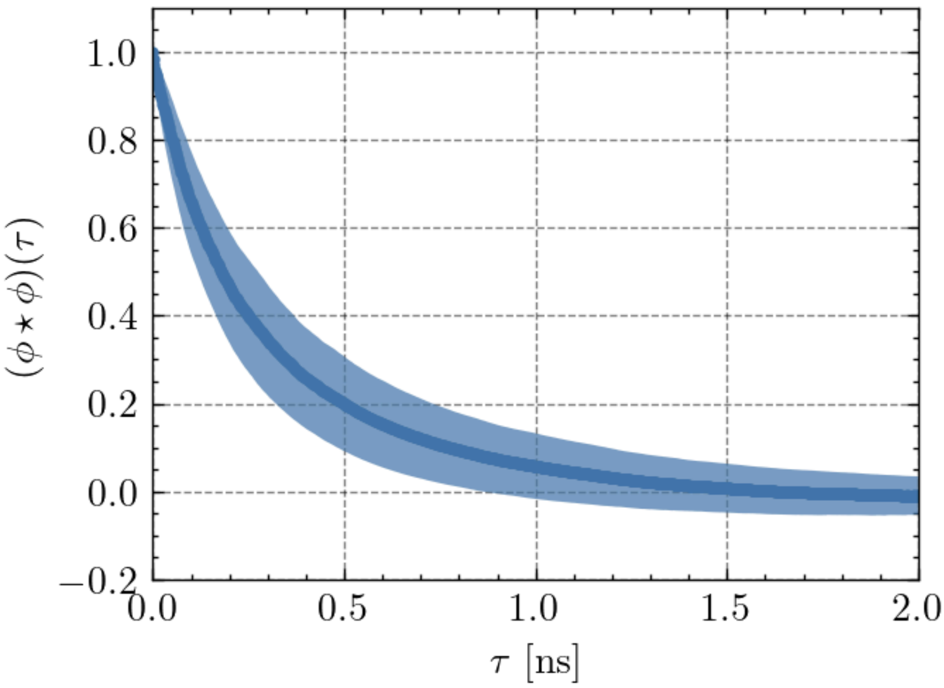
$$(X \star X)(\tau) = \frac{E[(X_t - \mu)(X_{t+\tau} - \mu)]}{\sigma^2}$$

with μ and σ for mean and standard deviation.

Potential Landscape

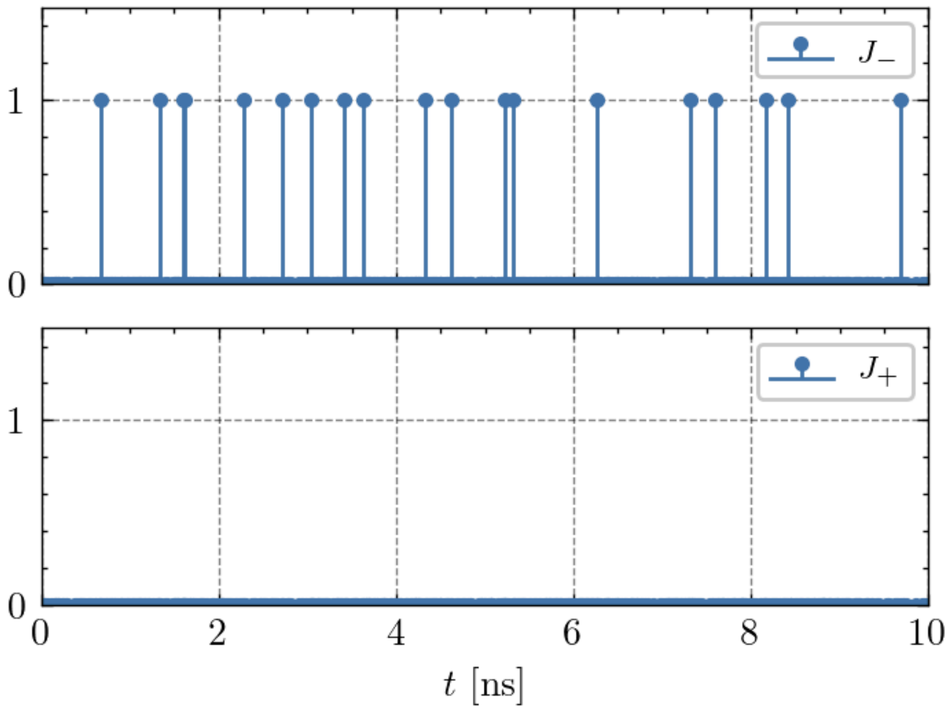


For a simulation of a 7 x 7 network after equilibration, we execute N_{Jumps} Monte Carlo steps resulting in a potential time series $\phi(t)_{i_{NP}}$ for 49 NPs of index i_{NP}. Above we show some example potential series. When calculating the autocorrelation for those potentials and average across the whole network the resulting plot shows a **ns time scale**.



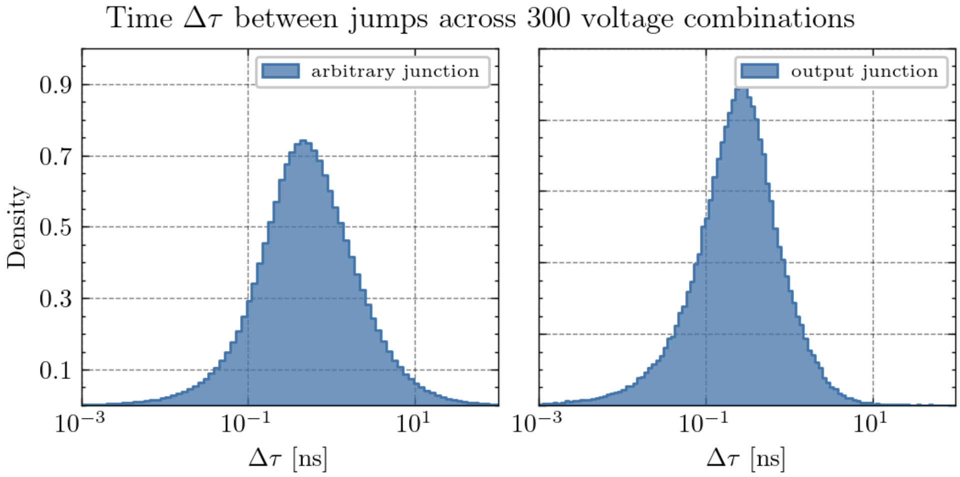
The indicated error results from calculating the autocorrelation for 300 combinations of control electrode voltages.

Electric Currents



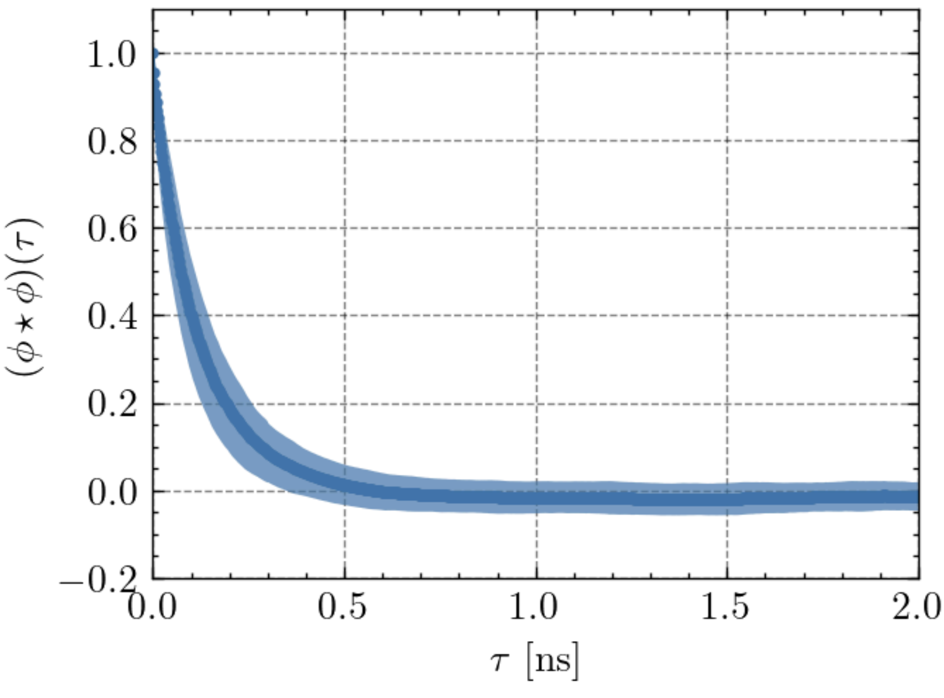
As there is no difference in autocorrelation between $\phi(t)$ and $I(t)$ we skip this part and instead measure the time passed $\Delta\tau$ in between occured jumps for a given junction. The plot above shows how often jumps occure at the output electrode junctions. There are always two jumps to be considered: J_- as Output-to-Network and J_+ as Network-to-Output jumps. In the upper case, the resulting electric current is of negative sign.

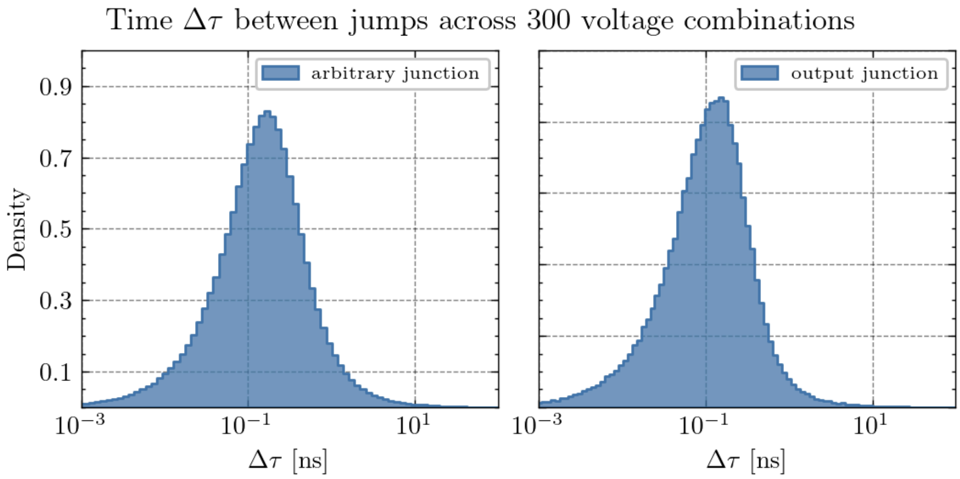
Here we compare the distribution $\Delta\tau$ for an arbitrary junction or the output electrode junction.



System Size

The plots below correspond to networks of 9 NPs. The time scale is shifted to smaller values.




Time $\Delta\tau$ between jumps across 300 voltage combinations
arbitrary junction
output junction
Density
0.9
0.7
0.5
0.3
0.1
10^{-3}
10^{-1}
10^{1}
$\Delta\tau$ [ns]