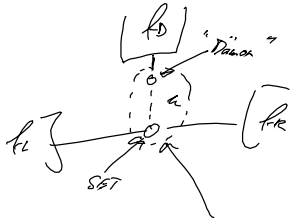
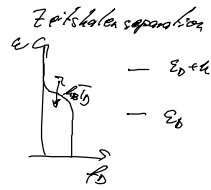


• Wdlt

Autonome Kanal-Paron



- ①  $\Gamma_D^{(L)} \gg \Gamma_{UR}^{(L)}$
- ②  $\beta_D \cdot \mu \gg 1$   
Näherungsgültig
- ③ Symmetriebruch  
 $\Gamma_L^a \gg \Gamma_R^a$   
 $\Gamma_L^a \ll \Gamma_R^a$



$$\dot{P}_{ij} = \sum_{kl} \lambda_{ij,kl} P_{kl}$$

↑                      ↑  
Zustand SET      Zustand Doten

$$\dot{P}_i = \sum_k \left[ \sum_{j \neq i} \lambda_{ij,ki} \frac{P_{kj}}{P_k} \right] P_k$$

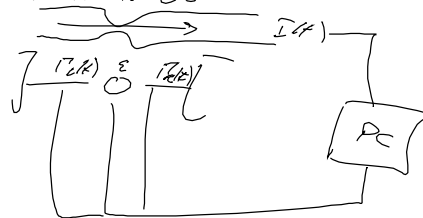
↓ ①

$$\frac{P_{kj}}{P_k} \xrightarrow{\text{①}} \bar{P}_{kj}$$

$$P_i = \sum_j P_{ij}$$

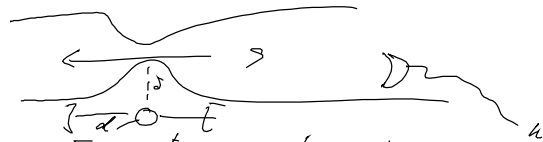
$$\approx \sum_k \lambda_{ik} P_k$$

effekt. Raten verhalten l.d. det. GG  
auslos



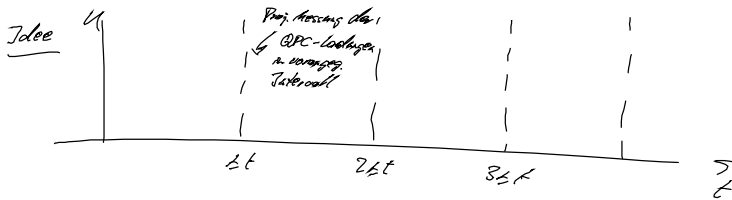
### 7.3 Ladungsdetektoren

bisher bei kontinuierl. FB-MBL kein Hersteller  
jetzt: mikrochip Detektor-Modell



$$W_{arc} = \sum_k \epsilon_{kl} \gamma_{kl}^+ \gamma_{kl}^- + (L \rightarrow R)$$

$$+ (1 - \delta_{kl}) \sum_{kl} (\epsilon_{kl} \gamma_{kl}^+ \gamma_{kl}^- + h.c.)$$



CG-Zeit  $\bar{t} = 2t$

falls  $H_S = A \otimes B \leftarrow \text{Bad} \left( \sum_{n_i} \gamma_{n_i}^+ \gamma_{n_i}^- + \text{h.c.} \right)$   
 System (4-Teilchen)  $\begin{matrix} e^{+i\omega_S t} A e^{-i\omega_S t} \\ A(t_1) A(t_2), \rho_S \end{matrix}$

in W-Bild

$$\dot{\rho}_S = -i \left[ \frac{1}{\hbar} \int_{-\infty}^{\infty} dt_1 \int_{-\infty}^{\infty} dt_2 \int du \delta(u) e^{-i u(t_1 - t_2)} A(t_1) A(t_2), \rho_S \right]$$

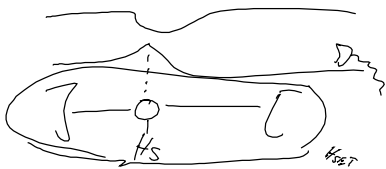
$$+ \frac{1}{\hbar} \int_{-\infty}^{\infty} dt_1 \int_{-\infty}^{\infty} dt_2 \int du e^{-i u(t_1 - t_2)} \left[ \gamma^{\pm}(u) A(t_1) \rho_S A(t_2) - \frac{1}{2} \{A(t_1) A(t_2), \rho_S\} \right]$$

a) falls die Zeitabhängigkeit in W-Bild  $A(t) \rightarrow A$  vernachlässigt werden kann  
 $\rightarrow$  lokale Lindblad-Operatoren (unidirekt. Transport durch QPC)

$$\rightarrow \dot{\rho}_S \propto \tilde{\gamma} \left[ e^{\pm i\omega_S t} A \rho_S A - \frac{1}{2} \{A^2, \rho_S\} \right]$$

b) falls die Messzeit  $\Delta t = \bar{t} \gg \bar{t}_{\text{corr}} \rightarrow$  betrachte gleich  $\bar{t} \rightarrow \infty$   
 $\rightarrow$  BHS Mastergleichung } betrachte messt  
 globale Lindblad-Operatoren  $\rightarrow$  TD-Konzepte

### 7.3.1. Einfacher Quantenpunkt



$$H_S = \epsilon d^\dagger d \rightarrow e^{-i H_S t} [d - \delta d^\dagger d] e^{+i H_S t} = A$$

$$Z_{\text{dot}}(z) = \left[ \gamma_L (e^{+iz} - 1) + \gamma_R (e^{-iz} - 1) \right] \left( -\frac{1}{0} \quad \frac{1}{(1-\delta)^2} \right)$$

QPC:  $L \rightarrow R$       $R \rightarrow L$

$[A, H_S] = 0$  kein Energie-Austausch  
 aber  $[A, H_{\text{dot}}] \neq 0$  Energie-Austausch ist klein

$$Z(z) = Z_{\text{QPC}}(z) + Z_{\text{SET}}$$

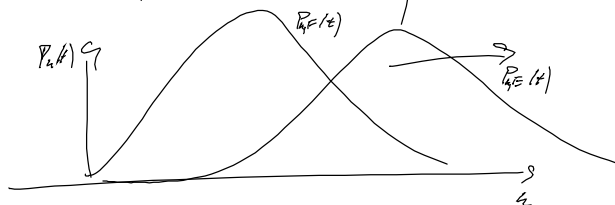
falls  $\gamma_{\alpha} \rightarrow 0$  (unid. Transport)

$$Z_{\text{QPC}}(z) = \gamma_{\alpha} (e^{\pm iz} - 1) \begin{pmatrix} 1 & 0 \\ 0 & (1-\delta)^2 \end{pmatrix}$$

$$\rho_S^{(n)}(t+\Delta t) = \frac{1}{\hbar} \int_{-\hbar}^{\hbar} e^{Z_{\text{QPC}}(z) \pm i z t} \rho_S(t) e^{-i z t} dz = \mathcal{K}_{\alpha}(t) \rho_S(t)$$

$$= \begin{pmatrix} \frac{(\gamma_{\alpha} \Delta t)^n}{n!} e^{-\gamma_{\alpha} \Delta t} & 0 \\ 0 & \frac{(1-\delta)^{2n} (\gamma_{\alpha} \Delta t)^n}{n!} e^{-\gamma_{\alpha} \Delta t} \end{pmatrix} \rho_S(t)$$

2 Poisson-Verteilungen



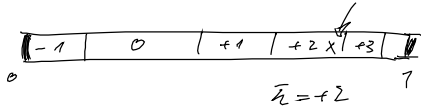
### Trajektorie

o berechne die WS

$$P_n(t) = \frac{1}{\hbar} \int_{-\hbar}^{\hbar} \text{Tr} \left\{ e^{Z(z) \pm i z t} \rho_S(t) \right\} e^{-i z t} dz$$

$-\infty < z < +\infty$   
 Produkt war endlich und  $\rho_S$

o Wähle gewichtetes Outcome zufällig: uniform-verteilt in  $[0, 1]$

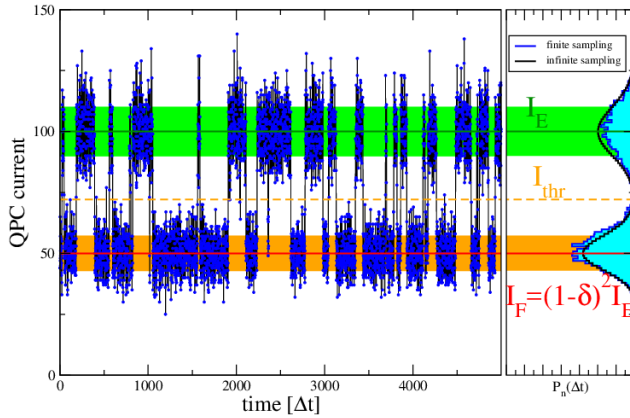


o Projektion  $\rho_{H(t)} = \frac{1}{\sqrt{2\pi}\sigma} \int_{-\infty}^{+\infty} e^{z(\lambda)\lambda} \rho(\lambda) e^{-i z \cdot \bar{z}} dz$

$$\bar{I}_n = \frac{\bar{I}}{\Delta t}$$

falls DA sich kon. während dt ändert

$$O(t) = \text{Tr} \{ \hat{O} \rho(t) \}$$



$$K_F = \sum_{k \neq k_{dir}} K_n(k, t)$$

$$K_E = \sum_{k \geq k_{dir}} K_n(k, t)$$

$$= \begin{pmatrix} 1 - P_{err}^0 & 0 \\ 0 & P_{err}^1 \end{pmatrix}$$

$$K_F = \begin{pmatrix} P_{err}^0 & 0 \\ 0 & 1 - P_{err}^1 \end{pmatrix}$$

=> messfehler sind im mikroskop. Detektor -modell enthalten

### 7.3.2. DQD: QAD-Messung



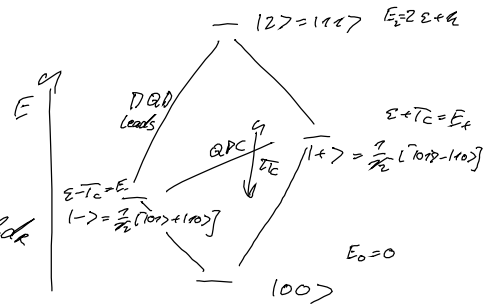
$$A = (1 - \delta d_i^\dagger d_i)$$

$$H_S = \epsilon (d_i^\dagger d_i + d_e^\dagger d_e) + T_C (d_i^\dagger d_e + d_e^\dagger d_i) + U d_i^\dagger d_i d_e^\dagger d_e$$

ins Wk-Bild

$$A(t) = e^{+iH_S t} A e^{-iH_S t} = A_0 + A_+ e^{+2i T_C t} + A_- e^{-2i T_C t}$$

$$\frac{1}{2} - \frac{\delta}{2} (d_i^\dagger d_i + d_e^\dagger d_e) \quad [H_S, A_0] = 0$$



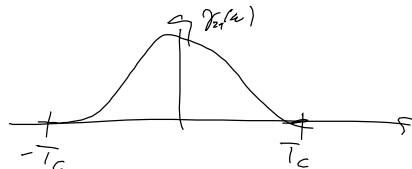
• kein Land-Schiff:  $\Gamma(\omega) \rightarrow 0$

• unid. Transport  $q_m \rightarrow 0$

Energie-Auflösung  $\pm 2\Gamma$

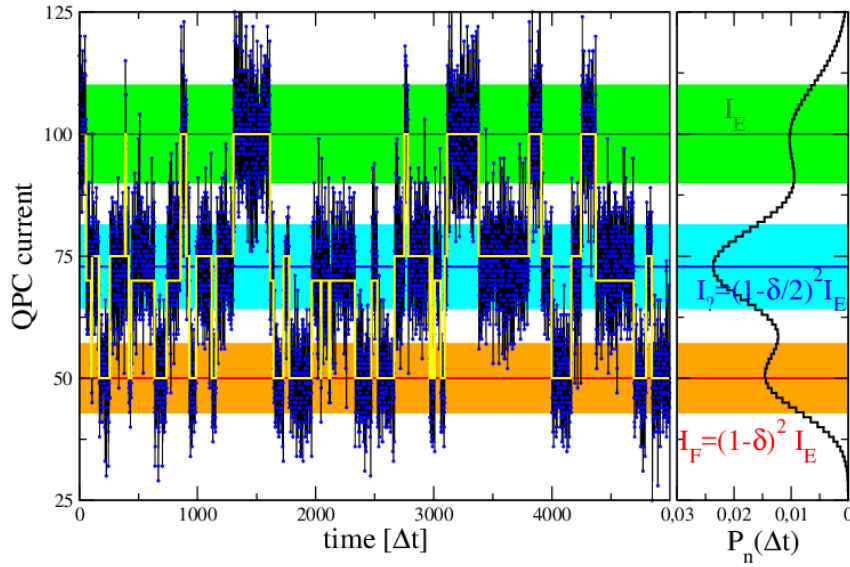
$$\dot{\rho}_S = \Gamma_{L,R} (+2T_C) [e^{i\pi} A_- \rho A_- - \frac{1}{2} \{A_- A_-, \rho\}] + \Gamma_{L,R} (-2T_C) [e^{-i\pi} A_+ \rho A_+ - \frac{1}{2} \{A_+ A_+, \rho\}] + \Gamma_{L,R} (0) [e^{i\pi} A_0 \rho A_0 - \frac{1}{2} \{A_0^2, \rho\}]$$

kein Energie-Auflösung

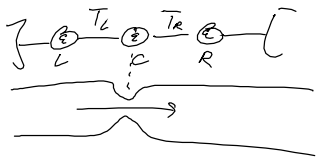


$$[A_0, H_S] = 0$$

$$\begin{aligned}
 A_0 |00\rangle &= |00\rangle \\
 A_0 |11\rangle &= (1-\delta) |11\rangle \\
 A_0 |1\pm\rangle &= (1-\frac{\delta}{2}) |1\pm\rangle \\
 \text{für } \mathcal{Z}_{\text{eff}}^{(2)}: \\
 \mathcal{Z}_{\text{eff}}^{(2)} &= \mathcal{Z}_{\text{eff}}^{(1)} (e^{+i\pi} - 1) \begin{pmatrix} 1 & & & \\ & (1-\frac{\delta}{2})^2 & & \\ & & (1-\frac{\delta}{2})^2 & \\ & & & (1-\delta)^2 \end{pmatrix}
 \end{aligned}$$



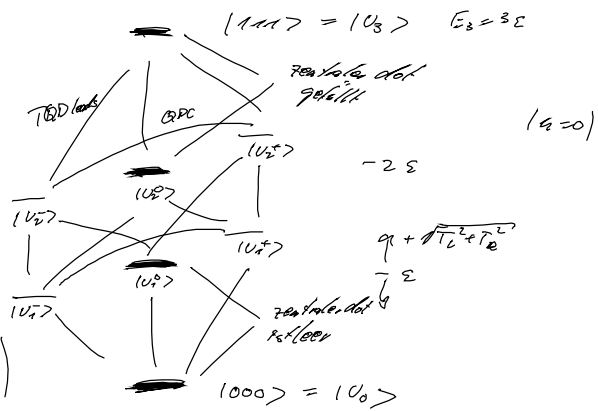
7.3.3. TQD: QND-Messung



$$A = \frac{1}{2} \delta \cdot d_0^+ d_c$$

$$A(t) = \hat{A}_0 + \left( \hat{A}_- e^{-2i\sqrt{\Gamma_L^2 + \Gamma_R^2} t} + \text{h.c.} \right)$$

QND-Messung  $\rightsquigarrow$  analog wie bei DQD



7.3.4. Projektive QPC

$$\dot{\rho} = -i \left[ H_S + \frac{\delta(t)}{i} A^\dagger \rho \right] + \left[ \gamma^2 \mathcal{M} \rho A - \frac{\gamma(t)}{2} \{A^\dagger, \rho\} \right]$$

$$A = \frac{1}{2} - \delta d_c^\dagger d_c$$

$$\gamma^2(k) = \gamma(k) \cdot e^{+i\tau} \quad (\text{unid. Transport})$$

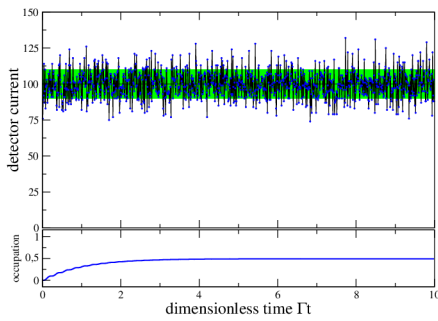
$$\text{Zdet}(\tau) \rho_S = \gamma \left[ e^{+i\tau} \left( \frac{1}{2} - \delta d_c^\dagger d_c \right) \rho \left( \frac{1}{2} - \delta d_c^\dagger d_c \right) - \frac{\gamma}{2} \left\{ \left( \frac{1}{2} - \delta d_c^\dagger d_c \right)^2, \rho \right\} \right]$$

$$\text{Zdet}(0) \rho_S = \dots = -\gamma \cdot \frac{\delta^2}{2} \left[ d_c d_c^\dagger \rho d_c^\dagger d_c + d_c^\dagger d_c \rho d_c d_c^\dagger \right]$$

in lokaler Basis  $|k_i, h_i, k_i\rangle \quad k_i \in \{0, 1\}$

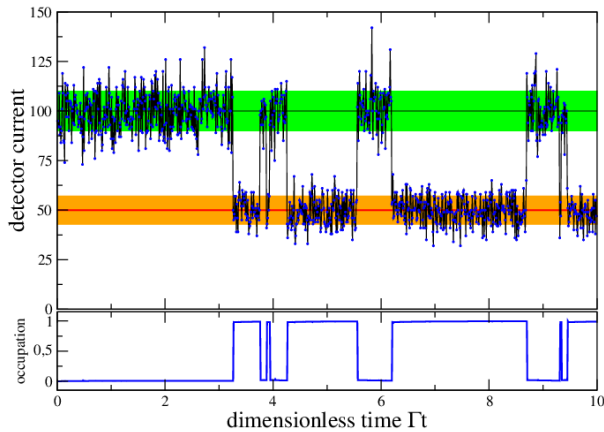
bestimmte Kohärenzen werden gedämpft

$$\left( \begin{array}{cccc|cccc} \rho_{000,000} & \rho_{000,100} & \rho_{000,010} & \rho_{000,001} & & & & \\ \rho_{000,100} & \rho_{000,100} & \rho_{000,100} & \rho_{000,100} & \rho_{000,100} & \dots & \dots & \\ \rho_{000,010} & \rho_{000,100} & \rho_{000,010} & \rho_{000,010} & \rho_{000,010} & \dots & \dots & \\ \rho_{000,001} & \rho_{000,100} & \rho_{000,010} & \rho_{000,001} & \rho_{000,001} & \dots & \dots & \\ \rho_{001,000} & & & & \rho_{001,000} & \dots & \dots & \\ \dots & & & & \dots & \rho_{001,001} & \dots & \\ \dots & & & & \dots & \dots & \rho_{001,001} & \end{array} \right) \rho_{111}$$



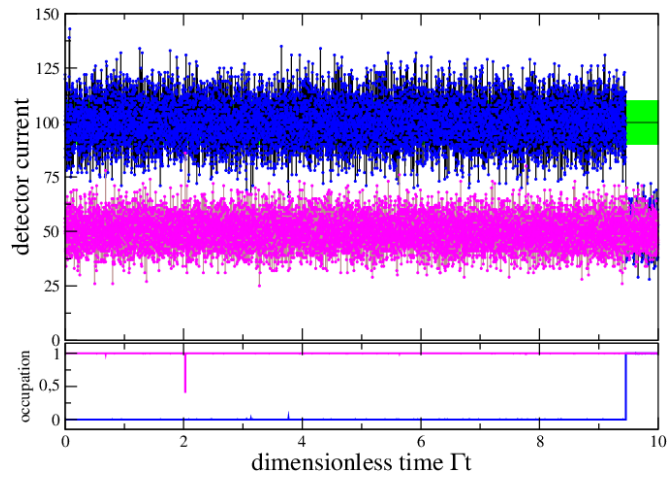
$\delta = 0$

$h_{cl}(t)$

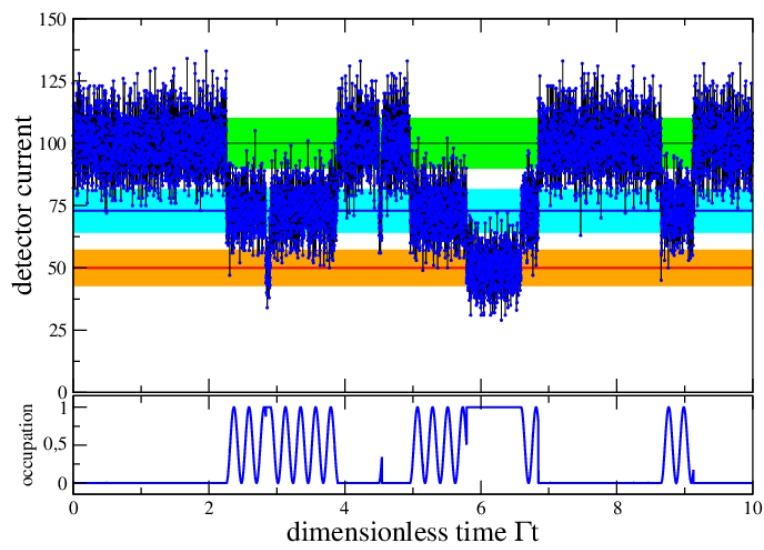


$\delta \neq 0$

endliches  $\delta t$



$\Gamma t \rightarrow \frac{\Gamma t}{10}$



QKD Messung