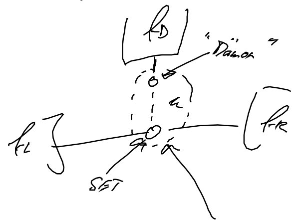
• WdH

autonomer Maxwell-Dämon



① $\Gamma_D^{(u)} \gg \Gamma_{L/R}^{(u)}$

② $\beta_D \cdot U \gg 1$

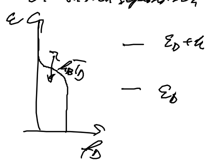
Messgenauigkeit

③ Symmetriebruch

$\Gamma_L^u \gg \Gamma_R^u$

$\Gamma_L^n \ll \Gamma_R$

Zeitskalenseparation



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

Zustand SET, Zustand Dämon

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

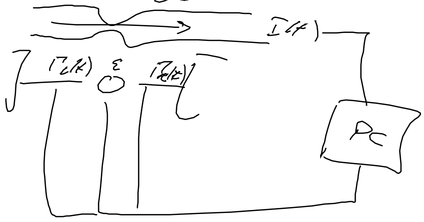
$$\dot{P}_i = \sum_k \left[\sum_{jl} \mathcal{L}_{ij,kl} \frac{P_{kl}}{P_k}\right] P_k \approx \sum_k \mathcal{L}_{ik} P_k$$

①, ①

effekt. Raten verletzen lok. det. GG

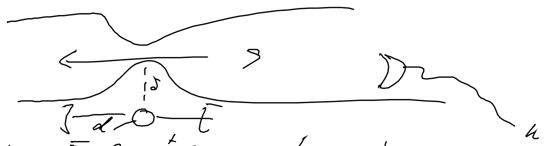
$$\frac{P_{kl}}{P_k} \xrightarrow{①} \bar{P}_{l|k}$$

analog



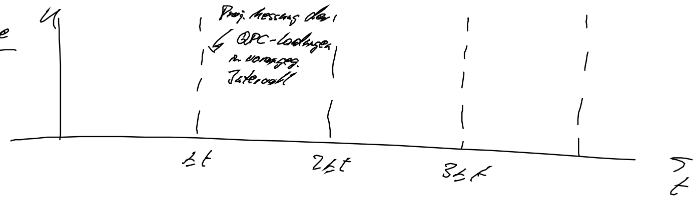
7.3. Ladungsdetektoren

bisher bei konkreten ÜG-MGL kein Besteller
jetzt: mikroskop. Detektor-Modell



$$H_{QPC} = \sum_k \varepsilon_{kL} \gamma_{kL}^\dagger \gamma_{kL} + (L \to R)$$
$$+ (\Omega - \delta \cdot d^\dagger d) \sum_{kk'} \left(t_{kk'} \gamma_{kL}^\dagger \gamma_{k'R} + h.c. \right)$$

Idee



$\rightsquigarrow$ CG-Zeit $\hat{\tau} = \Delta t$

falls $H_I = \underset{\substack{\uparrow\\ \text{System } (\mathbb{1}-\delta d^\dagger d)}}{A} \otimes B \leftarrow \text{Bad}\left(\sum_{kk'} \left(t_{kk'} \gamma_{kL}^\dagger \gamma_{k'R} + h.c.\right)\right)$

in WW-Bild

$$\dot\rho_S = -i\left[\frac{1}{2i\cdot 2\tau}\int_0^\tau dt_1 \int_0^\tau dt_2 \int d\omega\, \sigma(\omega)\, e^{-i\omega(t_1-t_2)}\, A(t_1)A(t_2), \rho_S\right]$$

$$+\frac{1}{2\pi\tau}\int_0^\tau dt_1\int_0^\tau dt_2\int d\omega\, e^{-i\omega(t_1-t_2)}\left[\gamma^\chi(\omega)\, A(t_2)\rho_S A(t_1) - \frac{1}{2}\{A(t_1)A(t_2), \rho_S\}\right]$$

$e^{+iH_S t_1} A e^{-iH_S t_2}$

a.) falls die Zeitabhängigkeit im WW-Bild $A(t) \to A$ vernachlässigt werden kann

$\Rightarrow$ lokale Lindblad-Operatoren (unidirektl. Transport durch QPC)

$$\longrightarrow \dot\rho_S \propto \gamma\left[e^{+i\chi} A\rho A - \frac{1}{2}\{A^2, \rho\}\right]$$

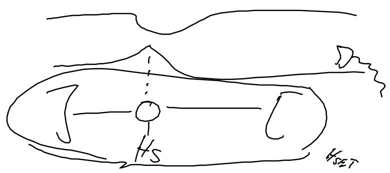
b.) falls die Messzeit $\Delta t = \tau \gg \tau_{corr} \longrightarrow$ betrachte gleich $\tau \to \infty$

$\Rightarrow$ BMS Mastergleichung

globale Lindblad-Operatoren $\to$ TD-Konsistenz

} betrachte zuerst

7.3.1. Einfaches Quantenpunkt



$$H_S = \varepsilon d^\dagger d \longrightarrow e^{-iH_S t}\underbrace{[\mathbb{1}-\delta d^\dagger d]}_{A} e^{+iH_S t} = A$$

$$\mathcal{Z}_{\substack{det\\QPC}}(\chi) = \left[\underset{\substack{\uparrow\\ \text{QPC: } L\to R}}{\gamma_{21}}\left(e^{+i\chi}-1\right) + \underset{\substack{\uparrow\\ R\to L}}{\gamma_{12}}\left(e^{-i\chi}-1\right)\right]\left(\begin{array}{c|c} 1 & 0 \\ \hline 0 & (1-\delta)^2\end{array}\right)$$

$[A, H_S] = 0$ kein Energie-Austausch

aber $[A, H_{SET}] \neq 0$ Energie-Austausch ist klein

$$\mathcal{Z}(\chi) = \mathcal{Z}_{QPC}(\chi) + \mathcal{Z}_{SET}$$

falls $\gamma_{12} \to 0$ (unid. Transport) $\quad \mathcal{Z}_{QPC}(\chi) = \gamma_{21}\left(e^{+i\chi}-1\right)\begin{pmatrix}1 & 0\\ 0 & (1-\delta)^2\end{pmatrix}$

$$\rho^{(n)}(t+\Delta t) = \frac{1}{2\pi}\int_{-\pi}^{+\pi} e^{\mathcal{Z}_{QPC}(\chi)\Delta t}\rho(t)\, e^{-in\chi}\, d\chi = \underset{\substack{\uparrow\\ \text{Kraus-Abbildung}}}{\mathcal{K}_n(\Delta t)}\,\rho(t)$$

$$= \begin{pmatrix}\frac{(\gamma_{21}\Delta t)^n}{n!}e^{-\gamma_{21}\Delta t} & 0\\ 0 & \frac{(1-\delta)^{2n}(\gamma_{21}\Delta t)^n}{n!}e^{-\gamma_{21}\Delta t}\end{pmatrix}\rho(t)$$

2 Poisson-Verteilungen

Trajektorie

- berechne die WS

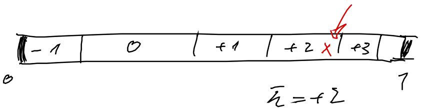
$$P_n(\Delta t) = \frac{1}{2\pi}\int_{-\pi}^{+\pi}\mathrm{Tr}\left\{e^{\mathcal{Z}(\chi)\cdot\Delta t}\rho(t)\right\}e^{-in\chi}\,d\chi$$

$-\infty < n < +\infty$

praktisch nur endlich viele

∘ Wähle gewichtetes Outcome

Zufallszahl: uniform-verteilt in [0, 1]



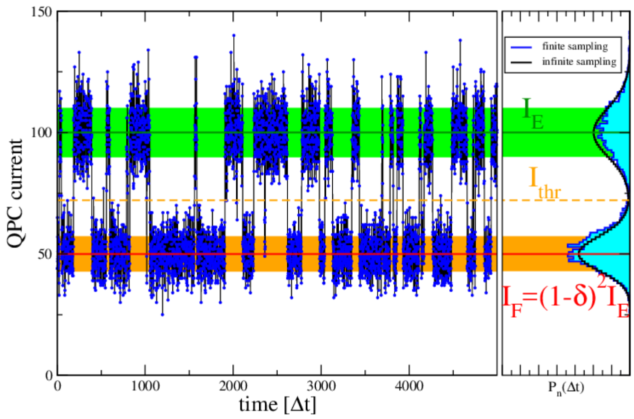
$\bar n = +2$

$I_{\bar n} = \frac{\bar n}{\Delta t}$

∘ Projiziere $\rho(t+\Delta t) = \frac{1}{2\pi \cdot P_{\bar n}} \int_{-\pi}^{+\pi} e^{\mathcal{L}(\chi)\Delta t} \rho(t)\, e^{-i\bar n \chi}\, d\chi$

falls Dh sich kaum während Δt ändert

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



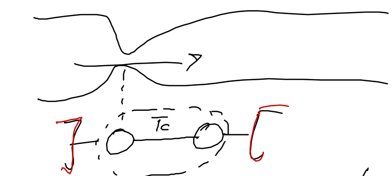
$\mathcal{K}_F = \sum_{n<n_{thr}} \mathcal{K}_n(\Delta t)$

$\mathcal{K}_E = \sum_{n\geq n_{thr}} \mathcal{K}_n(\Delta t) = \begin{pmatrix} 1-P^0_{err} & 0 \\ 0 & P^1_{err} \end{pmatrix}$

$\mathcal{K}_F = \begin{pmatrix} P^0_{err} & 0 \\ 0 & 1-P^1_{err} \end{pmatrix}$

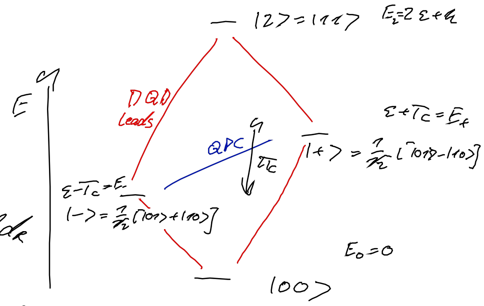
⇒ Messfehler sind im mikroskop. Detektor-Modell enthalten

7.3.2. DQD: QND-Messung



$A = (U - \delta d_L^\dagger d_L)$

$H_S = \varepsilon(d_L^\dagger d_L + d_R^\dagger d_R) + T_c(d_L^\dagger d_R + d_R^\dagger d_L) + U d_L^\dagger d_L d_R^\dagger d_R$



ins WW-Bild

$A(t) = e^{+iH_S t} A e^{-iH_S t} = \hat A_0 + \hat A_+ e^{+2iT_c t} + \hat A_- e^{-2iT_c t}$

$U - \frac{\delta}{2}(d_L^\dagger d_L + d_R^\dagger d_R)$ $\qquad [H_S, A_0] = 0$

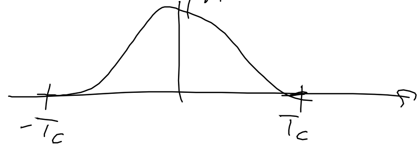
• kein Lamb-shift: $\Sigma(\omega) \to 0$

∘ mikr. Transport $\gamma_n \to 0$

Energie-Austausch $\pm 2T_c$

$\dot\rho_S = \gamma_{21}(+2T_c)\left[e^{i\chi} A_- \rho A_+ - \frac{1}{2}\{A_+ A_-, \rho\}\right] + \gamma_{21}(-2T_c)\left[e^{+i\chi} A_+ \rho A_- - \frac{1}{2}\{A_- A_+, \rho\}\right]$
$+ \gamma_{21}(0)\left[e^{i\chi} A_0 \rho A_0 - \frac{1}{2}\{A_0^2, \rho\}\right]$

kein Energie-Austausch



$[A_0, H_S] = 0$

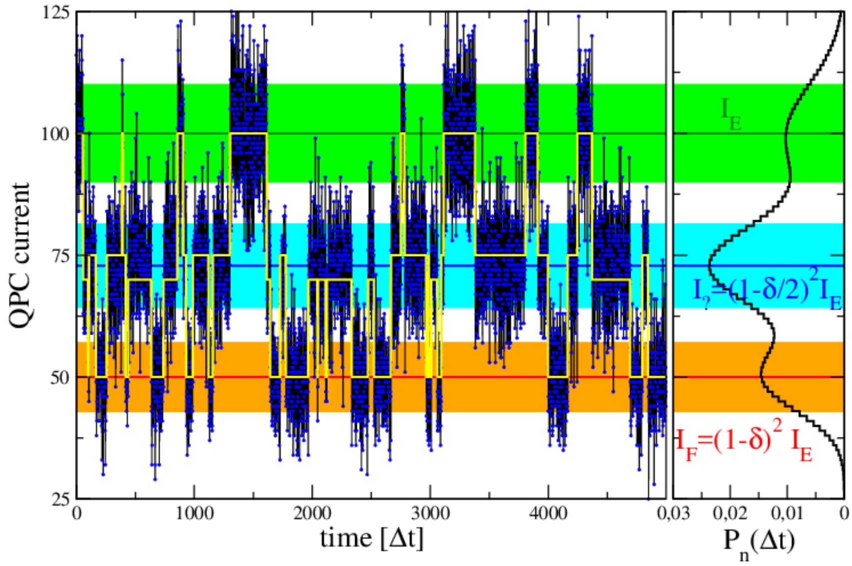
$A_0 |00\rangle = |00\rangle$

$A_0 |11\rangle = (1-\delta)|11\rangle$

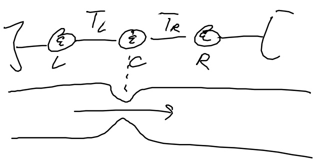
$A_0 |\pm\rangle = (1-\frac{\delta}{2})|\pm\rangle$

nur $\gamma_{21}(0)$:

$$\mathcal{L}_{det}^{(\chi)} = \gamma_{21}(0)\left(e^{+i\chi}-1\right) \begin{pmatrix} 1 & & & 0 \\ & (1-\frac{\delta}{2})^2 & & \\ & & (1-\frac{\delta}{2})^2 & \\ 0 & & & (1-\delta)^2 \end{pmatrix}$$



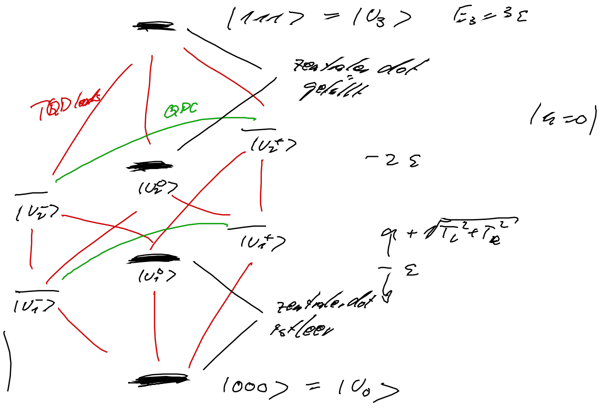
7.3.3. TQD: QND-Messung



$A = 1 - \delta \cdot d_c^\dagger d_c$

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

QND-Messung $\rightsquigarrow$ analog wie bei DQD



7.3.4. Projektiver QPC

$$\dot{\rho} = -i\left[H_S + \frac{\varepsilon(\tau)}{i} A^2, \rho\right] + \left[\gamma^{\tau}(\tau) A \rho A - \frac{\gamma(\tau)}{2}\{A^2, \rho\}\right]$$

$$A = t - \delta d_c^\dagger d_c$$

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

im Int-Bild

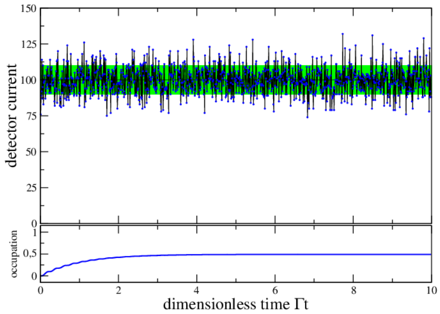
$$\mathcal{L}_{det}(\tau)\rho_S = \gamma\left[e^{+i\tau}(t - \delta d_c^\dagger d_c)\rho(t - \delta d_c^\dagger d_c) - \frac{1}{2}\{(t - \delta d_c^\dagger d_c)^2, \rho\}\right]$$

$$\mathcal{L}_{det}(0)\rho_S = \ldots = -\gamma \cdot \frac{\delta^2}{2}\left[d_c d_c^\dagger \rho d_c^\dagger d_c + d_c^\dagger d_c \rho d_c d_c^\dagger\right]$$

in lokaler Basis $|n_L, n_c, n_R\rangle$ $\quad n_i \in \{0,1\}$

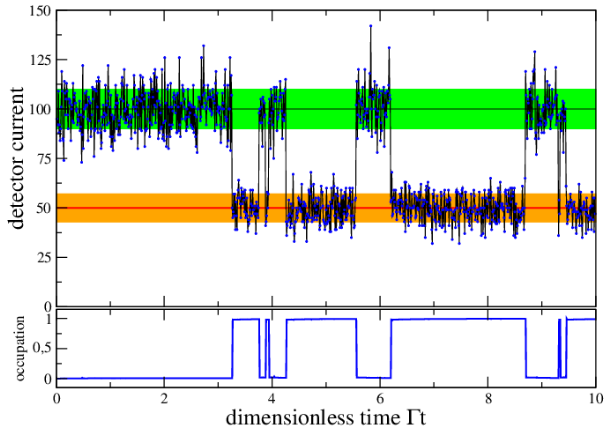
bestimmte Kohärenzen werden gedämpft

$$\begin{pmatrix} \rho_{000,000} & & & \\ & \begin{pmatrix} \rho_{100,100} & \cancel{\rho_{100,010}} & \rho_{100,001} \\ \cancel{\rho_{010,100}} & \rho_{010,010} & \cancel{\rho_{010,001}} \\ \rho_{001,100} & \cancel{\rho_{001,010}} & \rho_{001,001} \end{pmatrix} & & \\ & & \begin{pmatrix} \rho_{110,110} & & \ldots \\ & \rho_{101,101} & \\ \ldots & & \rho_{011,011} \end{pmatrix} & \\ & & & \rho_{111} \end{pmatrix}$$



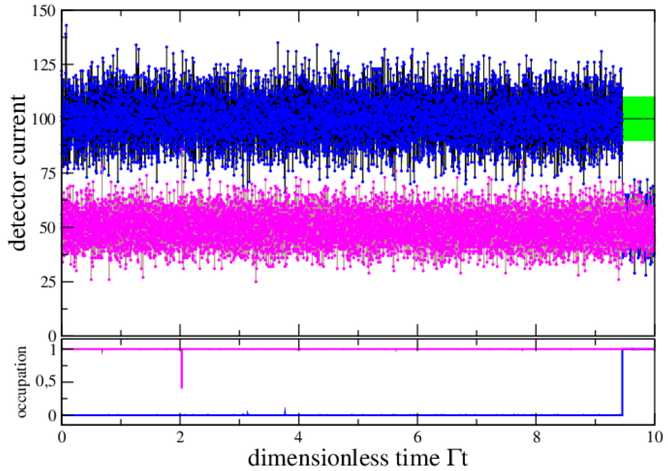
$\delta = 0$

$n_c(t)$

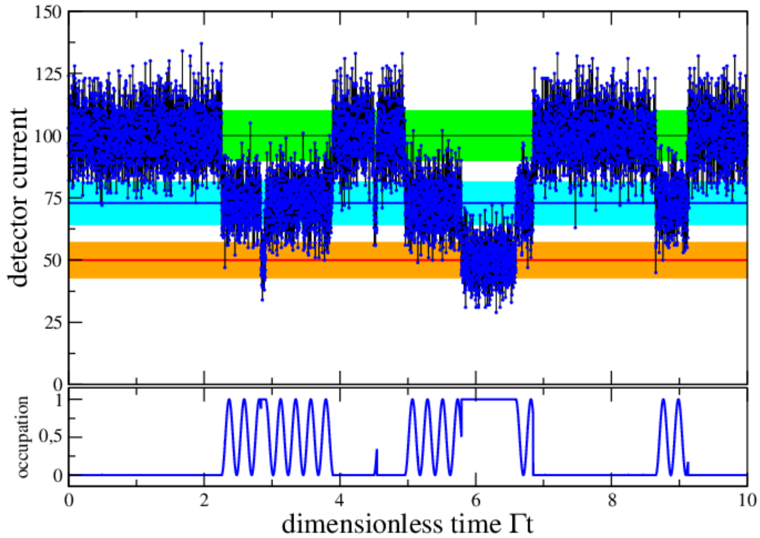


$\delta \neq 0$

endliches Δt



$\Delta t \to \frac{\Delta t}{10}$



QHD-Messung