Gaussian sum smoothing for continuously monitored quantum systems

J. Pinske

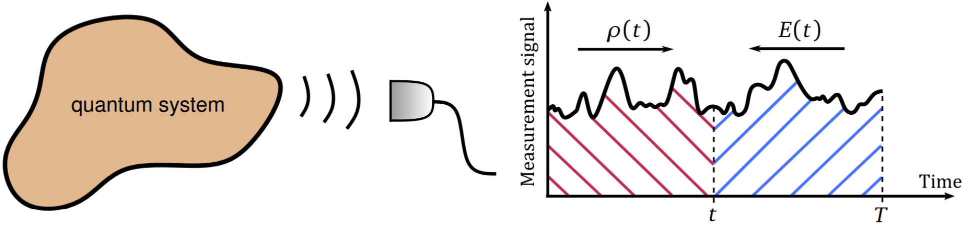
Institut für Physik, University of Rostock, Germany

Collaborators:

Sumukh S. Moudghalya and Stefan Scheel

Universität Rostock

Traditio et Innovatio

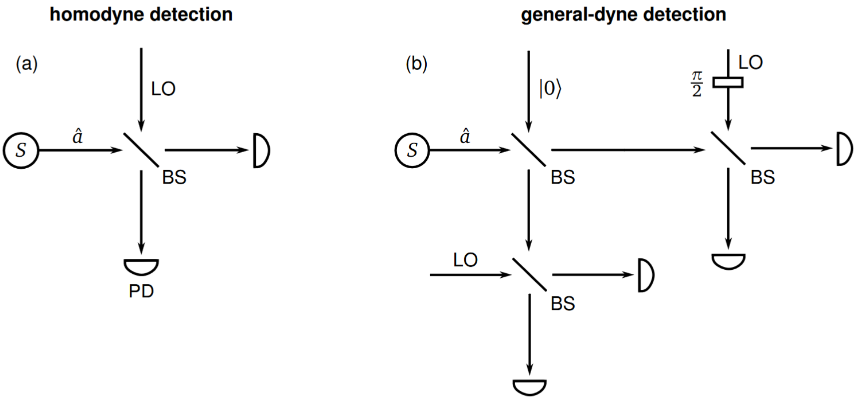


The density matrix $\rho(t)$ includes information before t and the effect $E(t)$ accounts for data after t.

Probability for outcome q at time t, given the entire measurement record $Y_{0\ldots T}$,

$$p_t(q|Y_{0\ldots T}) = \frac{\langle q|\rho_t|q\rangle \langle q|E_t|q\rangle}{\int \langle q'|\rho_t|q'\rangle \langle q'|E_t|q'\rangle \, dq'},$$

A light field $\hat{a}$ is analyzed by interfering it with a laser (LO) and detecting the output with photodetectors (PD):



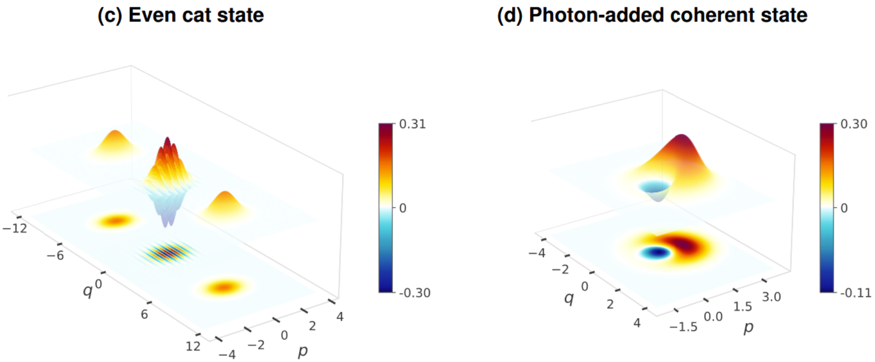
A hidden Markov model is described by **stochastic master equations** [1]

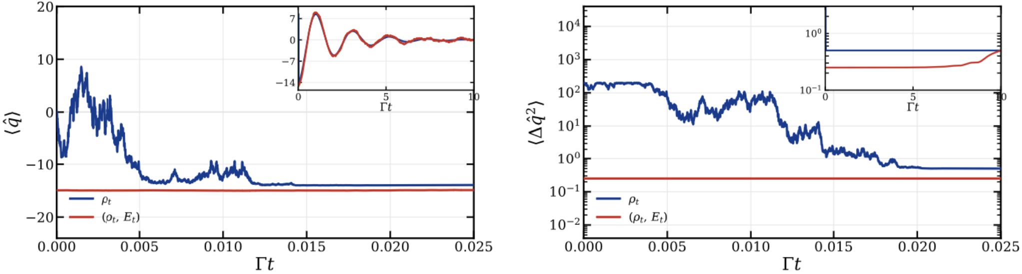
$$d\rho = i[\rho, H]dt + \Gamma\mathscr{D}[\hat{a}]\rho dt + \sqrt{\eta\Gamma}(\hat{a}\rho + \rho\hat{a}^\dagger)dY_t,$$
$$dE = i[H, E]dt + \Gamma\mathscr{D}[\hat{a}]^\dagger\rho dt + \sqrt{\eta\Gamma}(\hat{a}^\dagger E + E\hat{a})dY_{t-dt},$$

Obtain non-Gaussian features without solving Eq. (2) by expanding the state ρ_t using Gaussian operators G_k

$$\rho_t \approx \sum_k a_k G_k\big(\boldsymbol{r}_k(t), \boldsymbol{\Lambda}_k(t)\big).$$

Non-Gaussian quasiprobability → some a_k will be negative! → Not strictly a Gaussian mixture model!




20
10
0
−10
−20
$\langle \hat{q} \rangle$
0.000
0.005
0.010
0.015
0.020
0.025
Γt
ρ_t
(ρ_t, E_t)
7
0
−7
−14
0
5
10
Γt
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
$\langle \Delta \hat{q}^2 \rangle$
0.000
0.005
0.010
0.015
0.020
0.025
Γt
ρ_t
(ρ_t, E_t)
10^0
10^{-1}
0
5
10
Γt