SPIKES IN QUANTUM TRAJECTORIES

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Spikes emerge from the competition between continuous measurement and evolution.

Example: Continuously measure the energy of a qubit at thermal equilibrium.

Stochastic Master Equation

It can be shown (believe me) that the probability to be in the ground state $Q_t = \langle 0| \rho_t |0\rangle$ for a continuously monitored qubit coupled to a thermal bath verifies:

$$dQ_t = \underbrace{\lambda(p_{eq} - Q_t)\, dt}_{\text{effect of the bath}} + \underbrace{\sqrt{\gamma}\, Q_t(1 - Q_t)\, dW_t}_{\text{effect of measurements}}$$

- $\lambda(p_{eq} - Q_t)\, dt$ drags the probability towards p_{eq}, the probability at thermal equilibrium.
- $\sqrt{\gamma}\, Q_t(1 - Q_t)\, dW_t$ drags the probability towards 0 or 1 i.e. perfect certainty in the energy basis.

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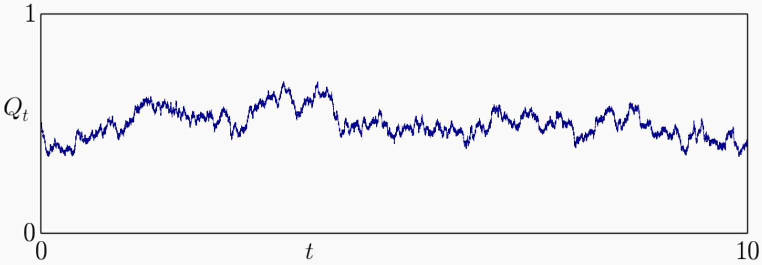
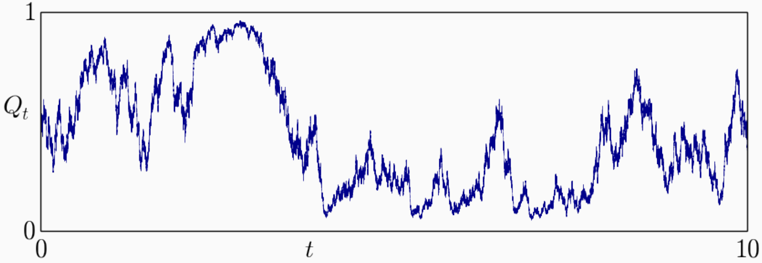


$\gamma = 0.1$ very weak continuous measurement



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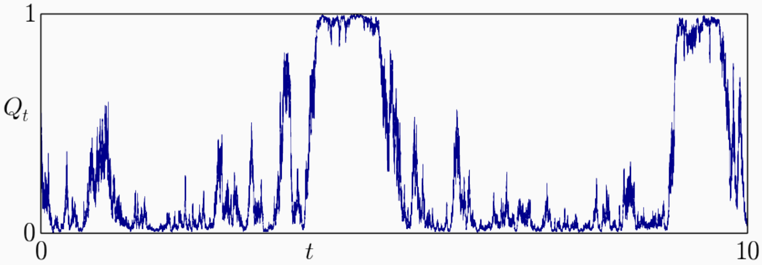

$\gamma = 10$ strong continuous measurement

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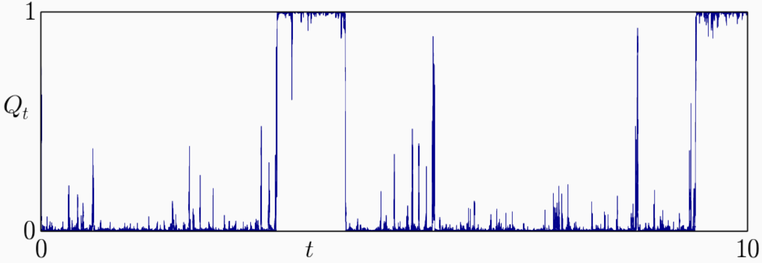

$\gamma = +\infty$ infinitely strong continuous measurement

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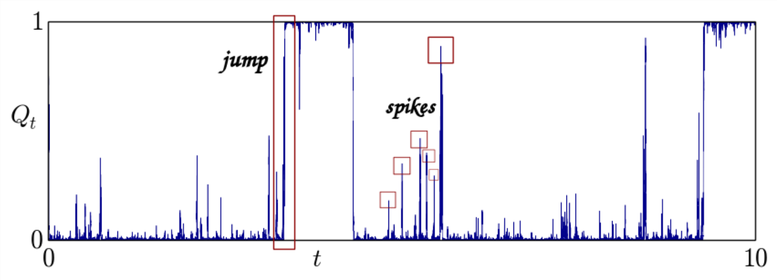

$\gamma = +\infty$

Conclusion

- Spikes become infinitely sharp when $\gamma \longrightarrow +\infty$ but do not vanish
- Spikes can be precisely quantified and studied
- Spikes are ubiquitous (only need strong measurement + incompatible evolution)
- Taking spikes into account leads to new interesting scaling limits for quantum trajectories

There is more to “strong” measurements than quantum jumps

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