Thermodynamics of initial coherences

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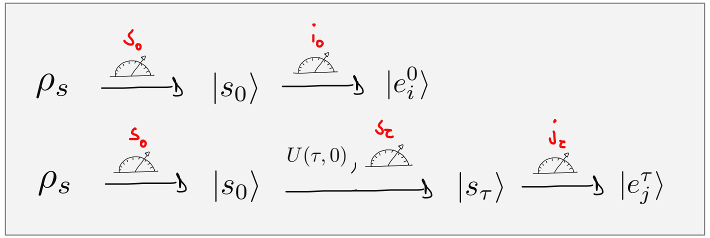
Fluctuation theorems via Bayesian inference

Generalization of TPM approach:



$$P(s_0, i_0, j_\tau) = p_s^0 p(i_0|s_0) p(s_\tau|s_0) p(j_\tau|s_\tau).$$

δ for unitaries!

Easy generalization to open system by tracking bath via standard TPM scheme:

$$P(s_0, i_0, \mu, j_\tau, \nu) = p_s^0 p_\mu p(i_0|s_0) p(s_\tau, \nu|s_0, \mu) p(j_\tau|s_\tau).$$

With the proper definition of backward process we arrive at the integral fluctuation theorem

$$\langle \exp(\beta(w - \Delta F) - \Delta\mathcal{C} - \mathcal{D})\rangle = 1.$$

Second law for coherences

Via Jensen's innequality we have that

$$\langle w\rangle \geq \Delta F + \beta^{-1}(\Delta\mathcal{C} + \mathcal{D}) \geq \Delta F + \beta^{-1}\Delta\mathcal{C}.$$

Coherences are useful when $\Delta\mathcal{C} \leq 0$.

$\mathcal{D} = S(\rho_\tau^{\mathrm{d}}||\rho_\beta) \geq 0$ is the classical nonequilibrium divergence.

In order to be advantageous, $\Delta\mathcal{C}$ must be negative: innitial coherences are strictly necessary.

Tight for unitary processes;
For open systems, entropy production reads:

$$\Sigma = \mathcal{I}_{S:E} + \mathcal{D}_E$$

Timescales and work extraction

Decrease of $\Delta\mathcal{C}$ can go either for $\langle w\rangle$ or for $\mathcal{I}_{S:E}$:

Transfer to $\langle w\rangle$ happens at the Rabi frequency timescale τ_w of each relevant energy gap.

Transfer to $\mathcal{I}_{S:E}$ happens at the timescale of decoherence τ_{dc}, via generalized cross-correlations between interaction operators.