

Effect of Open System Dynamics on Maximally Entangled Mixed States

Steven Campbell

scampbell37@qub.ac.uk

Advisors: Dr Mauro Paternostro
Dr Jim McCann



Motivation

Experimentally produceable

Bipartite

Multipartite?

Why examine these states?

To characterise them

See how they are affected by quantum noise

How 'useful' is a given quantum state?

Motivation

Given a particular set of MEMS how robust is their entanglement?

How do we quantify entanglement?

How do we quantify mixedness?

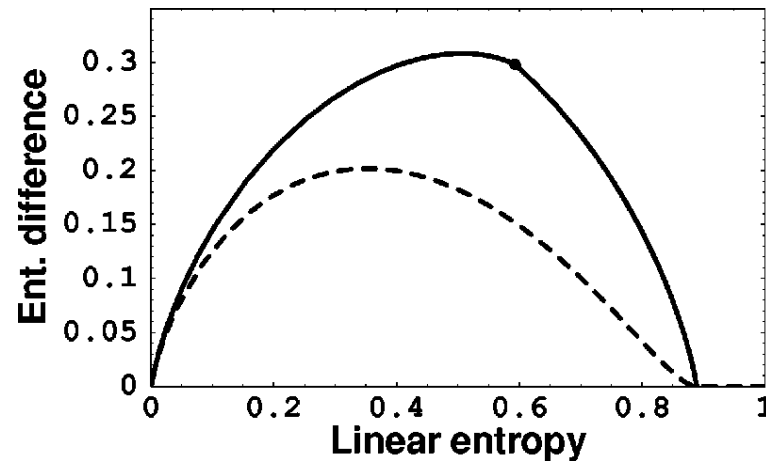


FIG. 5. Difference in entanglement ($E_F - E_R$) versus S_L for the MEMS in Eq. (4.6) and Werner states. The solid curve shows states from $\rho_{\text{MEMS}; E_F, S_L}$; the dashed curve shows the Werner states.

Measures of Entanglement

Entanglement of formation

$$E_F(\rho) \equiv \min_{\{p_i, \psi_i\}} \sum_i p_i E(|\psi_i\rangle\langle\psi_i|),$$

Relative entropy

$$E_R(\rho) \equiv \min_{\sigma \in D} \text{Tr}(\rho \log \rho - \rho \log \sigma),$$

Negativity

$$N(\rho) = 2 \max(0, -\lambda_{\text{neg}}),$$

Measures of Mixedness

von Neumann entropy

$$S_V(\rho) \equiv -\text{Tr}(\rho \log \rho) = -\sum_i \lambda_i \log \lambda_i,$$

Linear entropy

$$S_L(\rho) \equiv \frac{\mathcal{N}}{\mathcal{N}-1} [1 - \text{Tr}(\rho^2)],$$

Why Negativity and Linear entropy?

Quantum Channels

Operator Sum Representation

$$E(\rho) = \sum_i M_i \rho M_i^\dagger$$

The noisy quantum channels of interest to us will be:

Depolarizing Channel

Amplitude-Damping Channel

Phase-Damping Channel

Project Aims:

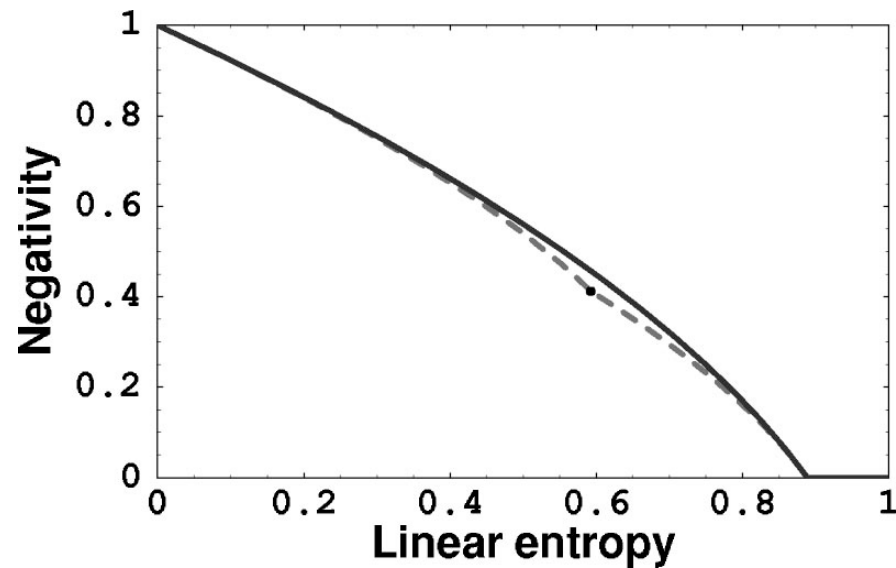
Given MEMS

Subject them to each of the quantum channels

Measure mixedness (via linear entropy) and entanglement (via negativity)

Compare to the original MEMS

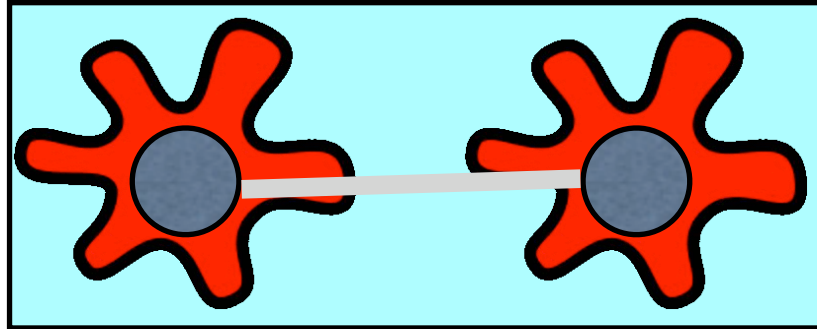
Which MEMS shall we look at?



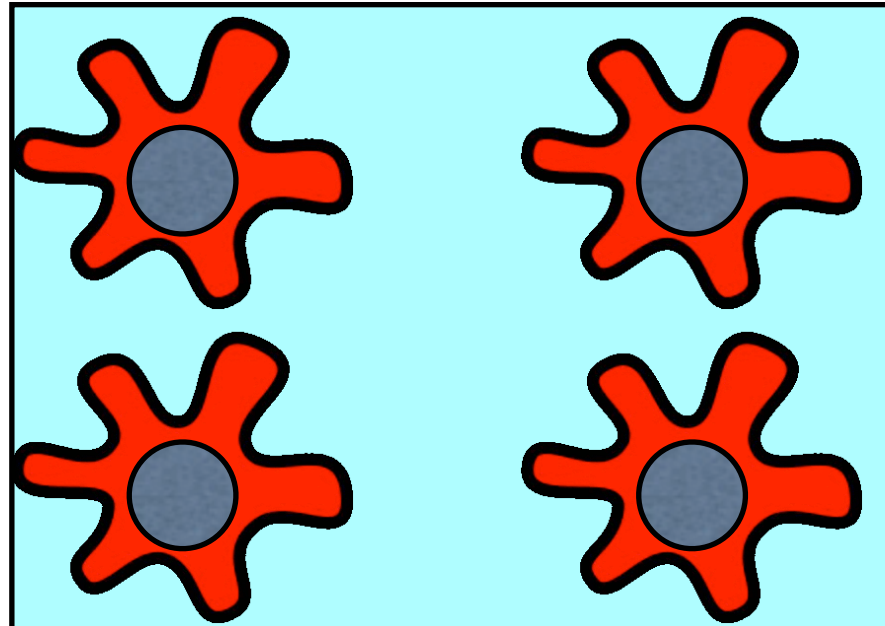
$$\rho_{\text{MEMS:N,S}_L}^{(1)} = \begin{pmatrix} (1+r)/4 & 0 & 0 & r/2 \\ 0 & (1-r)/4 & 0 & 0 \\ 0 & 0 & (1-r)/4 & 0 \\ r/2 & 0 & 0 & (1+r)/4 \end{pmatrix},$$

$$\rho_{\text{MEMS:N,S}_L}^{(2)} = \begin{pmatrix} (1+\sqrt{3r^2+1})/6 & 0 & 0 & r/2 \\ 0 & (4-2\sqrt{3r^2+1})/6 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ r/2 & 0 & 0 & (1+\sqrt{3r^2+1})/6 \end{pmatrix}.$$

Which MEMS are we looking at?



What happens when we increase the number of qubits in the system?



Thank you for listening

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Dr Jim McCann

For more information:

scampbell37@qub.ac.uk