List of Figures

1. The circuit of DQC1 model ........................................ 20
1.1 The figure depicts geometric representation of all the Bell diagonal states in the parameter space of $c_1, c_2, c_3$. The tetrahedron, defined by the corner points $(-1, 1, 1), (1, -1, 1), (1, 1, -1), (-1, -1, -1)$, is the physical set of Bell diagonal states. The octahedron inside tetrahedron represents the separable Bell diagonal states. The centers of the octahedron facets are marked with black dot and they are the separable Bell diagonal states with maximum discord. The figure is adapted form [37] .... 24
1.2 The picture depicts several types of correlations in a quantum state. $\alpha \rightarrow \beta$ denotes that the state $\beta$ is closest state to $\alpha$ as measured by relative entropy. For a state $\alpha$, $\chi_\alpha$ denotes its nearest classical state, $\pi_{\chi_\alpha}$ denotes nearest product state of $\chi_\alpha$ and $\pi_\alpha$ denotes nearest product state of $\alpha$. $T_\alpha, Q_\alpha, C_\alpha$ are the total, quantum and classical correlation in $\alpha$ respectively. The picture is adopted form the paper [99]. ............... 27
1.3 Pictorial representation of the state merging protocol. The picture has been taken from [28] ......................... 33
1.4 A pictorial representation of Maxwell’s experiment. In the picture blue molecules have higher average velocity and red ones have lower average velocity. ................................. 34
1.5 A pictorial representation of Maxwell’s experiment. In the picture blue molecules have higher average velocity and red ones have lower average velocity. ................................. 34
2.1 $10^5$ simulation shows about 66% violation of monogamy for the generic class $\mathcal{A}$. The red line marks the departure from monogamy. .................................................. 48
3.1 Monotonic nature of decay of MIN (or discord) for the initial pure two-qubit state under independent depolarizing noise. For $\alpha = 0$ or $1$ MIN remains zero always .................. 58
3.2 Monotonic nature of decay of MIN (or discord) for Werner state under independent depolarizing noise. For $\alpha = 0$ or $1$ MIN remains zero always .................. 58
3.3 The nature of decay of MIN for the pure initial state under independent dephasing noise. MIN for $\alpha = 0.5$ does not vanishes even in infinite time ................................. 59
3.4 The nature of decay of geometric discord for the pure initial state under independent dephasing noise. While the value of discord decays monotonically for all $\alpha$ ................................. 59
3.5 The nature of decay of MIN for Werner state under independent dephasing noise. .......................... 60

3.6 The nature of decay of geometric discord for Werner state under independent dephasing noise. .......................... 60

3.7 Monotonic nature of decay of geometric discord and MIN respectively for the Werner state under independent generalized amplitude damping for $p = 1, 0.5, 0.6$ respectively. The white curve in the figures of discord shows its changing nature while the decay of MIN remains smooth. .......................... 62

3.8 Monotonic nature of decay of geometric discord and MIN respectively for the pure state under independent generalized amplitude damping for $p = 1, 0.5, 0.67$ respectively. Discord shows its changing nature while MIN remains smooth. .......................... 63

3.9 Monotonic nature of decay of MIN for two-qubit pure state assuming simultaneous action of both dephasing and amplitude damping channels ($p = 1$) on each qubit. .......................... 64

3.10 Monotonic nature of decay geometric discord for two-qubit pure state assuming simultaneous action of both dephasing and amplitude damping channels ($p = 1$) on each qubit. .......................... 64

3.11 Comparison of the rate of decay of MIN for the Bell state $|\phi^+\rangle$ under the three decoherence channels. .......................... 65

3.12 Comparison of the rate of decay of MIN and discord under three types of decoherence channels for initial state $\rho_3$ at $\alpha = 0.25$. 65

3.13 Evolution of (a) MIN and (b) geometric discord respectively for amplitude damping noise for pure initial state $\sqrt{1-\alpha}|00\rangle + \sqrt{\alpha}|11\rangle$. Here we take Lorentzian spectral function for qubit environment coupling. We plot both the MIN and geometric discord for a fixed coupling bandwidth $\lambda = 0.1\gamma$ and fixed central frequency $\omega = \gamma$. The time axis is in the units of $1/\gamma$. Discontinuity nature of discord is also revealed from this dynamics. .......................... 68

3.14 Evolution of (a) MIN and (b) geometric discord respectively for phase damping noise for pure initial state $\sqrt{1-\alpha}|00\rangle + \sqrt{\alpha}|11\rangle$. Here we take Lorentzian spectral function for qubit environment coupling as previous case. We plot both the MIN and geometric discord for a fixed coupling bandwidth $\lambda = 0.1\gamma$ and fixed detuning $\Delta = 0.01\gamma$. The time axis is in the units of $1/\gamma$. This dynamics also reveals discontinuous nature of discord. 69

4.1 Pictorial representation of phase estimation. The picture has been adapted from [58] .......................... 74
4.2 Region plot in $f \hat{f}$-plane of the eigenvalue of $W$ in two-qutrit orthogonal invariant class. Both the regions are enclosed by the constraints (4.23). First figure shows the shaded region where $b_1 c_1 \geq 0$ and second one shows the shaded region where $b_1 c_1 < 0$. Hence in the first region $U_A = \frac{2}{3} - 2(3a_1^2 + 2b_1 c_1 + 2a_1 b_1 + 2a_1 c_1)$ and in the second $U_A = \frac{2}{3} - 2(3a_1^2 - 2b_1 c_1 + 2a_1 b_1 + 2a_1 c_1)$. 

4.3 LQU for Werner class of states in two-qutrit system for suitable parameter range of $b$. The class is obtained by putting $c = 0$ in (4.17). The highest value of $U_A$ reaches 0.5. 

4.4 LQU for Isotropic class of states in two-qutrit system for suitable range of the parameter $c$. The class is obtained by putting $b = 0$ in (4.17). The highest value of $U_A$ reaches 0.66 in this case. 

4.5 Comparison of upper bound of Discord and Negativity for a subclass of $O \otimes O$ invariant states with $a = \frac{1}{n^2}$ for $n = 3$. We choose the range of $b$ as $-\frac{1}{n^2} \leq b \leq -\frac{1}{n^2(n-1)}$ and $b + c = 0$. Positivity constraints fix the range of $b$ in $[-\frac{1}{9}, \frac{1}{18}]$. In this case the only negative eigenvalue of $\rho^T_A$ is $\frac{1}{n^2} + nb + c$. 

4.6 Comparison of lower bound of Discord and Negativity for a subclass of $O \otimes O$ invariant states with $a = \frac{1}{n^2}$ for $n = 3$. We choose the range of $b$ as $-\frac{1}{n^2} \leq b \leq -\frac{1}{n^2(n-1)}$ and $b + c = 0$. Positivity constraints fix the range of $b$ in $[-\frac{1}{9}, \frac{1}{18}]$. In this case the only negative eigenvalue of $\rho^T_A$ is $\frac{1}{n^2} + nb + c$. 

5.1 The figure shows the region corresponding to $w_{11} \geq w_{33}$ and $w_{33} \geq w_{11}$. The dotted upper boundary curve indicates the value of $\lambda_{\text{max}}$. The two marked red points indicate the minimum value of $\lambda_{\text{max}}$ in those regions and hence the points corresponds to the solution of the optimization problem, i.e., maximum LQU. 

5.2 Nature of entanglement as measured by negativity $N$ and uncertainty gap $\Delta$ for the states $\chi$. Both curve shows monotonic behavior. In fact maximum uncertainty gap is achieved at $\varepsilon = 1$. Uncertainty gap increases as $\varepsilon \to 1$ but negativity decreases. At $\varepsilon \approx 0.714$, both becomes equal and then negativity further decays to zero but $\Delta$ increases up to its maximum.