Complementarity between tripartite quantum correlation and bipartite Bell inequality violation in three qubit states

Avijit Misra
IMSc, Chennai

YOUNG QUANTUM

Harish-Chandra Research Institute
Allahabad, India

February 28, 2017

Plan of the talk

- Motivation of the study

Plan of the talk

- Motivation of the study
- Bipartite Bell inequality violation in three qubit states

Plan of the talk

- Motivation of the study
- Bipartite Bell inequality violation in three qubit states
- Tangle vs bipartite Bell inequality violation

Plan of the talk

- Motivation of the study
- Bipartite Bell inequality violation in three qubit states
- Tangle vs bipartite Bell inequality violation
- GGM vs bipartite Bell inequality violation

Plan of the talk

- Motivation of the study
- Bipartite Bell inequality violation in three qubit states
- Tangle vs bipartite Bell inequality violation
- GGM vs bipartite Bell inequality violation
- Discord monogamy score vs bipartite Bell inequality violation

Plan of the talk

- Motivation of the study
- Bipartite Bell inequality violation in three qubit states
- Tangle vs bipartite Bell inequality violation
- GGM vs bipartite Bell inequality violation
- Discord monogamy score vs bipartite Bell inequality violation
- Conclusion

Plan of the talk

- Motivation of the study
- Bipartite Bell inequality violation in three qubit states
- Tangle vs bipartite Bell inequality violation
- GGM vs bipartite Bell inequality violation
- Discord monogamy score vs bipartite Bell inequality violation
- Conclusion

P. Pandya, AM, I. Chakrabarti, PRA **94**, 052126, 2016

Motivations

- Nonlocality $\rightarrow$ key resource for key distribution, quantum randomness generation etc.

Motivations

- Nonlocality $\rightarrow$ key resource for key distribution, quantum randomness generation etc.
- Linking quantum correlations and nonlocality in multiparty systems $\rightarrow$ important yet challenging problem.
  Horodecki *et al.*, PLA, **222**, 21 (1996)

Motivations

- Nonlocality $\rightarrow$ key resource for key distribution, quantum randomness generation etc.
- Linking quantum correlations and nonlocality in multiparty systems $\rightarrow$ important yet challenging problem.
  Horodecki *et al.*, PLA, **222**, 21 (1996)
- Statistics of two or one body $\rightarrow$ crucial for $\rightarrow$ many body nonlocality and entanglement criterion.
  J. Tura *et al.*, Science **344**, 1256 (2014)

Bell-CHSH inequality violation *Horodecki et al., PLA, **200**, 340 (1995)*

For an arbitary two-qubit state, ρ, maximum Bell-CHSH $\mathcal{S}_\rho$ value

$$\mathcal{S}_\rho = 2\sqrt{M(\rho)}$$

Bell-CHSH inequality violation *Horodecki et al., PLA*, **200**, *340 (1995)*

For an arbitary two-qubit state, ρ, maximum Bell-CHSH $\mathcal{S}_\rho$ value

$$\mathcal{S}_\rho = 2\sqrt{M(\rho)}$$

$M(\rho) = m_1 + m_2$, with m_1 and m_2 being the two largest eigenvalues of $T_\rho^T T_\rho$

$$(T_\rho)_{ij} = Tr(\sigma_i \otimes \sigma_j \rho)$$

Bell-CHSH inequality violation *Horodecki* et al., *PLA*, **200**, *340 (1995)*

For an arbitary two-qubit state, ρ, maximum Bell-CHSH $\mathcal{S}_\rho$ value

$$\mathcal{S}_\rho = 2\sqrt{M(\rho)}$$

$M(\rho) = m_1 + m_2$, with m_1 and m_2 being the two largest eigenvalues of $T_\rho^T T_\rho$

$$(T_\rho)_{ij} = Tr(\sigma_i \otimes \sigma_j \rho)$$

violation of Bell-CHSH inequality

$$M(\rho) > 1$$

Bell-CHSH inequality violation Horodecki et al., PLA, **200**, 340 (1995)

For an arbitary two-qubit state, ρ, maximum Bell-CHSH $\mathcal{S}_\rho$ value

$$\mathcal{S}_\rho = 2\sqrt{M(\rho)}$$

$M(\rho) = m_1 + m_2$, with m_1 and m_2 being the two largest eigenvalues of $T_\rho^T T_\rho$

$$(T_\rho)_{ij} = Tr(\sigma_i \otimes \sigma_j \rho)$$

violation of Bell-CHSH inequality

$$M(\rho) > 1$$

The amount of Bell-CHSH inequality violation$=\mathcal{B}(\rho_{AB}) = \max\{0, M(\rho_{AB}) - 1\}$

Monogamy of Bell Inequality Violation

B. Toner et al., arXiv:quant-ph/0611001

For a three qubit quantum state, if the quantum state shared by any two subparts of the three party system leads to the Bell inequality violation, then it precludes its violation for the states which the two subparts share with the third party of the tripartite system.

Monogamy of Bell Inequality Violation

B. Toner et al., arXiv:quant-ph/0611001

For a three qubit quantum state, if the quantum state shared by any two subparts of the three party system leads to the Bell inequality violation, then it precludes its violation for the states which the two subparts share with the third party of the tripartite system.

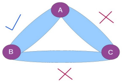


Figure: Monogamy of Bell inequality violation.

Monogamy of Bell Inequality Violation

B. Toner et al., arXiv:quant-ph/0611001

For a three qubit quantum state, if the quantum state shared by any two subparts of the three party system leads to the Bell inequality violation, then it precludes its violation for the states which the two subparts share with the third party of the tripartite system.

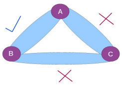


Figure: Monogamy of Bell inequality violation.

$$\mathcal{B}(\psi) = \max\{\mathcal{B}(\rho_{AB}), \mathcal{B}(\rho_{BC}), \mathcal{B}(\rho_{AC})\}$$

Genuinely entangled three qubit pure states *PRA* **62**, *062314 (2000)*

$$|\psi\rangle_{GHZ} = \sqrt{K}\left(c_\delta|000\rangle + s_\delta e^{i\phi}|\varphi_A\rangle|\varphi_B\rangle|\varphi_C\rangle\right)$$

Genuinely entangled three qubit pure states PRA **62**, 062314 (2000)

$$|\psi\rangle_{GHZ} = \sqrt{K}\left(c_\delta|000\rangle + s_\delta e^{i\phi}|\varphi_A\rangle|\varphi_B\rangle|\varphi_C\rangle\right)$$

c_δ and s_δ stand for cos δ and sin δ respectively

$K = \left(1 + c_\alpha c_\beta c_\gamma c_\phi s_{2\delta}\right)^{-1}$ is the normalizing constant

$|\varphi_A\rangle = c_\alpha|0\rangle + s_\alpha|1\rangle$,$|\varphi_B\rangle = c_\beta|0\rangle + s_\beta|1\rangle$,$|\varphi_C\rangle = c_\delta|0\rangle + s_\delta|1\rangle$

$\alpha, \beta, \gamma \in (0, \pi/2]$, $\delta \in (0, \pi/4]$ and $\phi \in [0, 2\pi)$

Genuinely entangled three qubit pure states *PRA* **62**, *062314 (2000)*

$$|\psi\rangle_{GHZ} = \sqrt{K}\left(c_\delta|000\rangle + s_\delta e^{i\phi}|\varphi_A\rangle|\varphi_B\rangle|\varphi_C\rangle\right)$$

c_δ and s_δ stand for $\cos\delta$ and $\sin\delta$ respectively

$K = \left(1 + c_\alpha c_\beta c_\gamma c_\phi s_{2\delta}\right)^{-1}$ is the normalizing constant

$|\varphi_A\rangle = c_\alpha|0\rangle + s_\alpha|1\rangle$,$|\varphi_B\rangle = c_\beta|0\rangle + s_\beta|1\rangle$,$|\varphi_C\rangle = c_\delta|0\rangle + s_\delta|1\rangle$

$\alpha, \beta, \gamma \in (0, \pi/2]$, $\delta \in (0, \pi/4]$ and $\phi \in [0, 2\pi)$

$$|\psi\rangle_{GHZ^R} = \sqrt{K}\left(c_\delta|000\rangle + s_\delta|\varphi_A\rangle|\varphi_B\rangle|\varphi_C\rangle\right)$$

Genuinely entangled three qubit pure states PRA **62**, 062314 (2000)

$$|\psi\rangle_{GHZ} = \sqrt{K}\left(c_\delta|000\rangle + s_\delta e^{i\phi}|\varphi_A\rangle|\varphi_B\rangle|\varphi_C\rangle\right)$$

c_δ and s_δ stand for $\cos\delta$ and $\sin\delta$ respectively

$K = \left(1 + c_\alpha c_\beta c_\gamma c_\phi s_{2\delta}\right)^{-1}$ is the normalizing constant

$|\varphi_A\rangle = c_\alpha|0\rangle + s_\alpha|1\rangle$,$|\varphi_B\rangle = c_\beta|0\rangle + s_\beta|1\rangle$,$|\varphi_C\rangle = c_\delta|0\rangle + s_\delta|1\rangle$

$\alpha, \beta, \gamma \in (0, \pi/2]$, $\delta \in (0, \pi/4]$ and $\phi \in [0, 2\pi)$

$$|\psi\rangle_{GHZ^R} = \sqrt{K}\left(c_\delta|000\rangle + s_\delta|\varphi_A\rangle|\varphi_B\rangle|\varphi_C\rangle\right)$$

$$|\psi\rangle_W = \frac{1}{\sqrt{\mathcal{W}}}\left(\sqrt{d}|000\rangle + \sqrt{a}|001\rangle + \sqrt{b}|010\rangle + \sqrt{c}|100\rangle\right)$$

$\mathcal{W} = (a + b + c + d)$ is the normalizing constant

$a, b, c > 0$ and $d = 1 - (a + b + c) \geq 0$.

Tangle vs Bell inequality violation

$$\tau(\psi_{ABC}) = C^2_{A:BC} - C^2_{AB} - C^2_{AC}.$$

$$C(\rho_{AB}) = \max\{0, \lambda_1 - \lambda_2 - \lambda_3 - \lambda_4\},$$

λ_i are the square roots of the eigenvalues of $\rho_{AB}\tilde{\rho}_{AB}$ in decreasing order,

$\tilde{\rho}_{AB} = (\sigma_y \otimes \sigma_y)\rho^*_{AB}(\sigma_y \otimes \sigma_y)$; ρ^*_{AB} in computational basis.

CKW, PRA **61**, 052306 (2000)

Tangle vs Bell inequality violation

Theorem: If the tangle of a three qubit pure state $|\psi\rangle_{GHZ^R}$ $(/|\psi\rangle_W)$ is equal to the tangle of another three qubit pure state $|\psi\rangle_m$, i.e., $\tau(\psi_{GHZ^R}/\psi_W) = \tau(\psi_{\mathrm{m}})$, then the bipartite Bell inequality violations necessarily follow,

$$\mathcal{B}(\psi_m) \geq \mathcal{B}(\psi_{GHZ^R}/\psi_W).$$

$$|\psi\rangle_m = \frac{|000\rangle + |111\rangle + m(|010\rangle + |101\rangle)}{\sqrt{2+2m^2}}, \text{ where } m \in [0,1]$$

The maximally Bell inequality violating state (MBV)

Tangle vs Bell inequality violation

Theorem: If the tangle of a three qubit pure state $|\psi\rangle_{GHZ^R}$ $(/|\psi\rangle_W)$ is equal to the tangle of another three qubit pure state $|\psi\rangle_m$, i.e., $\tau(\psi_{GHZ^R}/\psi_W) = \tau(\psi_\mathrm{m})$, then the bipartite Bell inequality violations necessarily follow,

$$\mathcal{B}(\psi_m) \geq \mathcal{B}(\psi_{GHZ^R}/\psi_W).$$

$|\psi\rangle_m = \frac{|000\rangle+|111\rangle+m(|010\rangle+|101\rangle)}{\sqrt{2+2m^2}}$, where $m \in [0,1]$

The maximally Bell inequality violating state (MBV)

$$\mathcal{B}(\psi) + \tau(\psi) \leq 1$$

Complementary relation: Tangle

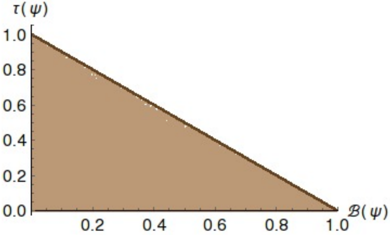


Figure: Complementary relation between tangle and bipartite Bell inequality violation.

Conjecture proved! :-)

PRL **118,** 010401 (2017) PHYSICAL REVIEW LETTERS week ending 6 JANUARY 2017

Anisotropic Invariance and the Distribution of Quantum Correlations

Shuming Cheng[1,2] and Michael J. W. Hall[1]

[1]*Centre for Quantum Computation and Communication Technology (Australian Research Council), Centre for Quantum Dynamics, Griffith University, Brisbane QLD 4111, Australia*

[2]*Key Laboratory of Systems and Control, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Beijing 100190, People's Republic of China*

(Received 31 October 2016; published 5 January 2017; publisher error corrected 18 January 2017)

We report the discovery of two new invariants for three-qubit states which, similarly to the three-tangle, are invariant under local unitary transformations and permutations of the parties. These quantities have a direct interpretation in terms of the anisotropy of pairwise spin correlations. Applications include a universal ordering of pairwise quantum correlation measures for pure three-qubit states; trade-off relations for anisotropy, three-tangle and Bell nonlocality; strong monogamy relations for Bell inequalities, Einstein-Podolsky-Rosen steering inequalities, geometric discord and fidelity of remote state preparation (including results for arbitrary three-party states); and a statistical and reference-frame-independent form of quantum secret sharing.

DOI: 10.1103/PhysRevLett.118.010401

Extension to mixed states

$$\tau(\rho) = \min_{\{p_i, |\psi_i\rangle\}} \sum_i p_i \tau(\psi_i)$$

Extension to mixed states

$$\tau(\rho) = \min_{\{p_i, |\psi_i\rangle\}} \sum_i p_i \tau(\psi_i)$$

$\tau(\rho)$ by definition convex

Extension to mixed states

$$\tau(\rho) = \min_{\{p_i, |\psi_i\rangle\}} \sum_i p_i \tau(\psi_i)$$

$\tau(\rho)$ by definition convex

$$\begin{aligned} \mathcal{S}(\rho_{AB}) &= |\mathrm{Tr}[(O^m_{AB} \otimes I_C)\rho_{ABC}]| \\ &= \left| \sum_i p_i \left(\mathrm{Tr}[(O^m_{AB} \otimes I_C) \, |\psi^i_{ABC}\rangle\langle\psi^i_{ABC}|] \right) \right| \end{aligned}$$

Extension to mixed states

$$\tau(\rho) = \min_{\{p_i, |\psi_i\rangle\}} \sum_i p_i \tau(\psi_i)$$

$\tau(\rho)$ by definition convex

$$\begin{aligned}
\mathcal{S}(\rho_{AB}) &= \left|\mathrm{Tr}[(O^m_{AB} \otimes I_C)\rho_{ABC}]\right| \\
&= \left|\sum_i p_i \left(\mathrm{Tr}[(O^m_{AB} \otimes I_C)\,|\psi^i_{ABC}\rangle\langle\psi^i_{ABC}|]\right)\right|
\end{aligned}$$

$$\begin{aligned}
\mathcal{S}(\rho_{AB}) \leq & \quad \textstyle\sum_i p_i \left|\mathrm{Tr}[(O^m_{AB} \otimes I_C)\,|\psi^i_{ABC}\rangle\langle\psi^i_{ABC}|]\right| \\
= & \quad \textstyle\sum_i p_i \left|\mathrm{Tr}[O^m_{AB}\rho^i_{AB}]\right|
\end{aligned}$$

Extension to mixed states

$$\mathcal{S}(\rho_{AB}) \leq \sum_i p_i \left|\mathrm{Tr}[O_{AB}^{i,m}\rho_{AB}^i]\right| ,$$

$$\mathcal{S}\left(\sum_i p_i \rho_{AB}^i\right) \leq \sum_i p_i \mathcal{S}(\rho_{AB}^i)$$

Extension to mixed states

$$\mathcal{S}(\rho_{AB}) \leq \sum_i p_i \left| \mathrm{Tr}[O_{AB}^{i,m} \rho_{AB}^i] \right| ,$$

$$\mathcal{S}\left(\sum_i p_i \rho_{AB}^i\right) \leq \sum_i p_i \mathcal{S}(\rho_{AB}^i)$$

$$\sqrt{M\left(\sum_i p_i \rho_{AB}^i\right)} \leq \sum_i p_i \left(\sqrt{M(\rho_{AB}^i)}\right)$$

Extension to mixed states

$$\mathcal{S}(\rho_{AB}) \leq \sum_i p_i \left|\mathrm{Tr}[O_{AB}^{i,m} \rho_{AB}^{i}]\right| ,$$

$$\mathcal{S}\left(\sum_i p_i \rho_{AB}^{i}\right) \leq \sum_i p_i \mathcal{S}(\rho_{AB}^{i})$$

$$\sqrt{M\left(\sum_i p_i \rho_{AB}^{i}\right)} \leq \sum_i p_i \left(\sqrt{M(\rho_{AB}^{i})}\right)$$

$$\mathcal{B}(\rho_{AB}) \leq \quad \textstyle\sum_i p_i \mathcal{B}(\rho_{AB}^{i})$$

Extension to mixed states

$$\mathcal{S}(\rho_{AB}) \leq \sum_i p_i \left|\mathrm{Tr}[O_{AB}^{i,m} \rho_{AB}^{i}]\right| ,$$

$$\mathcal{S}\left(\sum_i p_i \rho_{AB}^{i}\right) \leq \sum_i p_i \mathcal{S}(\rho_{AB}^{i})$$

$$\sqrt{M\left(\sum_i p_i \rho_{AB}^{i}\right)} \leq \sum_i p_i \left(\sqrt{M(\rho_{AB}^{i})}\right)$$

$$\mathcal{B}(\rho_{AB}) \leq \quad \textstyle\sum_i p_i \mathcal{B}(\rho_{AB}^{i})$$

Similarly, for ρ_{AC} and ρ_{BC}...

Extension to mixed states

$$
\begin{aligned}
\mathcal{B}(\rho_{AB}) &\leq \sum_i p_i \mathcal{B}(\rho^i_{AB}) \\
&\leq \sum_i p_i [\max\{\mathcal{B}(\rho^i_{AB}), \mathcal{B}(\rho^i_{BC}), \mathcal{B}(\rho^i_{AC})\}] \\
&\leq \sum_i p_i [\mathcal{B}(|\psi^i_{ABC}\rangle)]
\end{aligned}
$$

Extension to mixed states

$$
\begin{aligned}
\mathcal{B}(\rho_{AB}) \leq & \sum_i p_i \mathcal{B}(\rho^i_{AB}) \\
\leq & \sum_i p_i [\max\{\mathcal{B}(\rho^i_{AB}), \mathcal{B}(\rho^i_{BC}), \mathcal{B}(\rho^i_{AC})\}] \\
\leq & \sum_i p_i [\mathcal{B}(|\psi^i_{ABC}\rangle)]
\end{aligned}
$$

Therefore,

$$\mathcal{B}(\rho_{ABC}) \leq \sum_i p_i [\mathcal{B}(|\psi^i_{ABC}\rangle)]$$

Extension to mixed states

$$
\begin{aligned}
\mathcal{B}(\rho_{AB}) \leq & \sum_i p_i \mathcal{B}(\rho^i_{AB}) \\
\leq & \sum_i p_i [\max\{\mathcal{B}(\rho^i_{AB}), \mathcal{B}(\rho^i_{BC}), \mathcal{B}(\rho^i_{AC})\}] \\
\leq & \sum_i p_i [\mathcal{B}(|\psi^i_{ABC}\rangle)]
\end{aligned}
$$

Therefore,

$$\mathcal{B}(\rho_{ABC}) \leq \sum_i p_i [\mathcal{B}(|\psi^i_{ABC}\rangle)]$$

$$\mathcal{B}(\rho) + \tau(\rho) \leq 1$$

GGM vs Bell inequality violation

Generalized Geometric Measure of $|\psi_N\rangle$

$$\mathcal{G}(|\psi_N\rangle) = 1 - \Lambda^2_{max}(|\psi_N\rangle)$$

$\Lambda_{\mathrm{max}}(|\psi_N\rangle) = \mathrm{max}\,|\langle\chi|\psi_N\rangle|$, $|\chi\rangle$: $\rightarrow$ not genuinely multiparty entangled.

GGM vs Bell inequality violation

Generalized Geometric Measure of $|\psi_N\rangle$

$$\mathcal{G}(|\psi_N\rangle) = 1 - \Lambda^2_{max}(|\psi_N\rangle)$$

$\Lambda_{\max}(|\psi_N\rangle) = \max |\langle\chi|\psi_N\rangle|$, $|\chi\rangle$: $\rightarrow$ not genuinely multiparty entangled.

$$\mathcal{G}(|\psi_n\rangle) = 1 - \max\{\lambda^2_{I:L} | I \cup L = \{A_1, \ldots, A_N\}, I \cap L = \emptyset\}$$

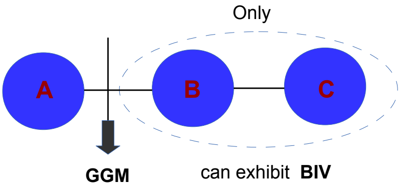
$\lambda_{I:L}$: $\rightarrow$ maximal Schmidt coefficient in the bipartite split $I : L$.

AUS, PRA **81**, 012308 (2010)

T. Das *et al.*, PRA **94**, 022336 (2016)

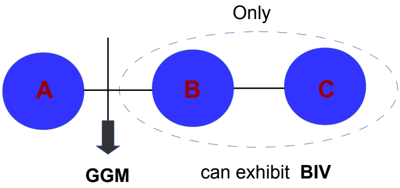
GGM vs Bell inequality violation

Lemma: If for a three qubit pure state $|\psi\rangle_{GHZ^R}$ $(/|\psi\rangle_W)$, the GGM is obtained from, say the $A:BC$ bipartite split, then the only reduced bipartite system of $|\psi\rangle_{GHZ^R}$ $(/|\psi\rangle_W)$ that can violate the Bell inequality is ρ_{BC}.



GGM vs Bell inequality violation

Lemma: If for a three qubit pure state $|\psi\rangle_{GHZ^R}$ $(/|\psi\rangle_W)$, the GGM is obtained from, say the $A:BC$ bipartite split, then the only reduced bipartite system of $|\psi\rangle_{GHZ^R}$ $(/|\psi\rangle_W)$ that can violate the Bell inequality is ρ_{BC}.



See also K. Sharma *et al.* PRA **93**, 062344 (2016)

GGM vs Bell inequality violation

Theorem: If the GGM of a three qubit pure state $|\psi\rangle_{GHZ^R}$ $(/|\psi\rangle_W)$ is equal to the GGM of another three qubit pure state $|\psi\rangle_m$, i.e., $\mathcal{G}(\psi_{GHZ^R}/\psi_W) = \mathcal{G}(\psi_{\mathrm{m}})$, then the bipartite Bell inequality violations necessarily follow,

$$\mathcal{B}(\psi_m) \geq \mathcal{B}(\psi_{GHZ^R}/\psi_W).$$

$$|\psi\rangle_m = \frac{|000\rangle + |111\rangle + m(|010\rangle + |101\rangle)}{\sqrt{2+2m^2}}, \text{ where } m \in [0,1]$$

The maximally Bell inequality violating state (MBV)

GGM vs Bell inequality violation

Theorem: If the GGM of a three qubit pure state $|\psi\rangle_{GHZ^R}$ $(/|\psi\rangle_W)$ is equal to the GGM of another three qubit pure state $|\psi\rangle_m$, i.e., $\mathcal{G}(\psi_{GHZ^R}/\psi_W) = \mathcal{G}(\psi_\mathrm{m})$, then the bipartite Bell inequality violations necessarily follow,

$$\mathcal{B}(\psi_m) \geq \mathcal{B}(\psi_{GHZ^R}/\psi_W).$$

$|\psi\rangle_m = \frac{|000\rangle+|111\rangle+m(|010\rangle+|101\rangle)}{\sqrt{2+2m^2}}$, where $m \in [0,1]$

The maximally Bell inequality violating state (MBV)

$$\mathcal{B}(\psi) + 4\mathcal{G}(\psi)\left(1 - \mathcal{G}(\psi)\right) \leq 1$$

Complementary Relation: GGM

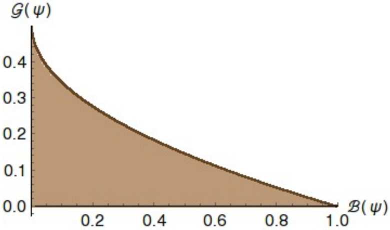


Figure: Complementary relation between GGM and bipartite Bell inequality violation.

DMS vs Bell inequality violation

Quantum Discord

The difference of total correlation and classical correlation

Total Correlation is quantified by the mutual information

$$
\begin{aligned}
I(\rho_{AB}) &= S(\rho_A) + S(\rho_B) - S(\rho_{AB}) \\
&= S(\rho_{AB}||\rho_A \otimes \rho_B)
\end{aligned}
$$

$S(\rho) = -\mathrm{tr}(\rho \log \rho)$

$S(\rho||\sigma) = -S(\rho) - \mathrm{tr}(\rho \log \sigma)$

The classical correlation is given in terms of the measured conditional entropy

$$J(\rho_{AB}) = S(\rho_A) - S(\rho_{A|B})$$

DMS vs Bell inequality violation

$$J(\rho_{AB}) = \max_{\{P_i\}} I(\rho'_{AB}),$$

$$\rho'_{AB} = \sum_i (\mathbb{I}_A \otimes P_i)\rho_{AB}(\mathbb{I}_A \otimes P_i)$$

Quantum Discord: $\rightarrow D(\rho_{AB}) = I(\rho_{AB}) - J(\rho_{AB})$.

DMS vs Bell inequality violation

$$J(\rho_{AB}) = \max_{\{P_i\}} I(\rho'_{AB}),$$

$$\rho'_{AB} = \sum_i (\mathbb{I}_A \otimes P_i)\rho_{AB}(\mathbb{I}_A \otimes P_i)$$

Quantum Discord: $\rightarrow D(\rho_{AB}) = I(\rho_{AB}) - J(\rho_{AB}).$

Discord Monogamy Score

DMS vs Bell inequality violation

$$J(\rho_{AB}) = \max_{\{P_i\}} I(\rho'_{AB}),$$

$$\rho'_{AB} = \sum_i (\mathbb{I}_A \otimes P_i)\rho_{AB}(\mathbb{I}_A \otimes P_i)$$

Quantum Discord: $\rightarrow D(\rho_{AB}) = I(\rho_{AB}) - J(\rho_{AB})$.

Discord Monogamy Score

$$\delta_D(|\psi\rangle_{ABC}) = D(|\psi\rangle_{A|BC}) - D(\rho_{AB}) - D(\rho_{AC})$$

J. Phys. A **34**, 6899 (2001); Phys. Rev. Lett. **88**, 017901 (2002)

Complementary Relation: DMS

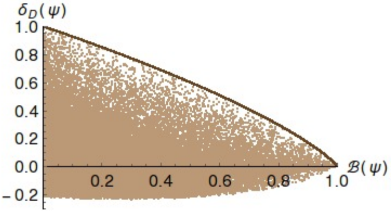


Figure: Complementary relation between discord monogamy score and bipartite Bell inequality violation.

Conclusion

- We have seen that there exists a complementary relation between genuine tripratite quantum correlations and bipartite Bell inequality violation in three qubit states

Conclusion

- We have seen that there exists a complementary relation between genuine tripratite quantum correlations and bipartite Bell inequality violation in three qubit states
- The MBV states $|\psi\rangle_m$, exhibit maximum Bell inequality violation for a fixed amount of genuine tripartite correlation


thanks!