Entanglement Transference and Non-Inertial Quantum Reference Frames

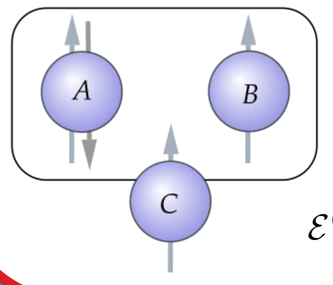
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Based on: arXiv:2603.23601



Perspectival QRFs

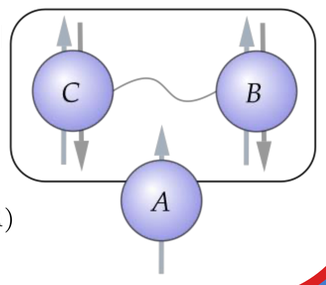
"How would a quantum observer perceive the Universe?"

- Perspectival approach to quantum reference frames describes states $|\psi\rangle$ relative to subsystem A as $|\psi\rangle^{(A)}$.
- What properties are invariant under QRF transformations?



Cepollaro *et al.* showed how entanglement and coherence are jointly conserved [1]:

$$\mathcal{E}^{(C)} + \mathcal{C}^{(C)} = \mathcal{E}^{(A)} + \mathcal{C}^{(A)}$$



How can we relate global states to perspectival states?

Consider the 3-qubit pure state:

$$|\psi\rangle_{ABC} = a\,|000\rangle + b\,|001\rangle + c\,|010\rangle + d\,|011\rangle + e\,|100\rangle + f\,|101\rangle + g\,|110\rangle + h\,|111\rangle$$

We propose the **Perspective Assigning Operation** [2] such that the state in the perspective of A is given by:

$$|\psi\rangle^{(A)}_{BC} = \sqrt{a^2+h^2}\,|00\rangle + \sqrt{b^2+g^2}\,|01\rangle + \sqrt{c^2+f^2}\,|10\rangle + \sqrt{d^2+e^2}\,|11\rangle$$

Entanglement Transference

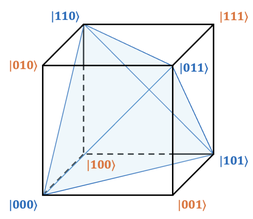
Consider:

- Entropy of **Entanglement:** $\mathcal{E}(\rho_{AB}) = \mathcal{S}(\rho_A)$
- Relative Entropy of **Coherence:** $\mathcal{C}(\rho_A) = \mathcal{S}(\rho_A) - \mathcal{S}(\rho_{A,\text{diag}})$
- Von Neumann entropy $\mathcal{S}(\rho) = -\text{Tr}(\rho \log \rho)$

Entanglement transference relates perspectival resources to global resources:

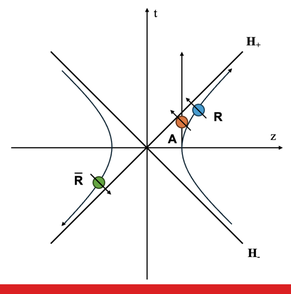
$$\mathcal{E}^{(A)}_{B,C} + \mathcal{C}^{(A)}_{B} = \mathcal{E}_{AB,C}$$

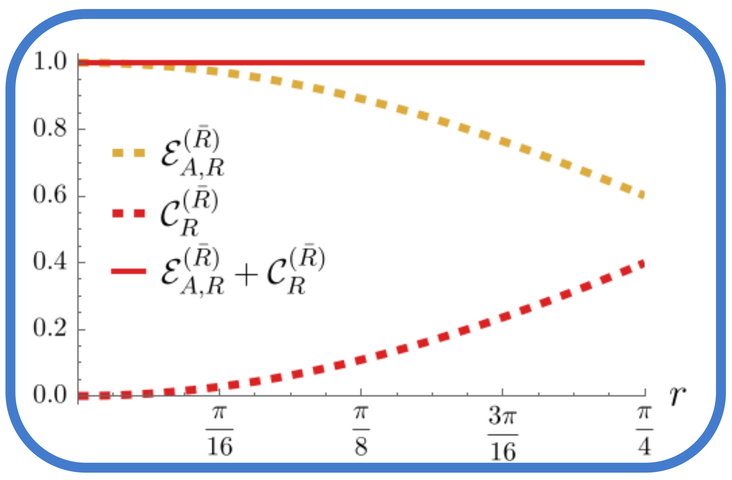
- Holds for (spin) parity states for 3-qubits,
- Appears to hold for more general entanglement and coherence quantifiers.



Entanglement Degradation

- One of the first results of RQI [2].
- Alice and Rob share a Bell state encoded in Minkowski field modes $|\phi\rangle \sim |00\rangle + |11\rangle$
- Rob undergoes uniform acceleration parametrized by r
- State in accelerated frame is $|\phi_r\rangle \sim \cos r|000\rangle + \sin r|011\rangle + |110\rangle$





Beyond this poster

- **Relativistic/Relational Quantum Resource Theory?**
- What might other quantum resources tell us about quantum gravity?
- How do perspectival resources relate to the standard 'global' quantities found in quantum information?
  - Entanglement Transference [2] offers a partial answer.
- How do these results translate beyond the perspectival approach to QRFs?

References

[1] C. Cepollaro, *et al.*, PRL 135, 010201 (2025) arXiv:2406.19448
[2] **E. A. Patterson**, Sijia Wang, and Robert B. Mann, arXiv:2603.23601 (2026)
[3] P. M. Alsing, *et al.*, PRA 74,032326 (2006) 10.1103/phys-reva.74.032326

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