Topological Aspects of Quantum Entanglement in Two Qubit Systems

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We present a constructive method to characterize topological properties and their connection to two-qubit quantum entanglement, in the framework of the tenfold classification [1] and Wootters' concurrence [2,3], utilizing the Cartan decomposition. This is established for the 2-qubit system through the antiunitary time reversal (TR) operator. The TR operator identifies concurrence and differentiates between entangling and non-entangling operators. This inclusion or exclusion of certain operators is shown to alter topological characteristics. The tenfold classification description of the 2-qubit system unveils aspects of the connection between entanglement and a geometrical phase. Topological features are obtained systematically by a mapping to a quantum graph, allowing for a direct computation of topological integers and of the 2-qubit equivalent of topological zero-modes. We discuss extension of this new approach to condensed matter systems, including examples of indistinguishable fermions and arrays of quantum dots.

References

[1] C.-K. Chiu, J. C. Teo, A. P. Schnyder, and S. Ryu, Reviews of Modern Physics 88, 035005 (2016).
[2] S. Hill and W. K. Wootters, Physical Review Letters 78, 5022 (1997).
[3] W. K. Wootters, Physical Review Letters 80, 2245 (1998).