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Quantum state preparation and dynamical symmetries: Coherent laser-induced preparation of multipartite W- and GHZ-quantum states and their interconversion.

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Coherent laser-induced excitation processes based on timescale hierarchies offer interesting perspectives for the controlled and deterministic preparation of entangled multipartite quantum states. Greenberger-Horne-Zeilinger (GHZ) and W-states are prominent examples of such multipartite quantum states which constitute valuable resources for quantum information processing. Motivated by current experimental efforts aiming at the controlled preparation and interconversion of these quantum states in neutral-atom systems in the Rydberg-blockade regime, we explore the theoretical potential of Lie-algebraic methods and dynamical symmetries for achieving state preparation and inverconversion between these important classes of multipartite quantum states. It is demonstrated that these dynamical symmetry-based methods provide promising theoretical approaches for exploring and optimizing laser pulse sequences capable of achieving these state preparation and interconversion tasks efficiently [1]. Thus, these methods constitute powerful theoretical alternatives to other nowadays frequently used approaches, such as the ones based on Lewis-Riesenfeld invariants [2].

[1] Th. Haase, G. Alber, V. Stojanovic, Phys. Rev. A 103, 032427 (2021)
'Conversion from W to Greenberger-Horne-Zeilinger States in the Rydberg-Blockade Regime of Neutral-Atom Systems: Dynamical-Symmetry-Based Approach'.
[2] H. R. Lewis, W. B. Riesenfeld, J. Math. Phys. 10, 1458 (1969)
'An Exact Quantum Theory of the Time-Dependent Harmonic Oscillator and of a Charged Particle in a Time-Dependent Electromagnetic Field'.

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