Quantum Physics

Perfect state transfer of a qudit over underlying networks of group association schemes

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As generalizations of results of Christandl et al.\cite{8,9""} and Facer et al.\cite{Facer}, Bernasconi et al.\cite{godsil,godsil1} studied perfect state transfer (PST) between two particles in quantum networks modeled by a large class of cubelike graphs (e.g., the hypercube) which are the Cayley graphs of the elementary abelian group Z_2^n. In Refs. \cite{PST,psd}, respectively, PST of a qubit over distance regular spin networks and optimal state transfer (ST) of a d-level quantum state (qudit) over pseudo distance regular networks were discussed, where the networks considered there were not in general related with a certain finite group. In this paper, PST of a qudit over antipodes of more general networks called underlying networks of association schemes, is investigated. In particular, we consider the underlying networks of group association schemes in order to employ the group properties (such as irreducible characters) and use the algebraic structure of these networks (such as Bose-Mesner algebra) in order to give an explicit analytical formula for coupling constants in the Hamiltonians so that the state of a particular qudit initially encoded on one site will perfectly evolve to the opposite site without any dynamical control. It is shown that the only necessary condition in order to PST over these networks be achieved is that the centers of the corresponding groups be non-trivial. Therefore, PST over the underlying networks of the group association schemes over all the groups with non-trivial centers such as the abelian groups, the dihedral group D_{2n} with even n, the Clifford group CL(n) and all of the p-groups can be achieved.

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