Classification of Parameter-Dependent Quantum Integrable Models, Their Parameterization, Exact Solution, and Other Properties

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We study general quantum integrable Hamiltonians linear in a coupling constant and represented by finite NxN real symmetric matrices. The restriction on the coupling dependence leads to a natural notion of nontrivial integrals of motion and classification of integrable families into Types according to the number of such integrals. A Type M family in our definition is formed by N-M nontrivial mutually commuting operators linear in the coupling. Working from this definition alone, we parameterize Type M operators, i.e. resolve the commutation relations, and obtain an exact solution for their eigenvalues and eigenvectors. We show that our parameterization covers all Type 1, 2, and 3 integrable models and discuss the extent to which it is complete for other types. We also present robust numerical observation on the number of energy level crossings in Type M integrable systems and analyze the taxonomy of types in the 1d Hubbard model.

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