Convergence in numerical solutions of the Dicke Hamiltonian.

Miguel Angel Bastarrachea-Magnani and Jorge G. Hirsch
Instituto de Ciencias Nucleares, UNAM

The Dicke model describes N two-level atoms interacting with a single mode of radiation field within a cavity. The Hamiltonian is very simple but not exactly solvable, and continues to drive research into its properties. The ground state of the system suffers a quantum phase transition to a superradiant state when the atom-field interaction is varied. For a finite number of atoms N the model is only integrable in two limits: when the atom-field interaction is zero or when it is infinite. In general, the Hamiltonian eigenstates must be calculated numerically. Because the photon number within the cavity is not bounded, the dimensionality of the Hilbert space is infinite, and it is necessary to truncate it in order to perform a numerical diagonalization. In this work we study the minimum value for the truncation in the photon number which allows the numerical convergence for the ground state and for significative part of the energy spectra, as function of the atom-field coupling for different values of the atom number. We employ two different basis, corresponding to the exact eigenstates in both integrable limits of the model. The most interesting result is that the calculations done in the basis associated to the infinite interaction limit always converges within a smaller space than the other, even along the phase transition region and for small values of the interaction.