Generalized isotropic Lipkin-Meshkov-Glick models: ground state entanglement and quantum entropies

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We introduce a new class of generalized isotropic Lipkin–Meshkov–Glick models with $su(m+1)$ spin and long-range non-constant interactions, whose non-degenerate ground state is a Dicke state of $su(m+1)$ type. We evaluate in closed form the reduced density matrix of a block of L spins when the whole system is in its ground state, and study the corresponding von Neumann and Rényi entanglement entropies in the thermodynamic limit. We show that both of these entropies scale as $a \log L$ when L tends to infinity, where the coefficient a is equal to $(m-k)/2$ in the ground state phase with k vanishing $su(m+1)$ magnon densities. In particular, our results show that none of these generalized Lipkin–Meshkov–Glick models are critical, since when $L \to \infty$ their Rényi entropy R_q becomes independent of the parameter q. We have also computed the Tsallis entanglement entropy of the ground state of these generalized $su(m+1)$ Lipkin–Meshkov–Glick models, finding that it can be made extensive by an appropriate choice of its parameter only when $m-k \geq 3$. Finally, in the $su(3)$ case we construct in detail the phase diagram of the ground state in parameter space, showing that it is determined in a simple way by the weights of the fundamental representation of $su(3)$.