Removal of K Mixing in Angular Momentum Projected Nuclear Wave Functions

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Angular momentum projection plays a key role in studying quantum many-body systems with rotational invariance such as atomic nuclei. With given quantum numbers JM, one can generate $2J + 1$ angular momentum projected states labeled with $-J \leq K \leq J$ from a deformed Slater determinant. Usually, a nuclear wave function with K mixing can be expressed as a superposition of all these $2J + 1$ projected states, where the coefficients can be obtained by solving the generalized eigenvalue equation. In this work, we report a new fundamental feature that the frequently discussed K mixing in the angular momentum projected nuclear wave function can be safely removed. Strikingly, we found that such nuclear wave function with K mixing can always be well approximated by a single projected state with any given K. This simplification can further improve methods related to angular momentum projection in chemistry, atomic and nuclear physics, particularly offering significant advantages in dealing with high-spin states.