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Multiple multi-orbit fermionic and bosonic pairing and rotational SU(3) algebras

V.K.B. Kota

Physical Research Laboratory, Ahmedabad 380 009, Gujarat, India

Abstract

In nuclei with valence nucleons are say identical nucleons and say these nucleons occupy several-j orbits, then it is possible to consider pair creation operator S_+ to be a sum of the single-j shell pair creation operators $S_+(j)$ with arbitrary phases, $S_+ = \sum_j \beta_j S_+(j); \beta_j = \pm 1$. In this situation, it is possible to define multi-orbit or generalized seniority that corresponds to the quasi-spin $SU(2)$ algebra generated by S_+, $S_- = (S_+)^\dagger$ and $S_0 = (\hat{n} - \Omega)/2$ operators; $\hat{n}$ is number operator and $\Omega = [\sum_j (2j+1)]/2$. There are now multiple pairing quasi-spin $SU(2)$ algebras, one for each choice of β_j's. Clearly, with r number of j shells there will be 2^{r-1} quasi-spin $SU(2)$ algebras. Also, the β_j's and the generators of the corresponding generalized seniority generating sympletic algebras $Sp(2\Omega)$ in $U(2\Omega) \supset Sp(2\Omega)$ have one-to-one correspondence. Using these, derived is the condition that a general one-body operator of angular momentum rank k to be a quasi-spin scalar or a vector vis-a-vis the β_j's. These then will give special seniority selection rules for electromagnetic transitions. A particular choice for β_j's as advocated by Arvieu and Moszkowski (AM), based on SDI interaction, when applied to these conditions will give the selection rules discussed in detail in the past by Talmi. We found, using the correlation coefficient defined in the spectral distribution method of French, that the β_j choice of AM gives pairing Hamiltonians having maximum correlation with well known effective interactions. The various results derived for identical fermion systems are shown to extend to identical boson systems with the bosons occupying several-ℓ orbits as for example in sd, sp, sdg and $sdpf$ IBM's. The quasi-spin algebra here is $SU(1,1)$ and the generalized seniority quantum number is generated by $SO(2\Omega)$ in $U(2\Omega) \supset SO(2\Omega)$. The different pairing $SO(2\Omega)$ algebras in the interacting boson models along with the tensorial nature of $E2$ and $E1$ operators in these models with respect to the corresponding $SU(1,1)$ will be presented. These different $SO(2\Omega)$ algebras will be important in the study of quantum phase transitions and order-chaos transitions in nuclei. Finally, there are, for a given set of oscillator orbits, multiple rotational $SU(3)$ algebras both in shell model and IBM's and they will be briefly discussed in the talk.