The proton-phonon-neutron parabolic rule for odd-odd nuclei

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Previously formulated proton-neutron parabolic rule[1)] (referred to as the rule I) is extended here to a multiplet obtained by coupling a proton plus phonon multiplet to a neutron (or vice versa) $|I\rangle \equiv |(j_p, 12)J, j_n; I\rangle$ [2)]:

$$E(I) = \mathcal{E}_{(j_p,12)J} + \mathcal{E}_{j_n} + \delta E_2(I) + \delta E_1(I),$$

$$\delta E_2(I) = \delta E_2\left[(J,j_n)I\right] \times F_2(j_p,J) ,$$

$$\delta E_1(I) = \delta E_1\left[(J,j_n)I\right] \times F_1(j_p,J) .$$

Here, $\delta E_2\left[(J,j_n)I\right]$ is given as in the rule (I), with J entering in the same way as would a single particle of angular momentum J. The renormalization factor is

$$F_2(j_p,J) = (-)^{j_p-J} (2J+1)\begin{Bmatrix} j_p & j_p & 2 \\ J & J & 2 \end{Bmatrix} \frac{\langle j_p \| Y_2 \| j_p \rangle}{\langle J \| Y_2 \| J \rangle} .$$

Similarly,

$$F_1(j_p,J) = (-)^{j_p-J} (2J+1)\begin{Bmatrix} j_p & j_p & 1 \\ J & J & 2 \end{Bmatrix} \frac{\langle j_p \| \sigma \| j_p \rangle}{\langle J \| \sigma \| J \rangle} .$$

Also, the generalizations to the superfluid case and to the multiparticle case are straightforward. In the latter case,

$$\alpha_K = \alpha_K^{(o)} \frac{\langle (j_{1p})^n \, j_p \| T_K \| \, (j_p)^n \, j_p \rangle}{\langle j_p \| T_K \| j_p \rangle} ,$$

with K=1,2 and $T_1=\sigma$, $T_2=Y_2$. It is suggested that the parabolic rule should serve as a guideline in the classification of states in odd-odd nuclei.

1) V.Paar, Nucl.Phys. A331 (1979)16
2) V.Paar and S.Brant, Nucl.Phys., to be published