

TWO-CENTRE MOLECULE-LIKE STATES OF NUCLEI

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Recently a method has been developed for projecting two-centre wave functions of the generator coordinate method type onto eigenfunctions of angular momentum operators J^2 and J_z ¹⁾. The generator parameter is the distance \underline{S} between centres of potential wells of the two fragments ²⁾. This wave function, in which the antisymmetrization of coordinates of all nucleons in both fragments is exact, can be used to calculate bound states of nuclei in which one can expect a clustering of nucleons in two fragments.

The space is spanned by functions

$$\psi^{JM}(\underline{x}) = \sum_{\alpha K} \int d\underline{S} f_{\alpha K}^{JM}(\underline{S}) \phi_{\alpha K}^{JM}(\underline{x}, \underline{S}), \quad \underline{x} = (\underline{x}_1, \dots, \underline{x}_{A+B}),$$

$$\phi_{\alpha K}^{JM}(\underline{x}, \underline{S}) = \int d\Omega \mathcal{D}_{KM}^J(\Omega)^* R(\Omega) \phi_{\alpha}(\underline{x}, \underline{S})$$

where ϕ_{α} is a two-centre Slater determinant having nucleons in a particular configuration α . $R(\Omega)$ is the rotation operator that rotates the coordinates \underline{x} through the Euler angles Ω and \mathcal{D}_{KM}^J are its matrix representation. When functions $f_{\alpha K}^{JM}(\underline{S})$ are treated as variational parameters one gets for them the Hill-Wheeler equation of the following form

$$\sum_{\alpha' K'} \int d\underline{S}' [\langle \phi_{\alpha' K'}^{JM'}(\underline{S}') | H | \phi_{\alpha K}^{JM}(\underline{S}) \rangle - E \langle \phi_{\alpha' K'}^{JM'}(\underline{S}') | \phi_{\alpha K}^{JM}(\underline{S}) \rangle] f_{\alpha K}^{JM}(\underline{S}) = 0$$

This integral equation can be reduced to an integral equation in one dimension by expanding the kernels and the functions $f_{\alpha K}^{JM}(\underline{S})$ in terms of spherical harmonics and performing angular integrations ¹⁾. The resulting equation has been used to calculate molecule like states of ⁷Li treating it as a composite of two clusters ⁴He and ³H. Both fragments were described in terms of single particle functions. As the nuclear two-body interaction the Volkov effective two-body potential was used; Coulomb interactions were neglected.

In fig. 1 the results of the calculation of the ground state energy corresponding to the unprojected two-centre determinant (dash-dotted line) and the energies obtained by projecting angular momentum eigenstates from two-centre determinants with fixed magnitude of the generator parameter \underline{S} are shown (full line for $J=1/2, 3/2$ and dashed line for $J=5/2, 7/2$).

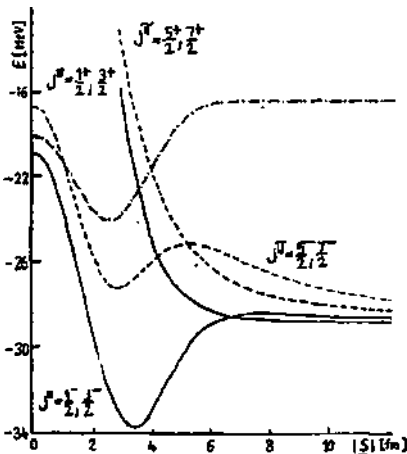


Fig. 1. Energy levels of ⁷Li.

References

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