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THREE-PARTICLE BINDING ENERGY and WAVE FUNCTION of 14A NUCLEI BASED on THE HH METHOD

As is known, light nuclei are well described by the shell model. However, the shell model does not take into account residual interactions between nucleons. It is the residual forces of proton-proton and neutron-neutron pairing that cause the zero spin of a nucleus whose shells are filled. We propose to apply a three-particle model for the ^{14}A nucleus, which we will consider as a system consisting of a ^{12}C core nucleus and two nucleons. The most acceptable approach to solving three-particle problems in nuclear physics is solving the Faddeev equation [1]. However, in the general case, one has to solve a system of two-dimensional differential or integral equations, which become more complicated when taking into account the Coulomb interaction between charged particles. From the point of view of simplicity of solving the problem of bound states of three particles, the method of hyperspherical functions [2,3] is the most convenient.
As an initial stage, we consider the ^{14}C=^{12}C+2n nucleus. We expand the desired three-particle wave function into a system of hyperspherical functions and additionally use the Rayleigh-Ritz variational principle:
$|\Psi^{J;\,J_z}\rangle = \sum_\mu c_\mu |\Psi^{J;\,J_z}_\mu\rangle \qquad (1),$
$\langle\delta\Psi^{J;\,J_z}|H-E|\Psi^{J;\,J_z}\rangle \qquad (2),$
where $\delta\Psi^{J;\,J_z}$ indicates the variation of $\Psi^{J;\,J_z}$ for arbitrary infinitesimal changes of the linear coefficients c_μ, μ is the index set. The problem of determining c_μ and the energy E is then reduced to a generalized eigenvalue and eigenvector problem of the matrix.The expansion states $|\Psi^{J;\,J_z}_\mu\rangle$ of Eq. (1) are then given by
$|\Psi^{J;\,J_z}_\mu\rangle = \rho^\mu Y_{\{G\}}(\Omega_5), \qquad (3)$
where ρ and $Y_{\{G\}}(\Omega_5)$ are hyperradius and hyperspherical function, respectively. Ω_5 is a five-dimensional solid angle. As a result, we obtain a system of linear equations for finding the energy and expansion coefficients:
$\sum_{K'L'S';l'_{x_1}\,l'_{y_1}\,\nu'}\Big[\langle KLS\,l_{x_1}\,l_{y_1}\nu|T-\kappa^2|K'L'S'l'_{x_1}\,l'_{y_1}\nu'\rangle\delta_{KK'}\delta_{LL'}\delta_{SS'}\delta_{l_xl'_x}\delta_{l_yl'_y}-\frac{2m}{\hbar^2}\langle KLSl_{x_1}\,l_{y_1}\nu|V_1+V_2+V_3|K'L'S'l'_{x_1}\,l'_{y_1}\nu'\rangle\Big]c^{l'_{x_1}\,l'_{y_1}}_{\nu'K'L'S'}=0. \qquad (4)$
$T=\frac{d^2}{d\rho^2}-\frac{K(K+4)+15/4}{\rho^2}$ is the hyperradial kinetic energy operator, $\kappa=\sqrt{\frac{2m}{\hbar^2}\epsilon}$ is a wave number for the bound state and V_1, V_2, V_3 are the interaction potentials between particles.
The calculations use the n-n potential from Ref.[4] and the ^{12}C-n potential (the Woods-Saxon) from Ref.[5], adjusted to describe low-energy data. We calculate the linear system of Eq. (4) and receive the following results for the ground state energy ($\epsilon_{^{12}C-2n}$) of ^{14}C=^{12}C+2n

Set of nn potentials	Our result for the binding energy (MeV)	Experimental value of the binding energy (MeV)
1 (Yukawa)	14.32	13.12
2 (Gaussian)	14.10	

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Section

Nuclear physics (Section 1)

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