Contribution ID: **230** Type: **Oral**

Electromagnetic properties of the 12C nucleus within the 3α model

Wednesday 2 July 2025 17:30 (20 minutes)

The aim of present work is to study electromagnetic properties of the 12C nucleus within the 3α cluster model. The αα- potentials of Ali-Bodmer [1] and BFW [2] are examined in describing the charge formfactor and root-mean square charge (RMS) radius of the carbon ground state. It was established that the l-independent Ali-Bodmer (AB) potential with a repulsive core yields a very strong underbinding with E=-0.60 MeV for the ground state energy Eexp=-7.27 MeV [3]. At the same time the application of the deep BFW αα -potential with two Pauli forbidden states in the S- wave and a single forbidden state in the D- wave is associated with a complicated problem of removal of Pauli forbidden states from the 3α- functional space. A variational method on symmetrized Gaussian basis is employed. For the elimination of the 3α Pauli forbidden states we use the direct orthogonalization method [4].

As was found in Ref. [4], there exist a special eigen state of the three-body projector(P), which plays a decisive role for the 0+ energy spectrum of the 12C nucleus. This critical eigen state of P^creates a ground state of 12C in a deep phase with the energy -19.90 MeV. Without this state, the 3α binding is too small and close to the results of the AB potential. The situation in the 2+ spectrum is similar.

In the present work, we estimate the charge formfactor and RMS radius of the 12C nucleus within the 3α cluster model using the AB and BFW potential models. In order to reproduce the experimental energy value of the 12C nucleus ground state, we preliminary add an attractive three-body potential (TBP) to the AB potential, while a repulsive TBP is employed for the BFW case.

The numerical results show that the model AB+TBP is able to reproduce approximately the position of qmin with an estimate of 1.67 fm-1 and the empirical value of Fch(max) with the estimate 1.31E-2 for the charge formfactor of the 12C nucleus. At the same time, the model BFW+TBP underestimates the second maximum of the Fch(q) by two order of magnitude. The position of the minimum is shifted to the right side with qmin =2.56 fm-1.

The estimate for the RMS radius is close to the experimental data within the model AB+TBP, while it is larger by about 30 % in the case of the BFW+TBP model.

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Primary authors: TURSUNOV, Ergash (INP, AS Uzbekistan); Mr SAIDOV, Matlub (INP, AS Uzbekistan)

Presenter: TURSUNOV, Ergash (INP, AS Uzbekistan)

Session Classification: 1. Experimental and theoretical studies of nuclei

Track Classification: Section 1. Experimental and theoretical studies of nuclei.