Three-nucleon calculations within the Bethe-Salpeter approach with separable kernel

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We investigate the relativistic properties of the three-nucleon bound system. We used covariant Bethe-Salpeter (BS) approach to achieve the goal. The relativistic analog of the Faddeev equation are considered in the BS formalism.

The nucleon-nucleon kernel is chosen to be in the separable form (rank I)

$$V(p_0, p, p_0^{'}, p^{'}) = \lambda g(p_0, p) g(p_0^{'}, p^{'})$$

In this case the two-particle T matrix has the following form

$$T(p_0, p, p_0^{'}, p^{'}; s) = \tau(s) g(p_0, p) g(p_0^{'}, p^{'})$$

where

$$\tau(s) = [\frac{1}{\lambda} - \frac{i}{4\pi^3}\int_{-\infty}^{\infty} dk^0 \int_0^{\infty} k^2 dk g^2(k^0, k) G(k^0, k; s)]^{-1}$$

and g is the form factor. We consider covariant relativistic Yamaguchi-type functions for the form factors:

$$g_Y(p_0, p) = \frac{1}{-p_0^2 + p^2 + \beta^2}.$$

In this case the system of the integral equations for the three-nucleon wave function has the following form

$$\Phi_j(q_4, q) = -\frac{1}{4\pi^3}\sum_{j'=1}^{2}\int_{-\infty}^{\infty} dq_4^{'} \int_0^{\infty} q^{'2} dq^{'} Z_{jj'}(iq_4, q; iq_4^{'}, q^{'}; s) \frac{\tau_{j'}[(\frac{2}{3}\sqrt{s} + iq_4^{'})^2 - q^{'2}]}{(\frac{1}{3}\sqrt{s} - iq_4^{'})^2 - q^{'2} - m^2} \Phi_{j'}(q_4^{'}, q^{'}),$$

where j=$^1S_0$,$^3S_1$, and Z is the so-called effective energy-dependent potential

$$Z_{jj'}(iq_4, q; iq_4^{'}, q^{'}; s) = C_{jj'}\int_{-1}^{1} d(cos\vartheta_{qq'}) \frac{g_j(-\frac{1}{2}q^0 - q^{0'}, |\frac{1}{2}\mathbf{q} + \mathbf{q}^{'}|) g_j(q^0 + \frac{1}{2}q^{0'}, |\mathbf{q} + \frac{1}{2}\mathbf{q}^{'}|)}{(\frac{1}{3}\sqrt{s} + q^0 + q^{0'})^2 - (|\mathbf{q} + \mathbf{q}^{'}|)^2 - m^2},$$

with $C_{jj'}$ is spin and isospin recoupling-coefficient matrix.

To solve the system of integral equations the Gaussian quadrature method is used. The mappings for the variable of integration $[0, \infty)$ and $(-\infty, \infty)$ to $[-1, 1]$ interval are used. The considered quadrature system allows to transfer the homogeneous system of integral equations to linear algebraic equations which can be solved using the programming language FORTRAN.

In the report the results for the $^1S_0$ and $^3S_1$ waves in the three-nucleon bound state wave-function are considered on the q_4 and q variables.