The effect of the negative component of the two nucleon system.

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Relativistic dynamics of the nuclear physics becomes important for high momentum phenomena, in particular for those associated spin observables. Furthermore, for the phenomena where pions appear, the relativistic treatment is essential, since the fundamental chiral symmetry is related to the relativistic nature of particles. The starting point of the relativistically covariant theory is the Bethe-Salpeter equation for the two nucleon system. In order to overcome a difficulty of solving the integral equation, a separable interaction is often employed, primarily as a mathematical manipulation [1].

In the present study, we investigate the effect of the negative energy state of the two nucleon system. Considering the two nucleon system in a relativistic work, we have ${}^3S_1^{++}$, ${}^3D_1^{++}$, ${}^3S_1^{--}$, ${}^3D_1^{--}$, ${}^1P_1^e$, ${}^1P_1^o$, ${}^3P_1^e$, ${}^3P_1^o$ states, where s is the spin, L is the angular momentum, J is the total momentum, ρ is the ρ-spin in ${}^{2s+1}L_J^\rho$).[3] Here the negative energy states, ${}^3S_1^{--}$, ${}^3D_1^{--}$, ${}^1P_1^e$, ${}^1P_1^o$, ${}^3P_1^e$ and ${}^3P_1^o$, appeared. This is the special character of the relativistic approach. We solve the Bethe-Salpeter equation,

$$T_{\alpha\beta}(k',k;s) = V_{\alpha\beta}(k',k;s) + \frac{i}{4\pi^3}\int d^4q \sum_{\gamma\delta} V_{\alpha\gamma}(k',q;s)S_{\gamma\delta}(q;s)T_{\delta\beta}(q,k;s)\,,$$

where k', k, q are the four momenta of the two nucleon, T the T-matrix, V the interaction kernel, S the two nucleon propagator [4], s the square of the total momentum, α and β express the ${}^3S_1^{++}$-state. The summation over γ, δ is done for the all eight state. We use the rank I separable ansatz for V

$$V_{\alpha\beta}(k',k;s) = \lambda\, g^\alpha(k')\, g^\beta(k),$$

then T-matrix can be expressed by

$$T_{\alpha\beta}(k',k;s) = \tau(s)\, g^\alpha(k')\, g^\beta(k)\,,$$

where the function g is the arbitary function of the four momentum. Here we use Yamaguchi type potential which includes the unkown parameters, and λ is also the unkown parameter. Now we can obtain the solution of the Bethe-Salpeter equation easily. We apply this formalism for the deuteron, which consist from the proton and the neutron. We determine the unknown parameters which can reproduce the phase shifit of the ${}^3S_1$-state, the binding ernergy and the low energy parameters, then we obtain the ratio of the wave function of the each partial wave states.

As a result, it turns out that the ratio of the negative energy states, which are included in the two nucleon system, is -0.01078%. At the same time, we calculate the influence of the negative energy states for the magnatic moment. If we include the nagative energy states, the value is 0.8576. Without the nagative energy states, the value is 0.8575. We can conclude that the influence of the nagative energy states for the magnatic moment is quite small.

In the present study, we have demonstrated the simplest case where we use the rank I separable interaction to solve Bethe-Salpeter Equation. In principle, if we introduce more terms for the separable interaction, it is possible to reproduce the character of the two nucleon in the high energy region better, where the relativistic effect must play the important role. Such a work is now in progress.

References

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