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Derivation of relativistic Yakubovsky equations under Poincare invariance

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Recently, higher chiral-order nucleon-nucleon potentials have been developed with the chiral effective fields theory [1]. The three-body Faddeev equation had been extended by involving three-body forces [2]. The four-body Yakubovsky equations have also been extended as well [3]. In order to increase the accuracy of not only its two-body forces but also three-body forces, it is indispensable to study not only three-body systems but also four-nucleon systems using ab initio calculation.

Moreover, it is not ignorable that the effect of relativity in high energy region. We have been studying that in the proton-deuteron scattering the effect reveals at the backward of the scattering angle for the elastic process and three-body breakup [4]. It is, of course, expected that such a relativistic effect also appears in case of four-nucleon system.

I would like briefly to present my oral that I explain the Faddeev-Yakubovsky four-body equations including the three-body force [3]. Furthermore, these equations are extended in the framework of relativity. As the result we have the following coupled equations with three-body force W,
$\alpha = -G_0TPP_{34}\alpha + G_0TP\beta + (G_0 + G_0T)(G_0 + G_0t^{\alpha})W(-P_{34}P + \tilde{P})(\alpha - P_{34}\alpha + \beta)$,
$\beta = G_0\tilde{T}\tilde{P}G_0(1 - P_{34})\alpha$,
where α and β are Yakubovsky components for 1+3 and 2+2 partitions, respectively, G_0 is Green's function, $T, \tilde{T}$ are transition matrices for 1+3 and 2+2 partitions, respectively. $P(\equiv P_{12}P_{23} + P_{13}P_{23})$, $\tilde{P}(\equiv P_{13}P_{24})$ and P_{34} are permutation operators. Detail is written in [3]. In particular, these transition matrices are the solutions of the following equations,
$T = \tau + \tau G_0 T$,
$\tau \equiv t^{\alpha}P + (1 + t^{\alpha}G_0)W(1 + P)$,
$\tilde{T} = t^{\beta} + \tilde{T}\tilde{P}G_0t^{\beta}$,
where t^{α} and t^{β} are 2-body transition matrix which are relativistically boosted depending on the partition sub-systems in the four-body system.

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