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Three-Nucleon Forces within the Representation of Clothed Particles

We will show a detailed derivation of matrix elements (in momentum space) of the three-nucleon interaction operator [1] built up within the field theoretical approach based on the method of unitary clothing transformations (UCTs) [2,3,4]. As before, we start from the instant form of relativistic dynamics after Dirac with the total field Hamiltonian H for Yukawa-type couplings between $\pi-$, $\eta-$, $\delta-$, $\omega-$, $\rho-$, $\sigma-$ mesons and nucleons and anti nucleons [4]. So, our approach is relativistic from the beginning and does not need in supplementary efforts to get any relativistic results. Recall that the UCT method is aimed at reformulating the theory in terms of the so-called clothed-particle creation (annihilation) operators α_c, e.g., $a_c^\dagger(a_c)$ for mesons, $b_c^\dagger(b_c)$ for nucleons and $d_c^\dagger(d_c)$ for antinucleons via UCTs $W(\alpha_c) = W(\alpha) = \exp R$, $R = -R^\dagger$ with help of the similarity transformation $\alpha = W(\alpha_c)\alpha_c W(\alpha_c)$ that connects a primary set α in the bare-particle representation (BPR) with the new operators in the clothed-particle representation (CPR). Of course, such a transformation can be done if following [5] one composes certain physical constraints on the unitary operator W. The $3N$ interaction operator of the $b_c^\dagger b_c^\dagger b_c^\dagger b_c b_c b_c$-type stems from the commutator $[V]^3 \equiv [R,[R,[R,V]]]$ that is constructed by using a recursive procedure exposed in [3]. Here operator V denotes a primary interaction between the fields included. We will compare the part of the matrix element $\langle \mathbf{p}_1'\mathbf{p}_2'\mathbf{p}_3'|[V]^3|\mathbf{p}_1\mathbf{p}_2\mathbf{p}_3\rangle$ due to the pion exchange with the Tucson-Melbourne 2π-exchange three-nucleon potential [6].

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