Generalized parton distributions and the parton structure of light nuclei

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Abstract

The measurement of nuclear Generalized Parton Distributions (GPDs) represents a valuable tool to understand the structure of bound nucleons and the phenomenology of hard scattering off nuclei. By using a realistic, non-relativistic microscopic approach for the evaluation of GPDs of ^{3}He, it will be shown that conventional nuclear effects, such as isospin and binding ones, or the uncertainty related to the use of a given nucleon-nucleon potential, are bigger than in the forward case so that, if great attention is not paid, conventional nuclear effects can be easily mistaken for exotic ones. It is stressed that ^{3}He, for which the best realistic calculations are possible, represents a unique target to discriminate between conventional and exotic effects. The complementary information which could be obtained by using a ^{3}H target, the possible extraction of the neutron information, as well as the relevance of a relativistic treatment, will be also addressed.

1 Introduction

The measurement of Generalized Parton Distributions (GPDs) [1], parametrizing the non-perturbative hadron structure in hard exclusive processes, represents one of the challenges of nowadays hadronic Physics. GPDs enter the long-distance dominated part of exclusive lepton Deep Inelastic Scattering (DIS) off hadrons. Deeply Virtual Compton Scattering (DVCS), i.e. the process $eH \longrightarrow e'H'\gamma$ when $Q^2 \gg m_H^2$, is one of the the most promising

*Invited talk at Light Cone 2010: Relativistic Hadronic and Particle Physics, June 14-18, 2010, Valencia, Spain. To appear in PoS, Proceedings of Science to access GPDs (here and in the following, Q^2 is the momentum transfer between the leptons e and e', and Δ^2 the one between the hadrons H and H') [1]. Relevant experimental efforts to measure GPDs are taking place, and a few DVCS data have been already published [2]. The issue of measuring GPDs for nuclei has been addressed in several papers [3]. While some studies have shown that the measurement of nuclear GPDs can unveil information on possible medium modifications of nucleons in nuclei [4], great attention has to be paid to avoid to mistake them with conventional nuclear effects. To this respect, a special role would be played by few body nuclear targets, for which realistic studies are possible and exotic effects, such as the ones of non-nucleonic degrees of freedom, not included in a realistic wave function, can be disentangled. To this aim, in Ref. [5], a realistic IA calculation of the quark unpolarized GPD H_q^3 of ^3He has been presented. The study of GPDs for ^3He is interesting for many aspects. In fact, ^3He is a well known nucleus, and it is extensively used as an effective neutron target: the properties of the free neutron are being investigated through experiments with nuclei, whose data are analyzed taking nuclear effects properly into account. For example, it has been shown, firstly in [6], that unpolarized DIS off trinucleons (^3H and ^3He) can provide relevant information on PDFs at large x_{Bj}, while it is known since a long time that its particular spin structure suggests the use of ^3He as an effective polarized neutron target [7]. Polarized ^3He will be therefore the first candidate for experiments aimed at the study of spin-dependent GPDs of the free neutron. In Ref. [5], the GPD H_q^3 of ^3He has been evaluated using a realistic non-diagonal spectral function, so that momentum and binding effects are rigorously estimated. The scheme proposed in that paper is valid for $\Delta^2 \ll Q^2, M^2$ and it permits to calculate GPDs in the kinematical range relevant to the coherent, no break-up channel of deep exclusive processes off ^3He. In fact, the latter channel can be hardly studied at large Δ^2, due to the vanishing cross section. Nuclear effects are found to be larger than in the forward case and to increase with Δ^2 at fixed skewedness, and with the skewedness at fixed Δ^2. In particular the latter Δ^2 dependence does not simply factorize, in agreement with previous findings for the deuteron target and at variance with prescriptions proposed for finite nuclei.

Here, the analysis of Ref. [8], which extended that of Ref. [5] into various directions, is reviewed. The main point of the contribution will be to stress that the properties of nuclear GPDs should not be trivially inferred from those of nuclear parton distributions.

2 Conventional nuclear effects on the GPDs of ^3He

Let us introduce the definition GPDs to be used in what follows. For a spin 1/2 hadron target, with initial (final) momentum and helicity $P(P')$ and $s(s')$, respectively, the GPDs $H_q(x,\xi,\Delta^2)$ and $E_q(x,\xi,\Delta^2)$ are defined through the light cone correlator

$$
\begin{aligned}
F^q_{s's}(x,\xi,\Delta^2) &= \frac{1}{2}\int \frac{d\lambda}{2\pi} e^{i\lambda x} \langle P's' | \bar{\psi}_q\left(-\frac{\lambda n}{2}\right) \not{n}\, \psi_q\left(\frac{\lambda n}{2}\right) | Ps \rangle \\
&= H_q(x,\xi,\Delta^2) \frac{1}{2} \bar{U}(P',s') \not{n} U(P,s) \\
&+ E_q(x,\xi,\Delta^2) \frac{1}{2} \bar{U}(P',s') \frac{i\sigma^{\mu\nu} n_\mu \Delta_\nu}{2M} U(P,s) \; ,
\end{aligned}
$$

where $\Delta = P' - P$ is the 4-momentum transfer to the hadron, ψ_q is the quark field and M is the hadron mass. It is convenient to work in a system of coordinates where the photon 4-momentum, $q^\mu = (q_0, \vec{q})$, and $\bar{P} = (P + P')/2$ are collinear along z. The skewedness variable, ξ, is defined as

$$
\xi = -\frac{n\cdot\Delta}{2} = -\frac{\Delta^+}{2\bar{P}^+} = \frac{x_{Bj}}{2-x_{Bj}} + \mathcal{O}\left(\frac{\Delta^2}{Q^2}\right) \; , \tag{1}
$$

where n is a light-like 4-vector satisfying the condition $n \cdot \bar{P} = 1$. (Here and in the following, $a^\pm = (a^0 \pm a^3)/\sqrt{2}$). In addition to the variables x, ξ and Δ^2, GPDs depend on the momentum scale Q^2. Such a dependence, not discussed here, will be omitted. The constraints of $H_q(x,\xi,\Delta^2)$ are: i) the "forward" limit, $P' = P$, i.e., $\Delta^2 = \xi = 0$, yielding the usual PDFs

$$
H_q(x,0,0) = q(x) \; ; \tag{2}
$$

ii) the integration over x, yielding the contribution of the quark of flavour q to the Dirac form factor (f.f.) of the target:

$$
\int dx H_q(x,\xi,\Delta^2) = F_1^q(\Delta^2) \; ; \tag{3}
$$

iii) the polynomiality property, involving higher moments of GPDs. In Ref. [9], an expression for $H_q(x,\xi,\Delta^2)$ of a given hadron target, for small values of ξ^2, has been obtained from the definition Eq. (1). The approach has been later applied in Ref. [5] to obtain the GPD H_q^3 of ^3He in IA, as a convolution between the non-diagonal spectral function of the internal nucleons, and the GPD H_q^N of the nucleons themselves. Let me recall the main formalism of

Ref. [5], which will be used in this paper. In the class of frames discussed above, and in addition to the kinematical variables x and ξ, already defined, one needs the corresponding ones for the nucleons in the target nuclei, x' and ξ'. The latter quantities can be obtained defining the "+" components of the momentum k and $k + \Delta$ of the struck parton before and after the interaction, with respect to $\bar{P}^+$ and $\bar{p}^+ = \frac{1}{2}(p + p')^+$ (see [5] for details). In Ref. [5], a convolution formula for H_q^3 has been derived in IA, using the standard procedure developed in studies of DIS off nuclei [11–13]. It reads:

$$
\begin{aligned}
H_q^3(x, \xi, \Delta^2) \;\; &\simeq \;\; \sum_N \int dE \int d\vec{p} \, [P_N^3(\vec{p}, \vec{p} + \vec{\Delta}, E) + \mathcal{O}(\vec{p}^2/M^2, \vec{\Delta}^2/M^2)] \\
&\times \;\; \frac{\xi'}{\xi} H_q^N(x', \xi', \Delta^2) + \mathcal{O}\left(\xi^2\right) \; . \qquad (4)
\end{aligned}
$$

In the above equation, $P_N^3(\vec{p}, \vec{p} + \vec{\Delta}, E)$ is the one-body non-diagonal spectral function for the nucleon N, with initial and final momenta $\vec{p}$ and $\vec{p} + \vec{\Delta}$, respectively, in ^3He:

$$
\begin{aligned}
P_N^3(\vec{p}, \vec{p} + \vec{\Delta}, E) \;\; &= \;\; \frac{1}{(2\pi)^3} \frac{1}{2} \sum_M \sum_{R,s} \langle \vec{P}' M | (\vec{P} - \vec{p}) S_R, (\vec{p} + \vec{\Delta}) s \rangle \\
&\times \;\; \langle (\vec{P} - \vec{p}) S_R, \vec{p} s | \vec{P} M \rangle \, \delta(E - E_{min} - E_R^*) \; , \qquad (5)
\end{aligned}
$$

and the quantity $H_q^N(x', \xi', \Delta^2)$ is the GPD of the bound nucleon N up to terms of order $O(\xi^2)$. The delta function in Eq (5) defines E, the removal energy, in terms of $E_{min} = |E_{^3He}| - |E_{^2H}| = 5.5$ MeV and E_R^*, the excitation energy of the two-body recoiling system. The main quantity appearing in the definition Eq. (5) is the overlap integral

$$
\langle \vec{P} M | \vec{P}_R S_R, \vec{p} s \rangle = \int d\vec{y} \, e^{i \vec{p} \cdot \vec{y}} \langle \chi^s, \Psi_R^{S_R}(\vec{x}) | \Psi_3^M(\vec{x}, \vec{y}) \rangle \; , \qquad (6)
$$

between the eigenfunction Ψ_3^M of the ground state of ^3He, with eigenvalue $E_{^3He}$ and third component of the total angular momentum M, and the eigenfunction $\Psi_R^{S_R}$, with eigenvalue $E = E_{min} + E_R^*$ of the state R of the intrinsic Hamiltonian pertaining to the system of two interacting nucleons. As discussed in Ref. [5], the accuracy of the calculations which will be presented, since a NR spectral function will be used to evaluate Eq. (4), is of order $\mathcal{O}\left(\vec{p}^2/M^2, \vec{\Delta}^2/M^2\right)$, or, which is the same, $\vec{p}^2, \vec{\Delta}^2 << M^2$. The interest of the present calculation is indeed to investigate nuclear effects at low values of $\vec{\Delta}^2$, for which measurements in the coherent channel may be performed. The main emphasis of the present approach, as already said, is not on the absolute values of the results, but in the nuclear effects, which can be estimated by taking any reasonable form for the internal GPD. Eq. (4) can be written in the form

$$H_q^3(x,\xi,\Delta^2) = \sum_N \int_x^1 \frac{dz}{z} h_N^3(z,\xi,\Delta^2) H_q^N\left(\frac{x}{z},\frac{\xi}{z},\Delta^2\right) \ , \tag{7}$$

where the off-diagonal light cone momentum distribution

$$h_N^3(z,\xi,\Delta^2) = \int dE \int d\vec{p}\, P_N^3(\vec{p},\vec{p}+\vec{\Delta})\delta\left(z+\xi-\frac{p^+}{\bar{P}^+}\right) \tag{8}$$

has been introduced. As it is shown in Ref. [5], Eqs. (7) and (8) or, which is the same, Eq. (4), fulfill the constraint $i) - iii)$ previously listed. The constraint $i)$, i.e. the forward limit of GPDs, is verified by taking the forward limit ($\Delta^2 \to 0, \xi \to 0$) of Eq. (7), yielding the parton distribution $q_3(x)$ in IA: [11,12,17]:

$$q_3(x) = H_q^3(x,0,0) = \sum_N \int_x^1 \frac{dz}{z} f_N^3(z)\, q_N\left(\frac{x}{z}\right) \ . \tag{9}$$

In the latter equation,

$$f_N^3(z) = h_N^3(z,0,0) = \int dE \int d\vec{p}\, P_N^3(\vec{p},E)\delta\left(z-\frac{p^+}{\bar{P}^+}\right) \tag{10}$$

is the forward limit of Eq. (8), i.e. the light cone momentum distribution of the nucleon N in the nucleus, $q_N(x) = H_q^N(x,0,0)$ is the distribution of the quark of flavour q in the nucleon N and $P_N^3(\vec{p},E)$, the $\Delta^2 \longrightarrow 0$ limit of Eq. (7), is the one body spectral function. The constraint $ii)$, i.e. the $x-$integral of the GPD H_q, is also fulfilled. By $x-$integrating Eq. (7), one obtains the contribution, of the quark of flavour q, to the nuclear f.f. Eventually the polynomiality, condition $iii)$, is formally fulfilled by Eq. (4).

In the following, $H_q^3(x,\xi,\Delta^2)$, Eq. (4), will be evaluated in the nuclear Breit Frame. The non-diagonal spectral function Eq. (5), appearing in Eq. (4), will be calculated by means of the overlap Eq. (6), which exactly includes the final state interactions in the two nucleon recoiling system The realistic wave functions Ψ_3^M and $\Psi_R^{S_R}$ in Eq. (6) have been evaluated using the AV18 interaction [15]. In particular Ψ_3^M has been developed along the lines of Ref. [16]. The same overlaps, evaluated along the line of Ref. [14], have been already used in Ref. [5,17].

The other ingredient in Eq. (4), i.e. the nucleon GPD H_q^N, has been modelled in agreement with the Double Distribution representation [10], as described in [18] (See Ref. [5]). In Ref. [5] it has been shown that the described formalism reproduces well, in the proper limits, the IA results for nuclear parton distributions and form factor. In particular, in the latter case, the IA calculation reproduces well the data up to a momentum transfer $-\Delta^2 = 0.25$ GeV^2, which is enough for the aim of this calculation. In fact, the region of higher momentum transfer is not considered here, being phenomenologically not relevant for the calculation of GPDs entering coherent processes.

Conventional nuclear effects on the GPDs of ^3He will be now discussed. The aim is that of avoiding to mistake them for exotic ones in possible measurements of nuclear GPDs, and to stress the relevance of experiments using ^3He targets. As already done in Ref. [5], the full result for H_q^3, Eq. (4), will be compared with a prescription based on the assumptions that nuclear effects are neglected and the global Δ^2 dependence is described by the f.f. of ^3He:

$$H_q^{3,(0)}(x,\xi,\Delta^2) = 2H_q^{3,p}(x,\xi,\Delta^2) + H_q^{3,n}(x,\xi,\Delta^2) \; , \tag{11}$$

where the quantity

$$H_q^{3,N}(x,\xi,\Delta^2) = \tilde{H}_q^N(x,\xi) F_q^3(\Delta^2) \tag{12}$$

represents effectively the flavor q GPD of the bound nucleon $N = n,p$ in ^3He. Its x and ξ dependences, given by $\tilde{H}_q^N(x,\xi)$, are the same of the GPD of the free nucleon N, while its Δ^2 dependence is governed by the contribution of the flavor q to the ^3He f.f., $F_q^3(\Delta^2)$. The effect of nucleon motion and binding can be shown through the ratio

$$R_q(x,\xi,\Delta^2) = \frac{H_q^3(x,\xi,\Delta^2)}{H_q^{3,(0)}(x,\xi,\Delta^2)} \; , \tag{13}$$

i.e. the ratio of the full result, Eq. (4), to the approximation Eq. (11). The ratio Eq. (13) shows nuclear effects in a very natural way. As a matter of facts, its forward limit yields an EMC-like ratio for the parton distribution q and, if ^3He were made of free nucleons at rest, it would be one.

In Figs. 1 to 3, results will be presented concerning: A) flavor dependence of nuclear effects; B) binding effects; C) dependence on the nucleon-nucleon potential.

A) Flavor dependence of nuclear effects. In the upper left panel of Fig. 1,

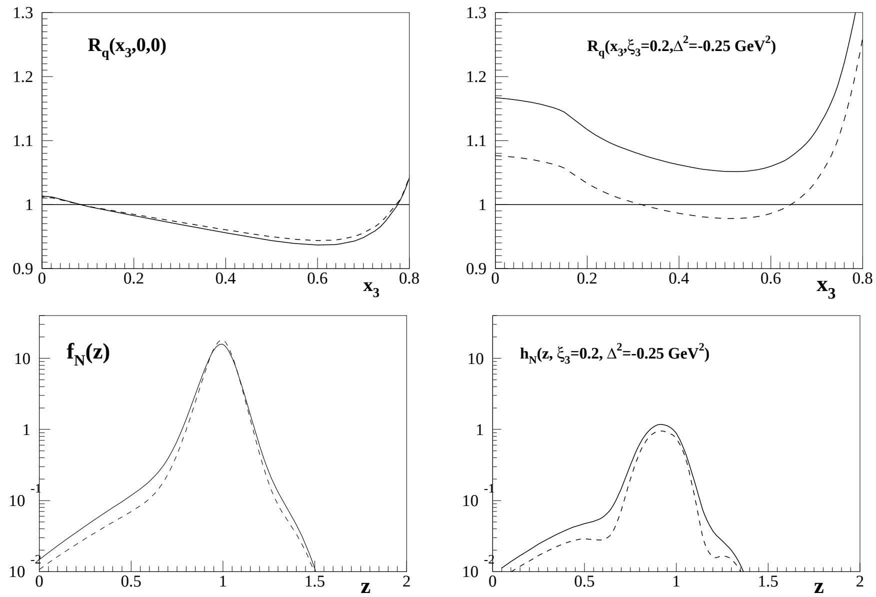

Figure 1: Left: upper panel: the dashed (full) line represents the ratio Eq. (13), for the u (d) flavor, in the forward limit; lower panel: the dashed (full) line represents the light cone momentum distribution, Eq. (10), for the proton (neutron) in ^{3}He. Right: the same as in the left panel, but at $\Delta^2 = -0.25$ GeV^2 and $\xi_3 = 0.2$.

the ratio Eq. (13) is shown for the u and d flavor, in the forward limit, as a function of $x_3 = 3x$. The trend is clearly EMC-like. It is seen that nuclear effects for the d flavour are very slightly bigger than those for the u flavour. The reason is understood thinking that, in the forward limit, the nuclear effects are governed by the light cone momentum distribution, Eq. (10): no effects would be found if such a function were a delta function, while effects get bigger and bigger if its width increases. In another panel of the same figure, the light cone momentum distribution, Eq. (10), for the proton (neutron) in ^3He is represented by the dashed (full) line. The neutron distribution is slightly wider than the proton one, meaning that the average momentum of the neutron in ^3He is a little larger than the one of the proton. Since the forward d distribution is more sensitive than the u one to the

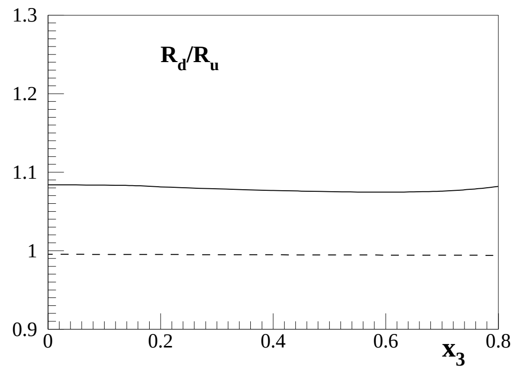

Figure 2: The ratio of the ratios Eq. (13), for the d to the u flavor, at $\Delta^2 = -0.25$ GeV^2 and $\xi_3 = 0.2$ (full line) and in the forward limit (dashed line).

neutron light cone momentum distribution, nuclear effects for d are slightly larger than for u, as seen in the upper panel of the same figure. In the same figure, the same analysis of Fig. 1 is performed, but at $\Delta^2 = -0.25$ GeV^2 and $\xi_3 = 3\xi = 0.2$. In this case, nuclear effects are governed by the non-diagonal light cone momentum distribution, Eq. (8), shown in the lower panel of the figure. In this case, the difference between the neutron and proton distributions is quite bigger than in the forward case, governing the difference in the ratio Eq. (13) for the two flavors, which is of the order of 10 %, as it is seen in Fig. 3. From Figs. 1-3 three main conclusions can be drawn. 1) if one infers properties of nuclear GPDs thinking to those of nuclear PDs, conventional nuclear effects as big as 10 % can be easily lost, or mistaken for exotic ones. 2) Secondly, this behavior is a typical conventional effect, being a prediction of IA in DIS off nuclei. If a 10 % effect would be observable in experimental studies of nuclear GPDs, the presence of such a flavor dependence, or its absence, would be clear signatures of the reaction mechanism of DIS off nuclei. Its presence would mean that the reaction involves essentially partons inside nucleons, whose dynamics is governed by a realistic potential in a conventional scenario; on the contrary, its absence would mean that, in a different, exotic scenario, other degrees of freedom have to be advocated. 3) Eventually, it is clear that, for this kind of studies, ^3He is a unique target, for which experiments are worth to be done: the flavor dependence cannot be investigated with isoscalar targets, such as ^2H or ^4He, while for heavier nuclei calculations cannot be performed with comparable precision.

B) Binding effects. In the previous section it has been explained how Eq.

(7) takes into account properly the nucleon momentum and energy distributions through a non-diagonal spectral function. In the following, the result obtained neglecting binding effects, i.e., by using a momentum distribution instead of a spectral function, will be shown. When a momentum distribution is used instead of a spectral function, not only the IA, but also another approximation, the so called "closure approximation", has been used: an average excitation energy, $\bar{E}^*$, has been inserted in the expression of the delta function appearing in the definition of the spectral function Eq. (5), so that the completeness of the two body recoiling states can be used [12]:

$$
\begin{aligned}
P_N^3(\vec{p},\vec{p}+\vec{\Delta},E) &\simeq \bar{\sum}_M \sum_s \langle \vec{P}' M | a_{\vec{p}+\vec{\Delta},s} a^\dagger_{\vec{p},s} | \vec{P} M \rangle \delta(E - E_{min} - \bar{E}^*) \\
&= n(\vec{p},\vec{p}+\vec{\Delta})\, \delta(E - E_{min} - \bar{E}^*) \ , \qquad (14)
\end{aligned}
$$

and the spectral function is approximated by a one-body non diagonal momentum distribution times a delta function defining an average value of the removal energy. Whenever the momentum distribution is used instead of the spectral function, in addition to the IA the above closure approximation has been used assuming $\bar{E}^* = 0$, i.e., binding effects have been completely neglected. The difference between the full calculation and the one using the momentum distribution, for the ratio Eq. (13), is shown in Fig. 3. It is seen that, while the difference is a few percent in the forward limit, it grows in the non-forward case, becoming an effect of 5 % to 10 % between $x = 0.4$ and 0.7. From this analysis, the same three main conclusions, arisen in the study of the flavor dependence can be drawn.
C) Dependence on the nucleon-nucleon potential. In Fig. 3, the difference is shown between the full calculation, Eq. (13), evaluated with the AV18 interaction [15], and the same quantity, evaluated by means of the AV14 one. It is seen that there is basically no difference in the forward limit, confirming previous findings in inclusive DIS [17], while a sizable difference is seen in the non forward case (preliminary results of this behavior have been accounted for in a talk at a Conference [5]). From these analyses the same conclusions of the previous two subsections can be drawn. We note on passing that a difference between observables evaluated using AV18 and AV14 potentials is not easily found, in particular in inclusive DIS.

3 GPDs for the ^3H target

In the perspective of using ^3H targets after the 12 GeV upgrade of JLab [19], it is useful to address what could be learnt from simultaneous measurements with trinucleon targets, ^3He and ^3H. The procedure proposed firstly in Ref. [6] for the unpolarized DIS to extract, with unprecedented precision, the ratio of down to up quarks in the proton, $d(x)/u(x)$, at large Bjorken x, is extended here to the case of the GPDs of trinucleons. To minimize nuclear effects, the following "super-ratio", a generalization of the one proposed in Ref. [6], can be defined

$$S_{qq'}(x, \xi, \Delta^2) = R_q^H(x, \xi, \Delta^2)/R_{q'}^T(x, \xi, \Delta^2) \ , \tag{15}$$

where the ratio

$$R_q^A(x, \xi, \Delta^2) = \frac{H_q^A(x, \xi, \Delta^2)}{Z_A H_q^p(x, \xi, \Delta^2) + N_A H_q^n(x, \xi, \Delta^2)} \ , \tag{16}$$

has been introduced for ^3He ($A = H$) and ^3H ($A = T$), with $q = u, d$, $Z_A(N_A)$ the number of protons (neutrons) in the nucleus A, and $H_q^N(x, \xi, \Delta^2)$ the GPD of the quark q in the nucleon $N = p, n$. Now, using the isospin symmetry of GPDs, we can call

$$H_u(x, \xi, \Delta^2) = H_u^p(x, \xi, \Delta^2) = H_d^n(x, \xi, \Delta^2) \ , \tag{17}$$
$$H_d(x, \xi, \Delta^2) = H_d^p(x, \xi, \Delta^2) = H_u^n(x, \xi, \Delta^2) \ , \tag{18}$$

so that Eq. (15) is given, for example for $q = d$ and $q' = u$, by the simple relation

$$S_{du}(x, \xi, \Delta^2) = \frac{H_d^H(x, \xi, \Delta^2)}{H_u^T(x, \xi, \Delta^2)} \ , \tag{19}$$

a quantity in principle observable. In the IA approach discussed here, using Eq. (7) to calculate the nuclear GPDs, one has therefore

$$S_{du}(x, \xi, \Delta^2) = \frac{\int_x^1 \frac{dz}{z} \left\{ h_p^H(z, \xi, \Delta^2) H_d\left(\frac{x}{z}, \frac{\xi}{z}, \Delta^2\right) + h_n^H(z, \xi, \Delta^2) H_u\left(\frac{x}{z}, \frac{\xi}{z}, \Delta^2\right) \right\}}{\int_x^1 \frac{dz}{z} \left\{ h_n^T(z, \xi, \Delta^2) H_d\left(\frac{x}{z}, \frac{\xi}{z}, \Delta^2\right) + h_p^T(z, \xi, \Delta^2) H_u\left(\frac{x}{z}, \frac{\xi}{z}, \Delta^2\right) \right\}} \ , \tag{20}$$

where $h_{p(n)}^{H(T)}(z, \xi, \Delta^2)$ represents the light cone off diagonal momentum distribution for the proton (neutron) in ^3He (^3H). If the Isospin Symmetry were valid at the nuclear level, one should have $h_p^H(z, \xi, \Delta^2) = h_n^T(z, \xi, \Delta^2)$, and $h_n^H(z, \xi, \Delta^2) = h_p^T(z, \xi, \Delta^2)$, so that the ratio Eq. (20) would be identically 1. From the previous analysis, it is clear anyway that these relations are only approximately true, and some deviations are expected. In Fig. 4, the super-ratio $S_{du}(x, \xi, \Delta^2)$, Eq. (15), evaluated by using the AV18 interaction for the nuclear GPDs in Eq. (7), taking into account therefore the

Coulomb interaction between the protons in ^3He and a weak charge independence breaking term, is shown for different values of $\Delta^2 \leq 0.25$ GeV^2 and ξ. While it is seen that, as expected, $S_{du}(x, \xi, \Delta^2)$ is not exactly 1 and the difference gets bigger with increasing Δ^2 and ξ, for the low values of Δ^2 and ξ relevant for the present investigation of GPDs, such a difference keeps being a few percent one. It would be very interesting to measure this ratio experimentally. If strong deviations from this predicted behavior were observed, there would be a clear evidence that the description in terms of IA, i.e. in terms of the conventional scenario of partons confined in nucleons bound together by a realistic interaction, breaks down. In other words one could have a clear signature of possible interesting exotic effects.

In summary, conventional nuclear effects on the unpolarized quark GPD for the trinucleons have been described, using a realistic microscopic calculation. The issue of applying the obtained GPDs to estimate cross-sections and to establish the feasibility of experiments, is in progress and will be presented elsewhere.

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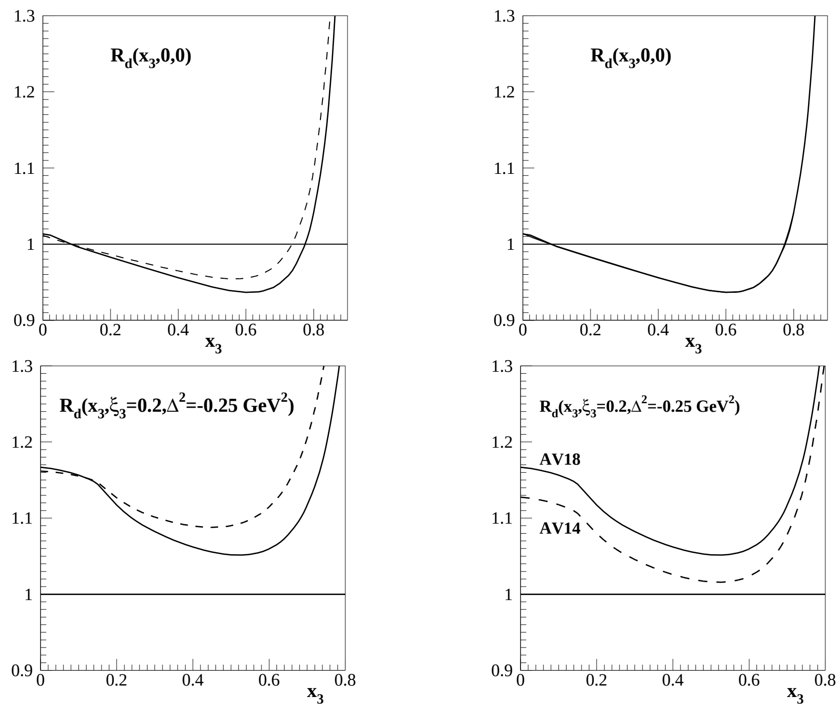

Figure 3: Left: upper panel: the ratio Eq. (13), in the forward limit, for the d flavor, corresponding to the full result of the present approach (full line), compared with the one obtained using in the numerator the approximation Eq. (14) with $\bar{E}^* = 0$, i.e., using a momentum distribution instead of a spectral function (dashed line); lower panel: the same as before, but evaluated at $\Delta^2 = -0.25$ GeV^2 and $\xi_3 = 0.2$. Right: upper panel: the ratio Eq. (13), in the forward limit, for the d flavor, corresponding to the full result of the present approach, where use is made of the AV18 interaction (full line), compared with the one obtained using in the numerator the AV14 interaction (dashed line): the two curves cannot be distinguished; lower panel: the same, but evaluated at $\Delta^2 = -0.25$ GeV^2 and $\xi_3 = 0.2$: now the curves are distinguishable.

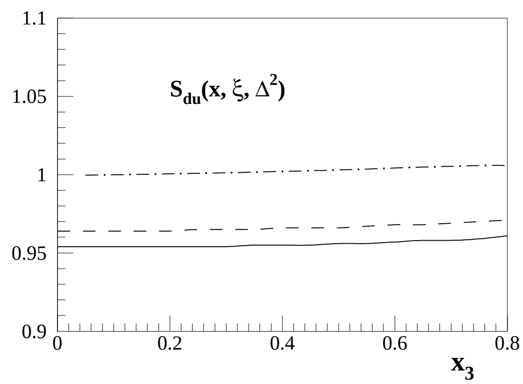

Figure 4: The ratio Eq. (20), in the forward limit (dot-dashed line), at $\Delta^2 = -0.15$ GeV^2 and $\xi_3 = 0.1$ (dashed line), and at $\Delta^2 = -0.25$ GeV^2 and $\xi_3 = 0.2$ (full line).