INFLUENCE OF SHORT-RANGE CORRELATIONS ON ^{4}He(e,e′)X REACTION CROSS SECTION

E.L. Kuplennikov
National Science Center "Kharkov Institute of Physics and Technology", Kharkov, Ukraine

Inelastic electron scattering on ^{4}He nucleus is considered in the energy and momentum transfer region related with the quasifree and pion electroproduction peaks. Comparisons are shown between the data and models based on a quasifree reaction mechanism. The dynamic short-range correlation contribution is found to be significant in this kinematical region.

PACS 25.30.Fj

1. INTRODUCTION

It is known that the NN-interaction has a strongly repulsive core. It is natural to expect that when two nucleons come within a distance of the order of the core radius (about 0.5 fm), they get accelerated. As a result, the nucleon momentum in nuclei (p) can be larger than the Fermi limit (p_F). Theoretical calculations confirmed that taking into consideration strongly repulsive forces occurring at short distances (dynamic Short Range Correlations (SRC)) leads to qualitative modifications of the results obtained in the independent particle model [1]. The nucleon momentum distribution ρ(p) at large momenta $p>p_F$ is determined by pair and many-particle correlations.

Putting some assumptions, the double differential cross section of the inclusive (e,e') electron scattering in the quasifree peak (QFP) region (region, where nucleons are directly ejected from the nucleus without passing through quasi-bound states) is proportional to the integral of ρ(p) [2]. So, SRC effects can be investigated in the inelastic electron scattering on nuclei under such kinematical conditions that the high-momentum component of ρ(p) manifests itself in a maximum way. These kinematical conditions are known. For large transfered momenta the QFP cross section at high- $\omega \gg \omega_{peak}$ and low- $\omega \ll \omega_{peak}$ energy loss is determined by the high momentum component of ρ(p).

Note, that SRC modify the energy spectra not only in the QFP "tails" at large or small energy loss**.** They can influence on a QFP cross section and its position [2,3]. Investigations have shown, that the QFP position is in considerable extent determined by the Jastrow correlation factor that is used in calculations. Besides, due to SRC the inclusive electron scattering can be accompanied by ejection of deuterons and NN- pairs from the nuclear-target [4]. This two-body emission via the direct correlation mechanism modifies the experimental cross section both in the QFP maximum and in the intermediate so-called dip-region (region between QFP and Δ (1232) resonance).

This paper reports the results of measurements of inelastic scattering at 20 and 30^0 of 1.169 GeV incident electrons from ^{4}He target in the QFP and first nucleon resonance region. Systematic features of the continuum scattering data are compared with calculations that use realistic NN-interaction. The influence of final state interaction (FSI) of the ejected nucleon with the residual nucleus and SRC on the QFP cross section is discussed.

2. EXPERIMENTAL PROCEDURE

The double differential cross section of the ^{4}He(e,e')X reaction are presented in figs. 1 and 2. The energy spectra of inelastic electron scattering were taken at the Kharkov linear accelerator LA-2 GeV. (incident electron energy 1.169 GeV, scattering angles 20 и 30^0). Measurements have been performed on low- temperature ^{4}He target over a wide energy loss region $0 \le \omega \le$ 0,75 GeV and overlapped quasi-free and pion electroproduction peaks. Scattered electrons were analyzed on their momenta with a double-focusing magnetic spectrometer and detected with a telescope of counters. The telescope consisted of two many-wire proportional chambers with momentum acceptance 0,14% per channel, a shower total-absorption detector and a Cherenkov threshold gas counter. To increase the statistical accuracy in the condition of small cross sections every experimental point was obtained by averaging the number of counts in the 5 MeV interval. The radiative corrections to the cross sections were introduced by the standard method [5]. The error bars include statistical errors only.

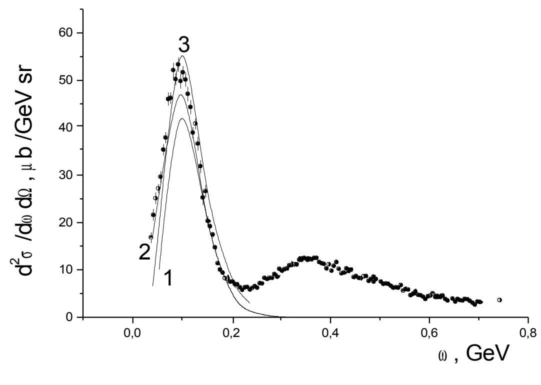

Fig. 1. *Inclusive differential cross sections for ^{4}He as a function of energy loss. The data were taken at a spectrometer angle 20^0 with beam energy of 1.169 GeV. Curves 1-3 are described in the text.*

3. RESULTS AND DISCUSSION

In Figs. 1 and 2 the experimental energy spectra of the ^{4}He(e,e')X reaction and results of modern theoretical calculations, which take into account pair and more complex short-range correlations between nucleons, are given. Curves 1 and 2 in Fig. 1 represent the counts in the frame of theoretical approach [6] for the realistic Urbana potential with and without s- pole respectively. s-pole reflects the most significant part of FSI. In this approach main attention is paid to the covariance, conservation of electromagnetic current and taking into account the structure of the ^{4}He nucleus. The approximation [6] takes into account SRC.

Curve 3 is a prediction of the harmonic oscillator model (HOM). The oscillator parameter P_0=130 MeV/c was obtained from the ^{4}He root-mean-square radius measured in the elastic electron scattering experiment. The parameter takes into account a correction of the center-of-mass motion. The separation energy was 19.8 MeV. It is seen from Fig. 1, that curves 1-3 differ between themselves in the QFP maximum. A reasonable agreement with experimental points takes place only for HOM calculations.

Calculations in the framework of approximation [6] for the realistic Urbana potential do not give reasonable agreement in the QFP maximum. At the same time, the calculations demonstrate the important role of the FSI. The absolute value of the QFP cross section, its width and position are changed. The calculated peak is some narrower then experimental one and is shifted relatively to experimental points and HOM calculations to the side of a high-energy loss. The contribution of the final N-nucleus interaction increases with momentum transfer decrease (compare Figs. 1 and 2).

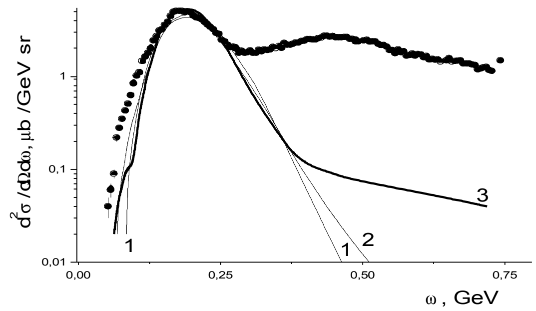

Fig. 2. *Inclusive differential cross section for ^{4}He as a function of energy loss. The data were taken at a spectrometer angle 30^0 with beam energy of 1.169 GeV. Curves 1-3 are described in the text.*

The curves 1 and 2 in Fig. 2 are the results of calculations in the frame of HOM and approach [6] for Urbana potential respectively. In the latter version curves with and without s- pole coincide, that is for given kinematical conditions influence of the final N-nucleus interaction is negligible. Curve 3 – counts with nucleon momentum distribution, which was obtained by the variational method ATMS [7] for Reid Soft Core potential. The curve 3 is calculated within the ATMS and Y_1 approximation with relativistic kinematics for the recoil nucleon [2].

It can be seen from fig. 2 that nuclear models, which take into account the pair and more complex SRC, give rather good description of the QFP maximum. At the same time, account with the ATMS nucleon momentum distribution and theoretical approximation [6] predicts a significant difference at the high energy loss side $\omega \gg \omega_{peak}$ of the QFP between themselves and relatively to HOM calculations.

Taking into account SRC increases the cross section and improves the agreement with the experiment at high energy loss. But the contribution of high momentum component into the total cross section is small. Its value is not sufficient to get agreement in the dip-region. The ATMS nucleon momentum distribution predicts the highest value of the cross section in this kinematical region. Even in the electroproduction peak maximum contribution of the ATMS calculations into the total one is small but not negligible. It consists approximately 4%.

As regards low energy loss side $\omega \ll \omega_{peak}$ of the QFP, none of the above used theoretical approaches gives reasonable agreement with experimental points. There is the substantial excess of the experimental cross section compared to all theoretical calculations.

4. CONCLUSIONS

The inelastic cross section from ^{4}He have been measured in the QFP and delta-resonance region at E_1=1.169 MeV and θ=20 and 30^0. Comparison of the cross section was made with calculations that use realistic NN-interactions. It was shown that no theoretical calculation, which uses SRC effects is able to reproduce the data at high- and low-energy loss side of the QFP.

REFERENCES

1. Jibuti, R.Y. Kezerashvili. Effects of Short-Range Correlations and Distortion in the Reaction 4He(e,e'p) 3H // *Phys. Lett.* 1975, v. B57, p. 433.
2. S.V. Dementij, A.Y. Korchin, E.L. Kuplennikov et al. Nucleon-Nucleon Correlations and Inelastic Electron Scattering on ^{4}He // *Journal of the Phys. Soc. of Japan.* 1988, v. 57, p. 2988.
3. E.L. Kuplennikov, A.Yu. Korchin, A.A. Nemashkalo et al. Studying the quasifree peak maximum shift in the 4He(e,e')X reaction // *Yadern. Fiz.* 1990, v. 51, p. 1210 (in Russian).
4. S.I. Nagorny, E.L. Kuplennikov, E.V. Inopin. Deep-inelastic electron scattering on light nuclei in the intermediate energy range // *Yadern. Fiz*. 1983, v. 38, p. 345 (in Russian).
5. L.W. Mo, Y.S. Tsai. Radiative corrections to elastic and inelastic ep and mp scattering // *Rev. Mod. Phys.* 1969, v. 41, p. 205.
6. A.A. Zayats, V.A. Zolenko, Y.A. Kasatkin et al. Electrodesintegration of 4He nucleus: 4He(e,e'N)T // *Yadern Fiz*. 1992, v. 5, p. 325 (in Russian).
7. Y. Akaishi. Random number method in few body calculation // *Nucl. Phys.* 1984, v. A416, p. 409.