Nuclear Medium Modification of the Bound Nucleons

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One of the main questions of nuclear physics is "How is the structure of the bound nucleons distorted inside nuclei?" Another question, connected with the first one is "Do quarks manifest themselves in a ground state nuclei?" Neither of them have been solved so far. The fact that the nucleon structure is modified inside nuclei was observed as deviation from unity the ratio $r^A(x) = F_2^A(x)/F_2^D(x)$, where $F_2^A(x)$ and $F_2^D(x)$ are the structure functions per nucleon measured in a nucleus of mass A and a deuteron, respectively. This deviation was called the "EMC - effect". Another manifestation of the nuclear medium influence is the unexpected behavior of, so called, Color Transparency (CT) in quasielastic A(p,2p) and A(e,e'p) reactions at large angles which have been carried out over the last decades. The color or nuclear transparency $T = \sigma^A/(A\sigma N)$, where σ^A and σ^N are the cross sections of the reaction on the nucleus and free proton, measured in A(p,2p) at BNL, has shown a rise consistent with CT for $Q^2 = 3 - 8(GeV/c)^2$, but decreases at higher momentum transfer. This decrease apparently violating CT was the subject of active discussion. Moreover, no evidence for the onset of CT within the given range of Q^2 has been found in the quasielastic A(e,e'p) reactions.

Our analysis of the above phenomena lead us to the conclusion that they are manifestation of the modification of the quark structure of bound nucleons in comparison with that one of the free nucleons. In our approach the nucleons forming a nucleus are bound via correlations of quarks from adjacent nucleons. Quarks of bound nucleons inside nuclei are arranged in the lattice – like structure. Applying, elaborated by the author, the Strongly Correlated Quark Model (SCQM) of the nucleon and assuming that the structure function $F_2^A(x)$ of the nucleus is an incoherent sum of all the nucleons in the nucleus normalized to one nucleon, we demonstrate that the quark structure functions inside bound nucleons are modified in such a way that the constituent quark states become dominating over the current quark states, i.e. the current quark states are essentially suppressed. This rearrangement of the probability of quark states in bound nucleons results in distortion of their structure functions (left plot in Fig. 1).

Suppression of the current quark states is the source of unexpected behavior of CT in quasielastic A(p,2p) reaction at large angles. Current quark states correspond in our model to the small size quark configurations inside nucleons. Quasielastic A(p,2p) reaction at high Q^2 at large angles takes place if small quark configuration is realized in both the incident and nuclear protons. The higher is Q^2 the smaller should be both quark configurations. Suppression of small quark configurations inside one of the interacting protons leads to changing in the behavior of CT from increasing to decreasing at sufficiently high Q^2 (right plot in Fig. 1)

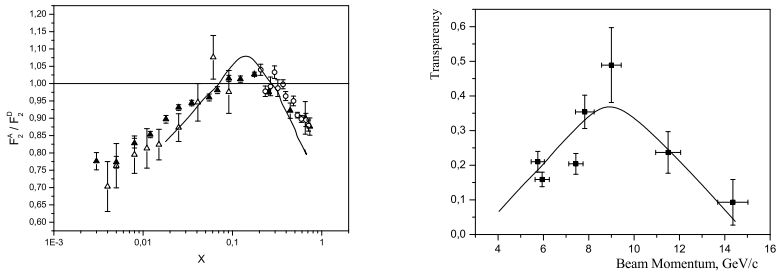

Figure 1: Left: EMC – effect. Right: Color Transparency. The curves are the results of calculation.

References

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[2] G. Musulmanbekov, This paper will be published in Proc. Int. Conf. Exotic Nuclear Systems 2005, AIP Press, New York.