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CONTRIBUTIONS OF PAIR CORRELATIONS TO PION-NUCLEUS DOUBLE CHARGE EXCHANGE

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Although the importance of pair correlations in nuclear structure physics has been recognized for a long time, studies of the role of these correlations in nuclear reactions are far from complete. Pion double charge exchange (DCX) is particularly effective for investigating pair correlations in nuclei because in this reaction any primary process requires the participation of two nucleons. Differential cross sections for pion DCX connecting double isobaric analog nuclei have been measured extensively in recent years at LAMPF.[1-4] The nuclei studied range from A=14 to 56. It caught almost everyone by surprise when calculations based on two sequential single charge exchanges (TSSCX) failed to describe the magnitude as well as the angular dependence of the differential cross section for the $^{18}O(\pi^+,\pi^-)^{18}Ne$(DIAS) reaction at 164 MeV.

Several authors have either calculated the effects of ground-state correlations[5] or included contributions of nonanalog intermediate states,[6] using the TSSCX theoretical framework. However, these approaches could not improve the angular dependence of calculated differential cross sections. Other researchers[7] have introduced a phenomenological component of the interaction which depends on the two-body density. The parameters of the density square-dependent terms were then determined from fitting elastic, SCX, and DCX cross sections by use of nuclear structure models which do not contain correlations. Consequently, this approach cannot offer information about pair correlations in nuclei.

Recognizing the importance of both the reaction mechanism and nuclear structure aspects of the DCX, I proposed in 1981 a new reaction theory which offers a consistent treatment of these two equally important components of pion DCX.[8] In this theory, the density square-dependent interaction is derived from the dynamical consideration of true pion absorption on a nucleon pair inside the nucleus. The strength of this new pion-nucleus interaction can then be calculated from the knowledge of the second-order pion-nucleus optical potential. With no free parameters for the pion-nucleus interaction and with the use of the coexistence nuclear model,[9,10] the theory gives satisfactory descriptions of the magnitude and the shape of 5° excitation functions as well as of the differential cross sections for the DCX reactions $^{18}O(\pi^+,\pi^-)^{18}Ne$(DIAS) and $^{42}Ca(\pi^+,\pi^-)^{42}Ti$(DIAS) between 120 and 290 MeV.[8,11] Our basic conclusions are: (1) the TSSCX mechanism alone can not describe pion DCX; (2) the position of the first minimum in the differential cross section is very sensitive to the inclusion of density square-dependent interaction; and, (3) on the other hand, the magnitude of the cross section is very sensitive to the inclusion of pair correlations (core excitation in the case with ^{18}O and ^{42}Ca).

In this conference, I will present results obtained from the application of this theory to the DCX reaction $^{14}C(\pi^+,\pi^-)\,^{14}O$(DIAS) at energies from 290 to 50 MeV. I will show the dramatic effects arising from pair correlations.[12] In particular, they can account for the high cross section at 50 MeV without the need of invoking the scattering of low-energy pions from an exotic 6-quark bag component as proposed by some researchers.[3] I feel that we are entering a new exciting era where pair correlation effects in nuclei can be examined quantitatively with pionic probes.

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