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PION DOUBLE CHARGE EXCHANGE ACROSS THE (3,3) π -NUCLEON RESONANCE

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ABSTRACT

Pion double charge exchange reactions have been studied across the (3,3) π -nucleon resonance. The reactions $^{16,18}\text{O}(\pi^+, \pi^-)^{16,18}\text{Ne}$ and $^{24,26}\text{Mg}(\pi^+, \pi^-)^{24,26}\text{Si}$ were studied from 100 MeV to 300 MeV. Energy excitation functions of $d\sigma/d\Omega$ are reported for all targets. Also presented are angular distributions of $d\sigma/d\Omega$ for ^{18}O and ^{26}Mg .

INTRODUCTION:

Pion Double Charge Exchange (DCX) first received consideration in the early 1960's¹ soon after the discovery of Isobaric Analog States (IAS). Since pions exist as an isobaric triplet ($T_z = -1, 0, +1$) there was the possibility that they might be used to excite Double Isobaric Analog States (DIAS) in a manner similar to the IAS.

One of the simplest examples of the DCX reaction should be seen

with a nucleus having two valence neutrons outside a closed shell core, such as ^{18}O . Here, if the core can be neglected, DCX might be expected to proceed by a simple two-step mechanism whereby the valence neutrons undergo sequential single charge exchange, passing through the intermediate IAS to the final DIAS. In this model one would expect the DCX cross section to be sensitive to correlations between the valence neutrons.

Several attempts²⁻⁴ were made to study this reaction to two-body final states throughout the 1960's. Due to limited capabilities of available experimental facilities with poor final state resolution and low pion flux these experiments were only able to place upper limits for the cross section on a few targets. The resulting cross sections of about $1 \mu\text{b/sr}$ were in considerable disagreement with theoretical calculations of the time⁵⁻⁷.

The recent advent of the "meson factories", such as LAMPF, SIN, and TRIUMF, have opened the door to renewed investigation of the DCX reaction. Several experiments have been conducted over the past several years attempting to observe discrete, two-body, final states of the DCX reaction⁸⁻¹⁰. DCX transitions were observed but, again, poor resolution prevented unambiguous identification of the final states.

Recently the EPICS pion spectrometer facility at LAMPF has been modified to undertake a study of DCX reactions at forward angles. Transitions to discrete final states, both analog and non-analog, have been observed and are reported here for several nuclei.

EXPERIMENT:

A Texas-New Mexico State-LASL collaboration designed a system for investigating DCX reactions, from 5° to 35° in the lab, which was incorporated into the EPICS¹¹ system. A circular bending magnet (in the horizontal plane) was positioned after the pion scattering target. This allowed separation of the charge exchanged pions of one polarity from the outgoing beam of the opposite polarity (fig. 1). Eliminating the unwanted pions significantly reduced the counting rate of the spectrometer entrance drift chambers. Targets chosen for the study were the isotopic pairs $^{16,18}\text{O}$ and $^{24,26}\text{Mg}$. The Oxygen targets were isotopically enriched ice. ^{24}Mg was a pressed MgO powder and ^{26}Mg was a self supported foil. It was hoped that a set of data from these targets would provide detailed information for the understanding of the DCX reaction mechanism and the role of two particle correlations in complex nuclei.

The $^{16,18}\text{O}$ pair was chosen in the light of the many calculations performed on DCX with ^{18}O , and because of the picture of ^{18}O as a ^{16}O core coupled with two valence neutrons which made this a good pair for the study of two particle correlations. The $^{24,26}\text{Mg}$ pair was chosen for similar reasons and also because of the nuclear structure differences between magnesiums and oxygens. Calculations indicate that the DCX reaction should be strongly sensitive to features of the nuclear surface¹² and nuclear structure. This experiment is designed to investigate these effects.

RESULTS:

Here are presented some preliminary cross sections from this on-going experiment. The cross section errors are dominated by the counting statistics. The cross sections have been normalized by comparison to π -proton elastic scattering at each energy, using π -proton cross sections from phase-shift calculations¹³.

The $^{18}\text{O}(\pi^+, \pi^-)^{18}\text{Ne}$ data consists of an energy excitation function of $d\sigma/d\Omega$ and angular distributions at 164 MeV and 291 MeV. The DIAS (g.s., 0_1^+) in ^{18}Ne and also the first excited state (1.88 MeV, 2_1^+) were observed (fig. 2). This is the first such measurement across the (3,3) π -nucleon resonance. The curve exhibits what appears to be an absorption minimum near 180 MeV. Included for comparison is the previous data of Burman⁸. Also included in the same figure is the data obtained from the $^{16}\text{O}(\pi^+, \pi^-)^{16}\text{Ne}$ (g.s.) energy excitation function. It has a very different energy dependence in that it continues to fall as the energy increases beyond the resonance.

The angular distributions of $d\sigma/d\Omega$ (fig. 3) show that the first minimum falls at a larger angle for 291 MeV than at 164 MeV. It is possible, with a black disk model and $J_0(kr)=0$ at the minimum of the 291 MeV data, to reproduce the accepted size of ^{18}O . This seems to indicate that the double analog transition dominates much more at 291 MeV than in the region around 164 MeV.

A similar study is being conducted on the pair $^{24,26}\text{Mg}$. The energy excitation functions for this pair (fig. 4) show shapes strikingly similar to the $^{16,18}\text{O}$ pair, the only difference being the relative magnitude between the pairs. It would appear then, that in this

mass region, the nuclear structure effects are not very significant in this reaction.

The data shown here is only preliminary and should be treated as such. We do not expect that further analysis will change the reported figures by more than a few percent.

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FIGURE CAPTIONS

- FIGURE 1: Plan view of the EPICS double charge exchange system.
- FIGURE 2: Excitation functions of DCX on $^{16,18}\text{O}$ at 5° lab angle. Included is the previous data of Burman, et al. at 0° .
- FIGURE 3: Angular distributions of DCX on $^{16,18}\text{O}$ at 164 MeV and 291 MeV.
- FIGURE 4: Excitation functions of DCX on $^{24,26}\text{Mg}$ at 5° lab angle. Notice the similarity of shapes with those of $^{16,18}\text{O}$.

EPICS SPECTROMETER

700 MeV/C

0 2.4 6.8 10 2.0 3.0
GRAPHIC SCALE IN METERS







