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TITLE. ETA-MESON PRODUCTION EXPERIMENTS AT LAMPF

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ETA-MESON PRODUCTION EXPERIMENTS AT LAMPF

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ABSTRACT

Results of recent experiments on the (π, η) reactions in nuclei are reported.

I. INTRODUCTION

The existing meson factories have greatly advanced our knowledge on pion-nucleus interactions. In contrast, the roles of heavy mesons (η, μ, ρ, σ , etc.) in nuclear physics have received very little attention. Very little information exists on the interaction between these heavy mesons with nucleons, and almost nothing is known about their interaction with nuclei. About two years ago, we proposed to study the (π, η) reaction on nuclear targets at LAMPF. A detailed discussion on the physics objectives of the (π, η) reaction can be found in Ref. 1. In this talk, I will present the results obtained very recently on the (π, η) reaction.

II. THE EXPERIMENTS

We have made the following measurements:

(a) ${}^3\text{He}(\pi^-, t)\eta$ reaction

Tritons are detected with a magnetic spectrometer at forward angles ($5^\circ < \theta_{\text{lab}} < 15^\circ$) with 620 MeV/c and 680 MeV/c π^- beam.

(b) ${}^3\text{He}(\pi^-, \eta)t$ reaction

The LAMPF π^0 -spectrometer² and the University of Virginia ${}^3\text{He}$ target³ have been used to measure this reaction through the detection of $\eta \rightarrow 2\gamma$ decays. Cross sections at forward angles ($0^\circ < \theta_{\text{lab}} < 30^\circ$) have been measured at six beam momenta between 590 MeV/c and 700 MeV/c.

(c) (π^+, η) reaction on ${}^7\text{Li}$, ${}^9\text{Be}$ and ${}^{13}\text{C}$

Energy resolution in these measurements is optimized to search for discrete states.

(d) Inclusive (π^+, η) reaction on ${}^3\text{He}$, ${}^4\text{He}$, ${}^7\text{Li}$, ${}^9\text{Be}$, ${}^{12}\text{C}$, ${}^{27}\text{Al}$, ${}^{40}\text{Ca}$, ${}^{120}\text{Sn}$ and ${}^{208}\text{Pb}$ at 620, 650 and 680 MeV/c.

The data are currently being analyzed. Some of the preliminary results are presented here.

III. EXPERIMENTAL RESULTS AND DISCUSSION

Fig. 1 shows the triton spectrum obtained in the ${}^3\text{He}(\pi^-, t)$ measurement using the Large Aperture Spectrometer⁴ (LAS). A peak is observed in the triton spectrum at a location expected for the ${}^3\text{He}(\pi^-, t)\eta$ binary reaction. Note that this peak stands out rather clearly above some backgrounds such as the ${}^3\text{He}(\pi^-, t)\pi^+\pi^-\pi^0$ reaction. Preliminary analysis gives a cross section of $1\mu\text{b}/\text{sr}$ for the ${}^3\text{He}(\pi^-, t)\eta$ reaction. Since tritons are detected at forward angles, the measurement corresponds to backward angle in the ${}^3\text{He}(\pi^-, \eta)t$ reaction. The momentum transfer at this angle is $\sim 800\text{ MeV}/c$. This is the first time that a discrete final state is observed in the (π, η) reaction on nuclear targets.

To measure the forward angle cross sections of the ${}^3\text{He}(\pi^-, \eta)t$ reaction, the LAMPF π^0 spectrometer was used. Fig. 2 shows that η mesons are clearly identified from the invariant mass plot. The η energy spectra are shown in Fig. 3 for the ${}^3\text{He}(\pi^-, \eta)$ reaction at three pion beam momenta. At 680 MeV, which is near the free $p(\pi^-, \eta)n$ threshold, the ${}^3\text{He}(\pi^-, \eta)t$ reaction appears as a shoulder of the quasi-free ${}^3\text{He}(\pi^-, \eta)$ reaction. As the beam momentum is lowered to 620 MeV/c, the separation between the ground state transition and the quasi-free continuum improves greatly. At 590 MeV/c pion momentum, which is just above the absolute threshold of the ${}^3\text{He}(\pi^-, \eta)t$ reaction and below the threshold of any other ${}^3\text{He}(\pi^-, \eta)$ channels, the ${}^3\text{He}(\pi^-, \eta)t$ reaction is unambiguously detected. It is intriguing that the subthreshold (π, η) reaction has such an appreciable cross sections. Several theoretical efforts⁵⁻⁷ to calculate the (π, η) cross section on nuclei are underway. In particular, a DWIA calculation⁶ by Liu describes the shape of the ${}^3\text{He}(\pi^-, \eta)t$ angular distribution rather well, but underestimates the magnitude by a factor of ~ 5 .

Fig. 4 shows the energy-integrated (π^+, η) inclusive cross sections on a number of nuclei measured at three pion momenta. In an attempt to understand the observed mass dependence of the (π^+, η) inclusive cross sections, we use a version of the Glauber theory developed by Kolbig and Margolis⁸. In this model, the inclusive cross section is proportional to the effective nucleon number N_{eff} . The ingredients for calculating N_{eff} are the nucleon density distribution, the hadron-nucleon total cross sections for the incident and the outgoing particles. The only unknown input in this calculation is the total cross section for ηN . The various curves on Fig 4 correspond to calculations using various values of $\sigma(\eta N)$. A good description of the mass dependence at all beam momenta is obtained with $\sigma(\eta N) = 15\text{ mb}$. The extracted ηN total cross section is rather small compared to the πN total cross section of 34 mb at this energy. This is in qualitative agreement with the theoretical expectation¹ that ηN interaction is weaker than the πN interaction.

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Fig.1. Energy spectrum of the ${}^3\text{He}(\pi^-, t)$ reaction at 680 MeV/c.

Fig.2. Invariant mass plot for the two photons detected in the $\pi^- + {}^3\text{He}$ reaction at 680 MeV/c using the LAMPF π^0 spectrometer.

Fig.3. n -energy spectra measured in the ${}^3\text{He}(\pi^-, n)$ reaction at three π^- momenta. The arrows indicate the location of the ${}^3\text{He}(\pi^-, n)t$ transition.

Fig.4. Inclusive (π^+, η) cross sections on several target nuclei. The dashed curves are Glauber calculations using various ηN total cross sections.