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$Ar^{40}(d,p)$ EXCITATION FUNCTIONS OVER THE GROUND-STATE ISOBARIC ANALOG ENERGY REGION*

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In a recent experiment reported by Moore et al.,[1] an anomalous behavior of the excitation function of the reaction $Zr^{90}(d,p)Zr^{91}$ was found. These anomalies occurred at incident deuteron energies corresponding to formation through the (d,n) channel of the $T_>$ states of Nb^{91} whose parent analogs are the ground and first excited states of Zr^{91}. The de-excitation proton yield for the (d,np) reaction was also found to rise sharply in the vicinity of the first anomaly. These anomalies were interpreted as giving evidence for strong coupling between the analog $(Zr+p)$ and $(Nb+n)$ channels.

Following a suggestion by Moore, we have investigated the possibility of a similar effect in the reaction $Ar^{40}(d,p)Ar^{41}$. This target is of interest as the analogs in K^{41} of some of the low-lying states of Ar^{41} are known, from high-resolution measurements at this laboratory,[2] to exhibit fine structure.

According to the Coulomb energy difference of 6.87 ± 0.04 MeV found in Ref. 2, the threshold for excitation of the isobaric analog of the ground state of Ar^{41} through the reaction $Ar^{40}(d,n)K^{41}$ should occur at 2.86 ± 0.04 MeV. We have measured excitation functions from 2.5 to 3.1 MeV for eight of the stronger proton groups shown in Fig. 1 whose l_n values are given in Table I. The data were taken using an on-line DDP-224 computer. The cryogenic gas-target chamber and energy control system for the 3-MeV electrostatic generator have been described elsewhere.[2] Yield curves were taken in steps of 10 keV at a laboratory angle of 135° and with an average beam through the gas target of 30 μA. In order to concentrate initially on the gross-structure effects, we accurately adjusted the energy at each point and then swept the beam energy by ± 5 keV. This was accomplished by sweeping the field in the beam-analyzing magnet by the appropriate amount. The curves in Fig. 2 were additionally smoothed by performing a three-point running average. The error bars indicated are computed for the three-point sum and not for the individual count. Because of fluctuations in the effective target density resulting from geometric difficulties, normalization was accomplished by dividing the proton count at each point by the $Ar^{40}(d,$

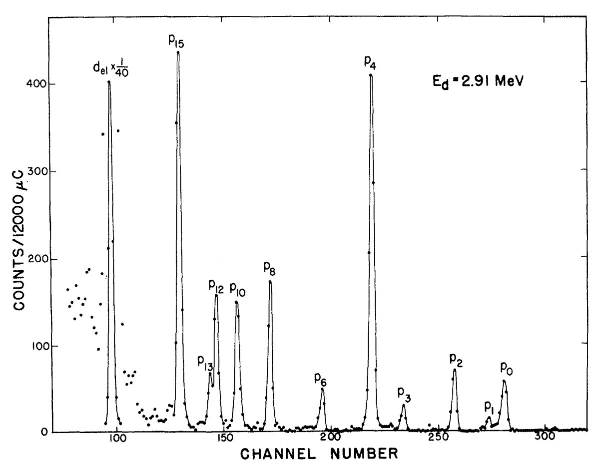

FIG. 1. A typical spectrum for one of the measurements with energy sweep ±5 keV.

Table I. Excitation energies and l_n values for the stronger levels measured in Ar^{41}. Spin and parity assignments are indicated wherever known from published data.

	Ar^{41*} (MeV)	l_n [a]	J^π [b]	J^π [c]
p_0	0	3	$\frac{7}{2}^-$	
p_2	0.517	1	$\frac{3}{2}^-$	
p_4	1.354	1	$\frac{3}{2}^-$	$\frac{3}{2}^-$
p_6	1.871	0		$\frac{1}{2}^+$
p_8	2.402	1		
p_{10}	2.746	1		
p_{12}	2.955	1		
p_{13}	3.017	1		
p_{15}	3.335	1		

[a]E. Kashy, A. M. Hoogenboom, and W. W. Buechner, Phys. Rev. 124, 1917 (1961).
[b]J. P. Allen, A. J. Howard, and D. A. Bromley, Bull. Am. Phys. Soc. 11, 81 (1966).
[c]Ref. 2.

$d)Ar^{40}$ yield. Our assumption that the (d,d) cross section is a smooth function appeared justified by several measurements. Measurements taken in 50-keV steps from 2.80 to 3.00 MeV show clearly the anomaly in the unnormalized p_0 yield and no anomaly in the (d,d) cross section. Similarly, the unnormalized data taken in 10-keV steps over the range 2.85-2.96 MeV shows the familiar behavior in the p_0 yield and again the (d,d) yield is smooth. Additional justification is offered by a completely smooth (d,d) yield observed in a high-resolution study over a span from 2.83-2.85 MeV. As seen in Fig. 2, the strong depression in the p_0 excitation function begins at 2.85 MeV and has its lowest point at 2.90 MeV. Little attempt was made to determine our absolute energy resulting in a probable error of ±10 keV.

In marked contrast to Moore's observations where a depression was seen only in a single proton group, our data show equally strong anomalies in p_0 and p_2 at the same energy. In fact, some sort of anomaly occurs near this energy in several proton groups indicating a possible relation to the (d,p) reaction strength. In the Zr^{90} data, taken at much higher energies, the de-excitation proton from the (d,np) reaction supported the hypothesis of strong coupling between the (d,n) and (d,p) channels. In this experiment the proton energy from the reaction $Ar^{40}(d,np)Ar^{40}$ was so low (~500 keV) as to prevent separation from background in the

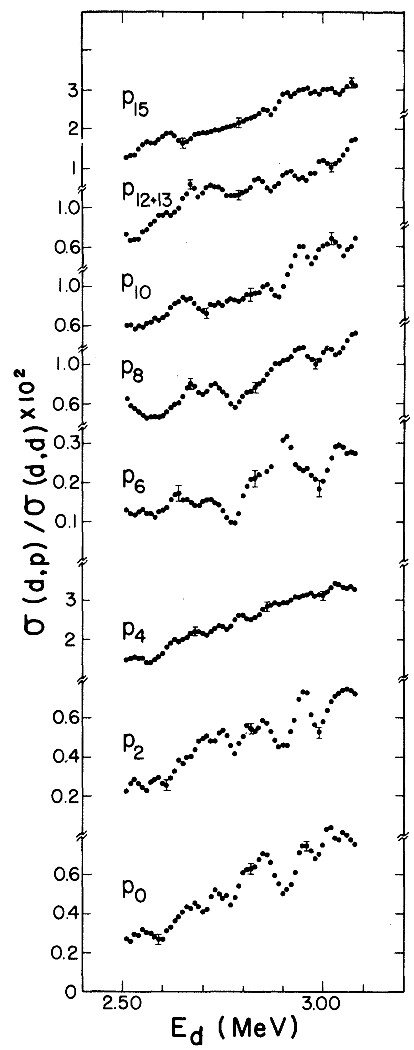

FIG. 2. Three-point running average of the excitation functions for the measured proton groups. The error bars indicate the statistical uncertainty for the three-point sum.

detector.

Additional attempts were made to measure the p_0 excitation function using the high-resolution data-acquisition system developed by Seibel et al.[3] Because of the low intensity (e.g., 200-300 counts/12 000 μC in the p_0 yield), we were able to measure only a single 4-keV span per charge of liquid helium in the cryogenic target chamber. The results of two such measurements, covering the region from 2.838-2.846 MeV, showed no evident fine structure. In these latter measurements, 120-eV steps were taken with a resolution of about 250 eV and with a yield at each point of about 60 counts.

Throughout this experiment, we were limited by the inherent design features of the target chamber. This chamber, specifically designed for producing a very thin gas target for use in high-resolution, high-yield experiments, prevented us from acquiring better statistics. However, a new target chamber is near completion that is intended to overcome many of the present disadvantages. Its 5-liter liquid-helium reservoir should nearly triple our present 90-min running time, and changes in design have been incorporated which should permit production of a thicker target. Using the new apparatus, a more detailed experiment is scheduled for the future.

The fact that the present experiment already shows not only the predicted anomaly, but also a more complex behavior than that evidenced in Moore's experiment, is, we feel, especially significant in view of the great current interest in analog states. We would like to express thanks to Dr. L. C. Biedenharn and Dr. W. P. Beres for helpful discussion.

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[1]C. Fred Moore, Charles E. Watson, S. A. A. Zaidi, James J. Kent, and James G. Kulleck, Phys. Rev. Letters 17, 926 (1966).

[2]G. A. Keyworth, G. C. Kyker, Jr., E. G. Bilpuch, and H. W. Newson, to be published.

[3]F. T. Seibel, N. R. Roberson, E. G. Bilpuch and H. W. Newson, to be published.

REPORTED COSMIC GAMMA-RAY SOURCE IN CYGNUS*

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Recently Duthie, Cobb, and Stewart[1] have presented evidence for a source of cosmic gamma rays at 304° right ascension and +35° declination with an intensity of $(1.5\pm0.8)\times10^{-4}$ γ's cm^{-2} sec^{-1}. In this Letter we wish to report the results of three high-altitude balloon flights with a γ-ray spark chamber which observed this same region of the sky. Two of these exposures were made prior to the Rochester flight while the third was nine months later. On none of the three flights did we observe any increase over the atmospheric background in the designated direction. Our conclusion is that either the Rochester result was due to a statistical fluctuation or an undetermined instrumental effect, or the source has increased in intensity by at least a factor 2 in nine months and then decreased again by at least a factor 10 in the following nine months.

Some results from our first flight have already been published[2] and the equipment is described in detail elsewhere.[3] The same system was used for the second flight except that the bottom counter in the coincidence telescope was changed to a Cherenkov counter. The sensitivity of this system was approximately the same as of that of the Rochester group. However, the uniform design, in contrast to their having a thick target followed by thin spark-chamber plates, provided better angular resolution, a lower energy threshold, and a rough energy determination. The third flight was made with an enlarged spark chamber whose sensitivity was greater by an order of magnitude.[4] The side anticoincidence panels (Fig. 1) are outside the acceptance cone of the coincidence counters. They greatly reduce spurious triggerings of the chamber by wide-angle

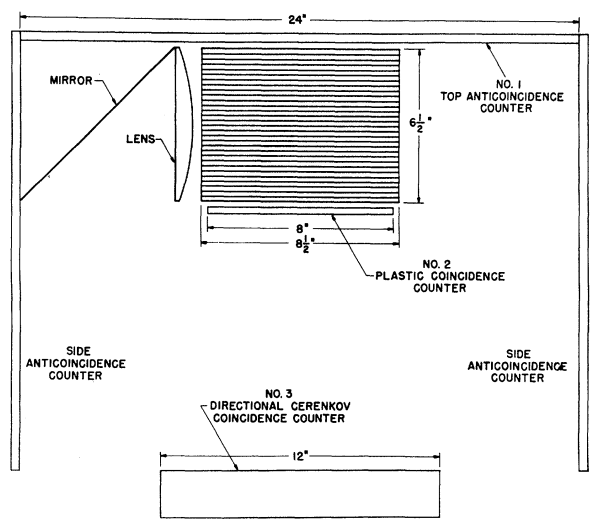

FIG. 1. The arrangement of the spark chamber and triggering counters is shown. There are 30 gaps of 0.5-cm spacing and the plates are 0.050-cm stainless steel.