# LEWIS EFFECT IN RESONANCE YIELD CURVES*

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Lewis[1] has recently pointed out that a thick-target yield curve taken at a narrow resonance with a charged particle beam of high-energy resolution should have a maximum just above the resonance energy followed by a shallow minimum, before it assumes a constant value. The qualitative explanation for this phenomenon, which the authors have chosen to call "the Lewis effect," is as follows: In passing through target material a charged particle loses energy in discrete steps $Q$. If some of these steps are larger than the natural width of a narrow resonance, some of the particles incident on a target at an energy well above the resonance energy, $E_R$, will jump over the resonance. If particles are incident at $E_R$ then all will have for a finite time the correct energy to interact. The yield curve should therefore exhibit a peak near $E_R$.

Gamma-ray yield curves from the $\mathrm{Al}^{27}(p,\gamma)\mathrm{Si}^{28}$ resonance reaction at 992 kev were studied with a proton beam having an energy spread at half maximum of about 125 ev. The natural width of this resonance is 80 ± 40 ev.[2] Yield curves were initially taken from aluminum films formed in the target chamber by evaporation of aluminum from a tungsten filament. A peak in the yield curves appeared but could not be reproduced. This was interpreted as being due to the accumulation of surface deposits on the target. A new method of target preparation was developed[3] in which aluminum is slowly and continuously deposited on the target backing while taking data.

Figure 1 shows several yield curves exhibiting the Lewis effect. Curve $A$ is a yield curve calculated as outlined below. The data labelled $B$ and $C$ were taken during continuous evaporation of aluminum. Curves $D$ and $E$ were initial runs from two different targets prepared by filament evaporation; subsequent runs in both cases failed to reveal the Lewis peak.

The yield per proton at a mean beam energy $E_b$ from an infinitely thick homogeneous target is given by

$$Y(E_b)=n_A\int_{E_i=0}^{\infty}\int_{E=0}^{\infty}g(E_b,E_i)\times\sigma(E_R,E)\eta(E,E_i)dEdE_i, \qquad (1)$$

where $n_A$ is the number of aluminum atoms per unit volume, $g(E_b,E_i)dE_i$ is the probability that a proton in the beam of mean energy $E_b$ has an incident energy between $E_i$ and $E_i+dE_i$, $\sigma(E_R,E)$ is the cross section for the resonance, and $\eta(E,E_i)dE$ represents the probability that a proton incident at an energy $E_i$ has an energy between $E$ and $E+dE$ somewhere inside the target.

The probability $p(Q,E)dQ$ that a proton at an energy $E$ will suffer a collision in which it loses

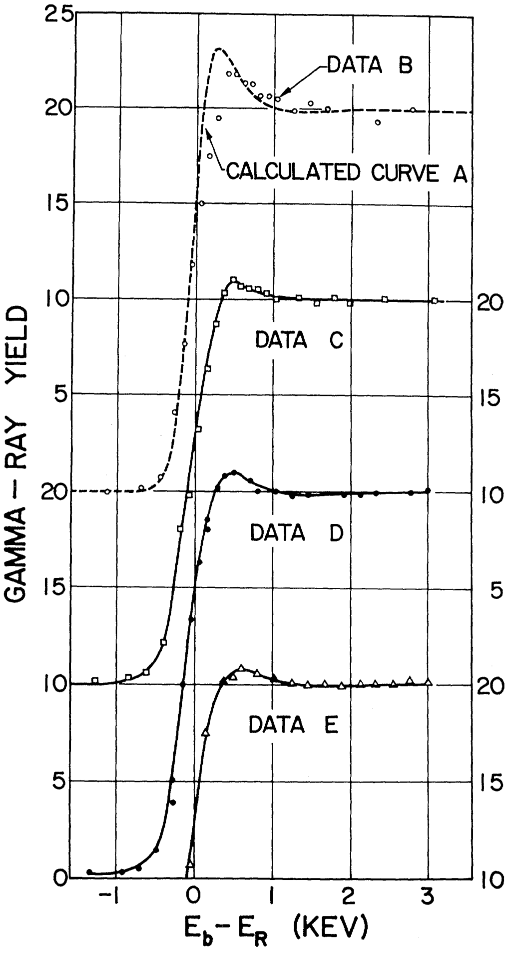

FIG. 1. Thick-target yield curves showing the Lewis effect from the $\mathrm{Al}^{27}(p,\gamma)\mathrm{Si}^{28}$ resonance at 992 kev. Mean beam energy, $E_b$, is plotted relative to the resonance energy, $E_R$. The position of $E_R$ is determined by the calculated yield curve. Plateau yields are normalized for easy comparison of peak amplitudes.

energy between $Q$ and $Q+dQ$ is given by[4]

$$p(Q,E)dQ = (K/EQ^2)dQ, \qquad (2)$$

where $K$ is a constant. Using for this resonance $Q_{\text{min}} = 12.3$ ev and $Q_{\text{max}} = 2160$ ev, the function $\eta(E, E_i)$ was numerically calculated on a computer using a Monte Carlo method.

The function $\eta(E, E_i)$ gives the yield per proton at energy $E_i$ from a resonance of infinitesimal width with a monoenergetic beam incident on the target. To account for nonzero resonance width and finite-beam energy resolution, the products of $\eta(E, E_i)$ values and thin-target yield curve values were graphically integrated to give curve $A$ in Fig. 1. The thin-target curve chosen for the calculation was from a target of 60-ev thickness.

Curve $A$ exhibits the peak and shallow minimum predicted by Lewis. The amplitudes of the peaks on experimental yield curves vary by a factor of two. This strongly suggests that surface contamination of the target plays an important role even on targets being continuously evaporated. Some of the discrepancy between the calculated curve of Fig. 1 and the data points $B$, which exhibit the highest experimentally observed peak, may be attributed to contaminants. On the other hand, the peak in the calculated curve may also be too high because of approximations in stopping-power theory.

The point of half plateau yield on the calculated yield curve, which is commonly assumed to be $E_R$, does not fall at $E_R$. For the parameters used here, the half-value point is about 100 ev below $E_R$.

Experimental work is being extended to other resonance reactions and an attempt will soon be made to utilize higher beam energy resolution. Calculations have shown that the Lewis peak increases in amplitude as resolution improves and as the values of $Q_{\text{max}}$ and $Q_{\text{min}}$ increase.

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[4] Robley D. Evans, The Atomic Nucleus (McGraw-Hill Book Company, New York, 1955), Chap. 18.

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# ASYMMETRY PARAMETERS IN THE DECAYS $\Sigma^+ \rightarrow p + \pi^0$ AND $\Lambda \rightarrow p + \pi^-$*

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In recent years, several authors have proposed theories that predict, either on the basis of various forms of global symmetry and the $|\Delta\vec{T}| = \frac{1}{2}$ rule,[1-6] or on the basis of extended chirality invariance,[7] that the asymmetry parameters in the decays $\Sigma^+ \rightarrow p + \pi^0 (\alpha_0)$ and $\Lambda \rightarrow p + \pi^- (\alpha_\Lambda)$ should obey the relations $\alpha_0 \approx -\alpha_\Lambda$. Here we have

$$\alpha = 2\text{Re}(S^*P)/(|S|^2 + |P|^2),$$

where $S$ and $P$ are the amplitudes for the two possible angular-momentum channels in each decay. Other theories predict the same sign for $\alpha_0$ and $\alpha_\Lambda$.[8,9] Asymmetry measurements have shown $|\alpha_0|$ and $|\alpha_\Lambda|$ to be large.[10-12] Two published measurements of the sign of $\alpha_\Lambda$ are in disagreement.[13,14] The experiment reported in this Letter was designed to establish the signs and magnitudes of both $\alpha_0$ and $\alpha_\Lambda$ by measuring the polarization of the decay proton from $\Sigma^+ \rightarrow p + \pi^0$ and $\Lambda \rightarrow p + \pi^-$ with a carbon-plate spark chamber.

Figure 1 shows the apparatus used in the experiment. Positive pions of 1.19-Bev/$c$ momentum from the Bevatron were incident upon a liquid-hydrogen target, producing the reactions $\pi^+ + p \rightarrow \Sigma^+ + K^+$, $\Sigma^+ \rightarrow p + \pi^0$. During approximately one-third of the run, the hydrogen target was replaced by a block of lithium deuteride. In this case, $\pi^+$ mesons of 1.02-Bev/$c$ momentum produced the reactions $\pi^+ + n \rightarrow \Lambda + K^+$, $\Lambda \rightarrow p + \pi^-$. The production of a $\Sigma^+$ or $\Lambda$ hyperon was indicated as in earlier experiments[10] by the identification of a $K^+$ with a counter telescope, including detection of the decay of the $K^+$ in the large water Čerenkov counter $C_K$. The hollow-plate spark chamber in the $K^+$ telescope and the carbon-plate "proton" spark chamber were triggered by a coincidence between the $K^+$ telescope signal, the signal from the "proton" counter telescope that detected particles with $v/c < 0.75$ entering the carbon-plate chamber, and the pulse from a gas Čerenkov