The dependence of β on k and A can be interpreted in terms of a classical picture of exponential absorption with distance, the absorption coefficient being related to the observed nucleon-nucleon total cross sections. The energy variations of the cross sections are best understood in terms of the basic formulas for the partial reaction and total cross sections:

$$\sigma_l^{(r)} = (1 - |\eta_l|^2)(2l+1)\pi\lambda^2,$$
$$\sigma_l^{(t)} = (1 - \mathrm{Re}\eta_l)\,2(2l+1)\pi\lambda^2.$$

For small real η, $\sigma_l^{(r)}$ is less sensitive to changes in η than $\sigma_l^{(t)}$, since the former is a quadratic function of η whereas the latter is linear. In addition, the reaction cross section does not depend on the phase of η, whereas the total cross section does. The observed large energy variation in the total cross section can only be obtained by choosing the phase for η close to zero.

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SECOND RESONANCE IN PION PHOTOPRODUCTION *

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Recently several authors have made attempts[1-3] to determine the angular momentum and multipole state in which the alleged second resonance in pion photoproduction takes place. Qualitative arguments have been advanced concerning the features of the angular distribution[2] and the recoil nucleon polarization[3] in case of unpolarized incident photons. The present note discusses another type of experiment which might help to determine the resonating state. It is the measurement of the differential cross section for polarized photons. In particular, it is proposed that $(d\sigma/d\Omega)_\perp$, the differential cross section for photons polarized perpendicular to the production plane, be measured. This quantity has the great advantage that even in the case of charged pions the meson current (or photoelectric term) does not contribute to it. It has been shown[4] that due to the change in sign of its interference terms, the meson current term becomes very important for charged pions in the region between the first resonance and 500-Mev photon laboratory energy. No investigations have been made above 500 Mev, but there is no reason to believe that at high energies we would again encounter the somewhat fortuitous situation that prevails below the first resonance, where the interference terms of the meson current contribution cancel to a great extent its own square contribution. On the other hand, it is not simple to include the effect of the meson current term in qualitative considerations, and in fact for instance reference 2 omits it. Whether this omission alters the qualitative conclusions is not known at the present. It is an advantage, therefore, to be able to say that the considerations in this note, like those in reference 3, are completely independent of the meson current term.

In the absence of the meson current term the important contribution, at the second resonance, will come from the S-wave term and the resonance state. In making this statement we assume that the various nonresonating P states (including the state which gives the first resonance) contribute relatively little, compared to the two states mentioned above. The goodness of this assumption is open to question until a quantitative study is made of the entire problem of high-energy photoproduction. Assumptions of similar nature, however, are also made in the arguments of references 2 and 3.

With the above assumptions it can be shown that if and only if the second resonance is in the $D_{\frac{3}{2}}$, $E1$ state as Peierls[2] suggests, will $(d\sigma/d\Omega)_\perp$ be isotropic. This conclusion can be arrived at from the equations

$$|M|_\perp^2 = \sum_{i=0}^{5} A_i x^i, \tag{1}$$

where

$$A_i = \sum_{j+k=i} U_j^{(k)}, \quad j = 0, \ldots 4; \; k = 0,1 \tag{2}$$

and

$$U_j^{(0)} = \sum_{\alpha+\beta=j} (H_{1\alpha}^* H_{1\beta} + H_{2\alpha}^* H_{2\beta}), \quad \alpha,\beta = 0,1,2 \tag{3}$$

$$U_j^{(1)} = -2 \sum_{\alpha+\beta=j} \mathrm{Re}(H_{1\alpha}^* H_{2\beta}). \tag{4}$$

We denoted here the matrix element by M, and $x \equiv \cos\theta$, where θ is the production angle in the center-of-mass system. In the above equations

$$H_{\mu\nu} = \sum_n c_{\mu\nu,n} B_n, \quad \mu=1,2; \; \nu=0,1,2 \tag{5}$$

where B_n is the amplitude of a certain angular momentum and multipole state, described by the index n, and $c_{\mu\nu,n}$ is a 6 by n matrix. For the first ten angular momentum states this matrix is

μ	ν	$S\frac{1}{2}$ $E1$	$P\frac{1}{2}$ $M1$	$P\frac{3}{2}$ $M1$	$P\frac{3}{2}$ $E2$	$D\frac{3}{2}$ $E1$	$D\frac{5}{2}$ $E3$	$D\frac{3}{2}$ $M2$	$D\frac{5}{2}$ $M2$	$F\frac{5}{2}$ $E2$	$F\frac{5}{2}$ $M3$
1	0	1	0	0	0	1	-3/2	3	-3	0	0
1	1	0	0	3	3	0	0	0	0	3	12
1	2	0	0	0	0	0	15/2	0	15	0	0
2	0	0	1	2	0	0	0	0	0	0	-9/2
2	1	0	0	0	0	0	0	6	9	0	0
2	2	0	0	0	0	0	0	0	0	0	45/2

.(6)

The derivation of these results will be given later in connection with a quantitative study of high-energy photoproduction. We note here only that the above notation in motivated by the form in which Chew et al.[5] expressed the contributions of the various angular momentum states to the photoproduction amplitude. In our notation the $H_{\mu\nu}$'s depend only on the $\mathcal{F}_\mu$'s ($\mu=1,\ldots,4$) of reference 5, and ν gives the power of x arising from the Legendre polynomials in $\mathcal{F}_\mu$. On the other hand, the particular bilinear combinations of $H_{\mu\nu}^*$ and $H_{\mu\nu}$ which constitute the $U_j^{(k)}$'s depend only on the way the four vectorial expressions of reference 5 enter the formula for the cross section. Thus j gives the power of x contributed by the $\mathcal{F}_\mu$'s, and k the power of x contributed by the vectorial forms.

One can see from the above equations that the angular distribution is isotropic if and only if

$$U_j^{(1)} = 0 \quad \text{for all } j, \tag{7}$$

and

$$U_j^{(0)} = 0 \quad \text{for all } j \neq 0. \tag{8}$$

The matrix (6) shows that, barring extremely fortuitous cancelations, these conditions are satisfied if and only if we have a linear combination of the $S\frac{1}{2}$, $E1$ and $D\frac{3}{2}$, $E1$ states.

It should be noted that the precise form of Eqs. (1) through (6) will be altered if angular momentum states even higher than those listed in Eq. (6) are considered but the final conclusion remains unchanged.

The experiment proposed here is a more difficult one than the measurement of the nucleon polarization suggested by reference 3. Production of pions by polarized photons, however, has been observed at Stanford[6] and thus the experiment is not unfeasible. Thus the present scheme might become a third, independent way of determining the state involved in the second resonance.

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POLARIZATION OF NUCLEONS IN INELASTIC SCATTERING FROM NUCLEI*

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Elastic scattering of nucleons by nuclei at high energies has been treated by several authors,[1] following the methods introduced by Watson and collaborators.[2] From a knowledge of the nucleon-nucleon scattering amplitude as given by a potential model or a phase-shift analysis[3] the high-energy elastic scattering of nucleons from nuclei, especially in the forward direction, can be calculated; for an even-even