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SUMMARY OF THE RESEARCH PROGRESS MEETING OF APRIL 19, 1951

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September 17, 1951

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Berkeley, California

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SUMMARY OF THE RESEARCH PROGRESS MEETING OF APRIL 19, 1951

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Some Heavy Metal Energy Cycles. Wm. Jenkins

A useful tool in investigating the decay properties of the heavy elements is the closing of the energy cycle. For example, in the U-Th-Pa-Ac cycle (Fig. 1) since the energy of the β transition from Pa to U and the α transitions are known, the Ac-Th transition energy may therefore be estimated. The method assumes that the transitions are all in the ground state, which is usually true for α emitters. Experimental work gives this result:

$$Th^{232}\ (180\ \text{Mev d, d 2p})\ Ra^{230} \xrightarrow[\beta]{63\ \text{min}} Ac^{230} \xrightarrow[\beta]{} Th^{230}$$

The cross section was too small (10^{-5} barns) for the particles to be detected in the β-spectrometer but the endpoints were observed to be 1.2 Mev and 2.2 Mev respectively. However, substituting this latter energy into the cycle and comparing 4.84 + 1.9 = 6.74 with 2.2 + 4.35 = 6.55, it is seen that an error has been made, probably in assuming the 1.9 β transition to be ground state. For the Pa-Ac-Th-Ra cycle the results are better: 4.35 + 0.2 = 4.55 and 1.2 + 3.40 = 4.60. The experimental data is given in Fig. 1.

Another example is illustrated in Fig. 2---underlined values are those estimated by this method, the others are experimental data. Starting with the Ac-Th transition the energy was measured with a spectrometer (Fig.3) and the value used to calculate the Pa-U and then the Np-Pu transition energies. The Np $\xrightarrow{\beta}$ Pa value, 0.51, corresponded exactly with experimental work and indicates that Np^{236} must be a pure β-emitter. The direction of decay between Cm^{240} and Am^{240} was not known until now, hence the double headed arrow; however,

the current study indicates that there must be K capture by the Am with the energy equal to 0.16 Mev and a limit of > 50 years and with a β limit of > 500 years. These facts are consistent with the transition energy. It is seen from this example that the properties of unknown isotopes can be predicted by this method of closing the energy cycle.

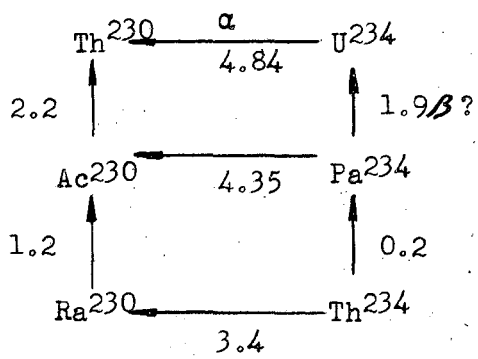

Fig. 1

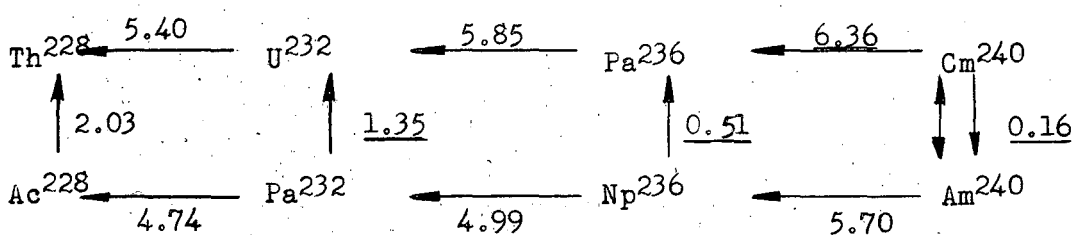

Fig. 2

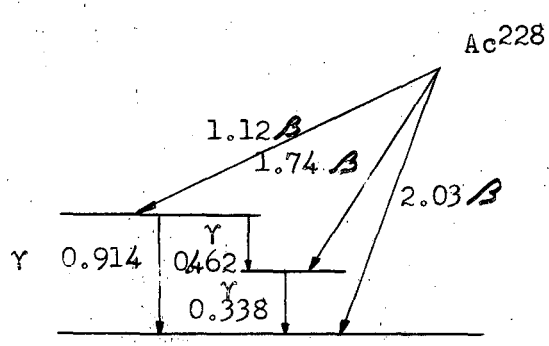

Fig. 3

D-P Scattering. Martin Stern.

The work on d-p scattering has been divided into three parts: (1) elastic d-p scattering, (2) inelastic d-p scattering with p-p interaction, and (3) the total d-p cross section. In all the experiments the 190 Mev scattered deuteron beam of the 184-inch cyclotron was collimated and directed toward carbon or polyethylene targets; the scattered particles were detected with stilbene scintillation counters.

1. The elastic scattering experiments are almost complete (See UCRL-1209). The pickup process occurs at 180°, the incoming deuteron colliding with the proton and exchanging with the proton at rest (Fig. 4). There are limitations to this work: one cannot go to small angles because of kinimatics; i.e., for every deuteron angle there are two possible proton angles; also at small angles the deuteron energy is similar to that of the beam and the particles cannot be detected in the counters (Fig. 5). The elastic d-p scattering cross section in the center of mass system is given as a function of the angle of deflection in Fig. 6. The data agrees with Chew's theory although there is some deviation at large angles; more work will be done in this area. Integration yields a total cross section of about 30 millibarns $\pm$ 8.

2. When a deuteron hits a proton these reactions are possible: (a) p-p, (b) n-p, (c) elastic scattering, and (d) inelastic scattering other than the (a) or (b) processes. However, small binding energies make p-p and n-p the most likely reactions, this fact being confirmed by cloud chamber work. If the target is considered to be at the center of a sphere and the counters moving on the surface of the sphere, it is found that the maximum counting rate occurs at an angle $\theta + \phi$ of 86° with an elastic peak at 70° also (Fig. 7). Differential cross section values for p-p scattering were 5.3 $\pm$ 0.7 and 6.2 $\pm$ 0.7 millibarns/ster. at 45° in the laboratory system. These results are surprising in view of Birge's value of 16 mb at 180°.

3. To determine total d-p cross sections, one gated counter was placed on each telescope arm and the two, not in coincidence, were swung about the target. The results are given in Fig. 8. Problems encountered were the inability to observe low energy protons and the counting of undesirable neutrons. Integrating under the curve in Fig. 8, one finds the total d-p cross section to be 140 mb $\pm$ 30, the attenuation cross section approximately 70 mb.

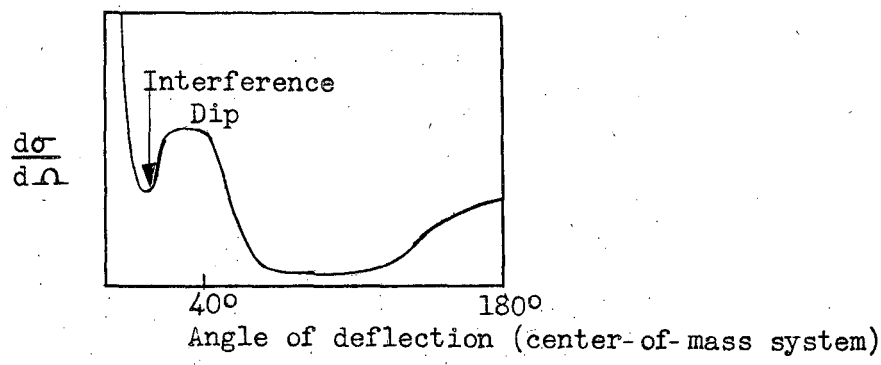

Fig. 4

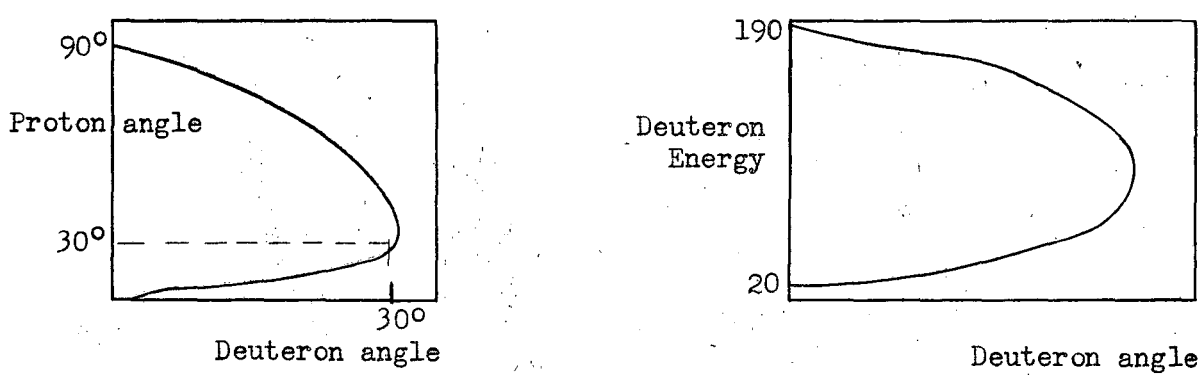

Fig. 5

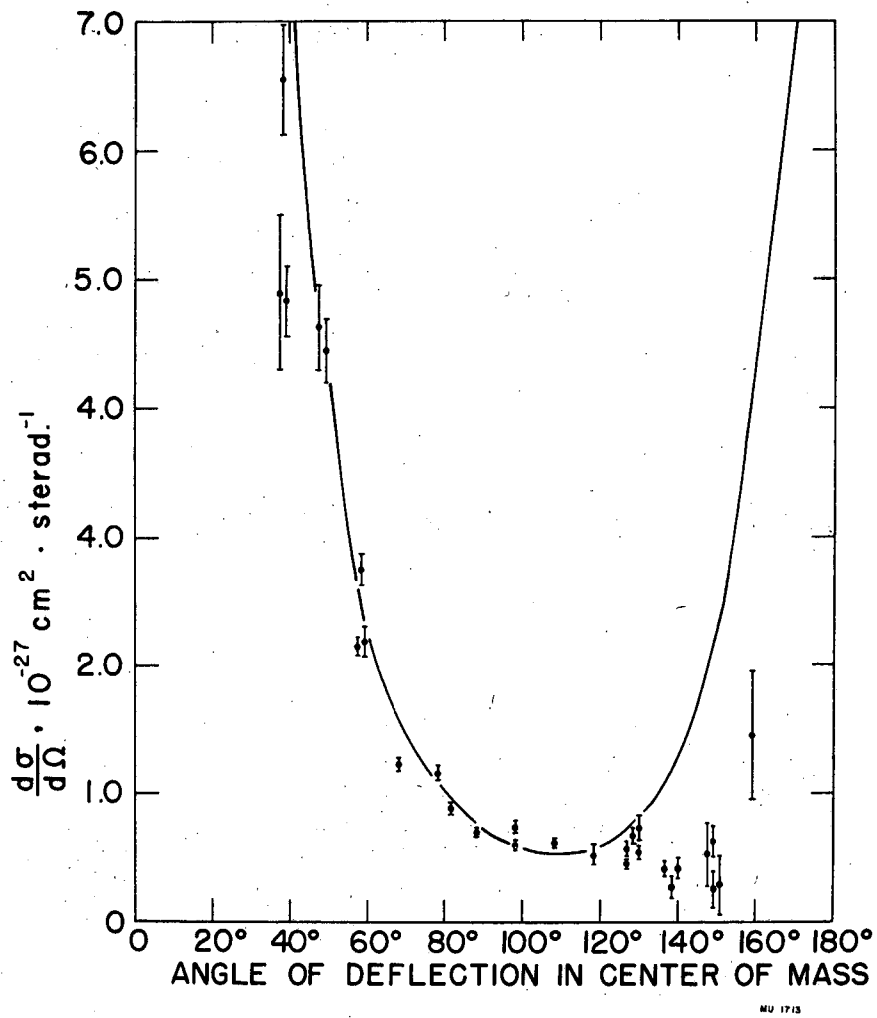
7.0
6.0
5.0
4.0
4.0
2.0
1.0
0
$\frac{d\sigma}{d\Omega} \cdot 10^{-27}$ cm^2 · sterad.$^{-1}$
0
20°
40°
60°
80°
100°
120°
140°
160°
180°
ANGLE OF DEFLECTION IN CENTER OF MASS
MU 1713

Fig. 6

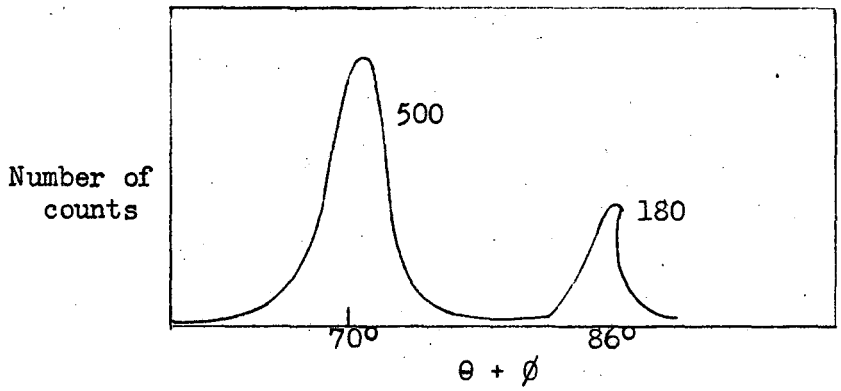

Fig. 7

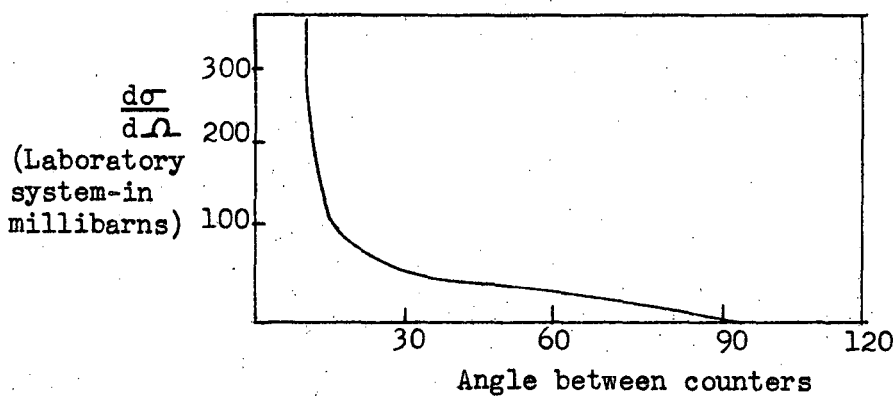

Fig. 8

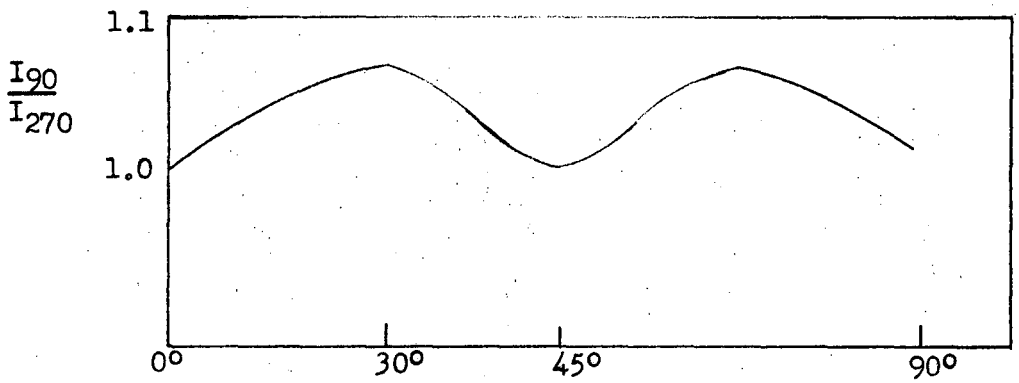

Fig. 9

Polarization in N-P Scattering. Louis Wouters.

At a recent progress meeting the speaker described an experiment to determine if polarization could be detected after multiple n-p scattering (See UCRL-1207). At that time it was planned to make counts at 30° and 45° from the second scatterer, but this proved to be infeasible for geometrical reasons. The setup now involves a changing of position of the first scatterer, i.e., the beam first travels 55-1/2" to the target at 190 Mev and 0° and then the probe is pulled out to 64" and 30° and the beam energy is 230 Mev. The energy of the outcoming neutron is the same (190 Mev) in both cases so the counters are not affected by this change and the rates at 45° and 30° may be compared (Fig. 9 - the minimum at 45° may be somewhat higher due to relativistic effects). This arrangement not only satisfies theoretical considerations but also has the advantage that equipment outside the cyclotron tank does not have to be moved.

If there were a strict p-n reaction one would expect a right-to-left ratio of 1.00 if no polarization were present and 1.10 for a complete elastic collision, although the character of the target (LiD) may lower the latter figure to 1.067. Results to date give a difference of 300 counts out of 4000 and a right-to-left ratio of 1.075 ± .075; none of the runs deviated beyond the statistics (2-3%). Runs with carbon targets gave the same data in both positions, within statistics, indicating as expected no polarization in this case. Further evidence that polarization occurred with the LiD target is that all changes in counting rate were observed on one and the same side of the beam.

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