Letters to the Editor

PUBLICATION of brief reports of important discoveries in physics may be secured by addressing them to this department. The closing date for this department is five weeks prior to the date of issue. No proof will be sent to the authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents. Communications should not exceed 600 words in length and should be submitted in duplicate.

Angular Distribution of Gamma Rays in Coulomb Excitation*

G. BREIT, M. E. EBEL, AND F. D. BENEDICT
Sloane Physics Laboratory, Yale University, New Haven, Connecticut
(Received August 2, 1955)

DISAGREEMENT of the angular correlation coefficient $a_2(\xi)$ of Alder and Winther[1] (AW) with experiment has been recently reported.[2] By means of improvements it has proved possible to remove most of the discrepancy. The work made use of the following steps.

The correspondence[3] between the semiclassical (SCT) and the quantum mechanical theories (QM) combined with numerical agreement[4] for zero excitation indicated the likelihood of a similar connection of QM and SCT radial matrix elements (RME) for finite excitation. It has been ascertained that QM and SCT values of the RME are nearly the same, provided SCT values for mean energies and only the integrals of Eq. (2′) of reference 3 are used.

On account of the disagreement between the signs of cross product terms in the AW formula with their numerical work and with a published[5] quantum formula for a_2, the SCT and QM formulas have been rederived. The AW formula was confirmed except for a sign in front of the whole coefficient of P_4. Calculations have been carried out for Pt employing the excitation energy $\Delta E=330$ kev of Pt^{194}. The combined effect of Rutherford scattering and of admixture of Pt^{196} with $\Delta E=358$ kev was inferred to be small by comparison of SCT calculations employing the signs of AW's numbers with calculations of McGowan and Stelson[2] on the effect of Rutherford scattering in which they use the sign just mentioned. The agreement with experiment is usually within the combined spread of statistical errors and differences between multichannel and single-channel values, as shown in Table I.

TABLE I. Comparison of angular factor a_2 with experiment for Pt for three proton energies E_p.

E_p Mev	a_2 Theory	a_2 Experiment
3.0	0.72	0.71 ±0.03
4.0	0.56	0.59 ±0.03
5.0	0.44	0.472±0.012

The somewhat arbitrary exaggeration of the experimental error appears justifiable in view of the absence of corrections for $\Delta E=358$ kev and Rutherford scattering corrections with cross term sign opposite to that of AW formula. Agreement with experiment regarding the slope of the (a_2,E_p) curve is improved mainly by the correct cross term sign; agreement with the absolute value of the experimental a_2 is improved by the change to the QM formula. After the present work was completed, the authors were kindly informed by Dr. L. C. Biedenharn of a slip in his derivation found independently and agreeing with the signs used here.

* This research was supported by the Office of Ordnance Research, U. S. Army.
[1] K. Alder and A. Winther, Phys. Rev. **91**, 1578 (1953).
[2] P. H. Stelson and F. K. McGowan, Phys. Rev. **98**, 249 (1955); F. K. McGowan and P. H. Stelson, Phys. Rev. **99**, 127 (1955).
[3] G. Breit and P. B. Daitch, Phys. Rev. **96**, 1447 (1954).
[4] Daitch, Lazarus, Hall, Benedict, and Breit, Phys. Rev. **96**, 1449 (1954).
[5] L. C. Biedenharn and C. M. Class, Phys. Rev. **98**, 691 (1955); Biedenharn, McHale, and Thaler, "Quantum Calculation of Coulomb Excitation" (preliminary version).

14-Mev (n,α) Cross-Section Measurements

H. G. BLOSSER, C. D. GOODMAN, T. H. HANDLEY, AND M. L. RANDOLPH
Oak Ridge National Laboratory, Oak Ridge, Tennessee
(Received July 27, 1955)

MEASUREMENTS have been made of the 14-Mev (n,α) cross sections of the isotopes Zn^{68}, Zr^{90}, Zr^{94}, and In^{115}. The results obtained differ radically from the trend reported in a previous survey of (n,α) reactions[1] and, in contrast with the earlier work,[1] are in order-of-magnitude agreement with the predictions of the statistical theory of nuclear reactions.[2] The agreement with statistical theory is (on the basis of these four measurements) of approximately the same degree as was found in a survey of (p,α) reactions[3] done at this Laboratory. Measurements of additional (n,α) cross sections are being made to ascertain the range of validity of the trend indicated by the four measurements reported here. Results of these additional measurements along with a more complete account of the present work will appear in another paper.

Cross sections were measured by a comparison technique in which the activity resulting from the reaction to be measured is compared with the activity resulting from a reaction of known cross section. For the known cross section, the value of 110 mb[4] for the 14-Mev (n,p) reaction on Fe^{56} was used. Targets consisted of a sandwich formed from a foil of zinc (or Zr, In, etc.) between two 1-mil iron foils. The activities of the front and back iron foils, which were equivalent to within about 2%, were averaged to determine the neutron flux passing through the target material in the center of the sandwich. After bombardment, the target material (atomic number Z) and the material

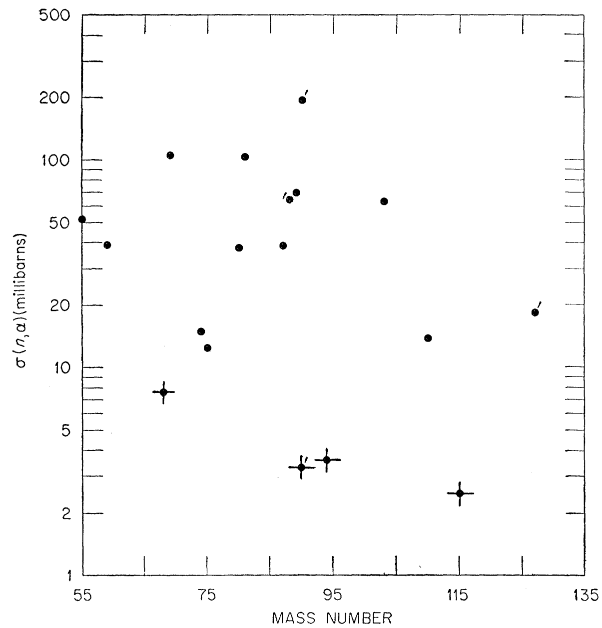

FIG. 1. (n,α) cross sections in millibarns. +—(n,α) cross sections observed in present experiment; ●—(n,α) cross sections observed in reference 1 for this mass region; ′—partial (n,α) cross section leading to an isomeric state.

of atomic number $Z-1$ were removed from the sample by radiochemical techniques. Samples were then counted under end-window Geiger counters and the induced (n,α) activities were determined by analysis of decay curves. In the case of zirconium, the decay curves were analyzed with the Oracle, the Laboratory's digital computer.

The cross section values obtained were: Zn^{68}, 7.6±0.8 mb; Zr^{90}, 3.3±0.6 mb; Zr^{94}, 3.6±0.5 mb; and In^{115}, 2.5±0.4 mb. In Fig. 1, these results are plotted along with the results from reference 1 for this mass region; the distinct difference between these results and the trend indicated by reference 1 may be seen. Zr^{90} is the only isotope included in both sets of measurements. For this isotope reference 1 reports a cross section of 194±107 mb. It should be noted that our value for the cross section on this isotope is in agreement with the results of recent measurements at Los Alamos by Brolley *et al.*[5] In view of the fact that chemical separations were not performed in the work of reference 1, it seems quite likely that the reported large (n,α) cross section on Zr^{90} is in considerable measure a result of (n,p) reaction on Zr^{92} which leads to a similar half-life. Examination of the (n,α) cross sections reported in that work indicates the possibility of a similar error in a number of the measurements so that the indicated trend is perhaps also in error. It is hoped that additional measurements now being undertaken will clarify this situation.

The authors which to express their deep indebtedness to Dr. B. L. Cohen for suggesting this experiment and for much useful discussion. The Cockcroft-Walton accelerator of the ORNL Biology Division provided the neutron source for these experiments.

[1] E. B. Paul and R. L. Clarke, Can. J. Phys. **31**, 267 (1953).
[2] J. M. Blatt and V. F. Weisskopf, *Theoretical Nuclear Physics* (John Wiley and Sons, Inc., New York, 1952).
[3] D. J. Coombe (to be published).
[4] *Neutron Cross Sections*, U. S. Atomic Energy Commission Report AECU-2040 (Technical Information Division, Department of Commerce, Washington, D. C., 1952), Supplement 2.
[5] Brolley, Bunker, Cochran, Henkel, Mize, and Starner, Phys. Rev. **99**, 330 (1955).

Mass Values of the *K* Mesons*

R. W. BIRGE, J. R. PETERSON, D. H. STORK, AND M. N. WHITEHEAD
Radiation Laboratory, University of California, Berkeley, California
(Received July 25, 1955)

ADDITIONAL data have been obtained from the stack of emulsions[1] exposed to 114-Mev *K* mesons at the Bevatron and from another stack exposed to 170-Mev *K* mesons. Both exposures were made with the use of the strong-focusing magnetic spectrometer.[2]

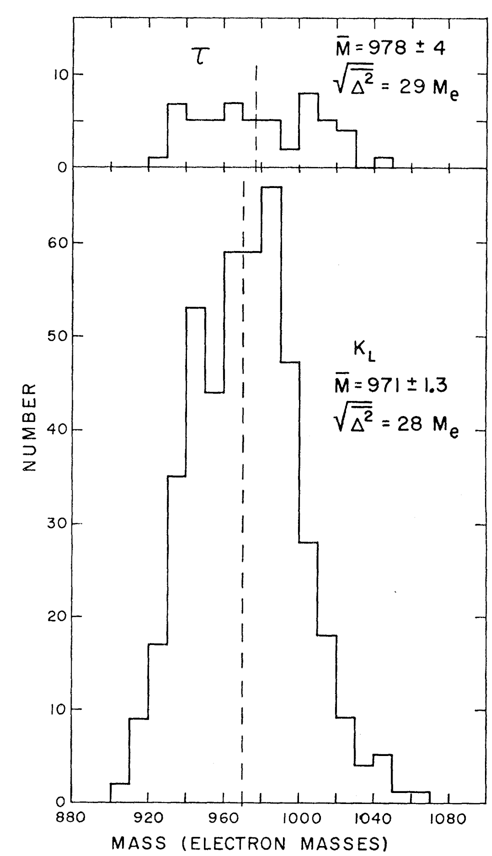

FIG. 1. Masses of 459 K_L and 55 τ mesons found in stack 16.