isotopic spin is conserved and if we assume that (a) there exists no charged particle of about the same mass as Λ^0 and (b) there exists no doubly charged particle of about the same mass as either Σ^- or K^-, then from the known reactions,[2]

$$\pi^- + p \rightarrow \Lambda^0 + K^0,$$
$$\pi^- + p \rightarrow \Sigma^- + K^+,$$

it is necessary to assume that the isotopic spin values for these particles are

$$I_\Lambda = 0, \quad I_K = \tfrac{1}{2}, \quad \text{and} \quad I_\Sigma = 1,$$

which is precisely the Gell-Mann scheme.[3] Thus, charge independence would imply that the differential cross sections for the above reactions (A_1) and (A_2) are the same.

$$\sigma(A_1) = \sigma(A_2).$$

On the other hand, information concerning the spins of K^- and Σ^- can be obtained by performing the reaction (B_1) together with its inverse reaction:

$$\Sigma^- + p \rightarrow K^- + d. \qquad (B_2)$$

From the principle of detailed balance the ratio of cross sections for these two reactions gives immediately the ratio $(2J_K+1)/(2J_\Sigma+1)$ with J_K and J_Σ as the spins of K^- and Σ^-, respectively.

Charge independence may also be verified by other reactions from K^- and d. However, they all involve some reactions with too many neutral particles as resultants, which make these reactions much harder to detect.

Absorption of K^- by He^4 or C^{12}.—It is also possible to verify the validity of charge independence by examining the absorption of K^- by He^4. We consider the following reactions:

$$K^- + He^4 \rightarrow \Sigma^0 + H^3, \qquad (C_1)$$

$$K^- + He^4 \rightarrow \Sigma^- + He^3, \qquad (C_2)$$

$$K^- + He^4 \rightarrow \Lambda^0 + H^3 + \pi^0, \qquad (D_1)$$

$$K^- + He^4 \rightarrow \Lambda^0 + He^3 + \pi^-, \qquad (D_2)$$

$$K^- + He^4 \rightarrow \Sigma^0 + He^3 + \pi^-, \qquad (E_1)$$

$$K^- + He^4 \rightarrow \Sigma^- + He^3 + \pi^0. \qquad (E_2)$$

If charge independence were true, the differential cross sections of the above reactions are related by

$$\sigma(C_2) = 2\sigma(C_1),$$
$$\sigma(D_2) = 2\sigma(D_1),$$
$$\sigma(E_1) = \sigma(E_2).$$

The same relations between these reactions still hold if one uses C^{12} instead of He^4 and adds two α particles to the right-hand sides of the above reactions.

The author wishes to thank Professor J. Steinberger, Professor R. Serber, and Professor C. N. Yang for discussions.

[1] See A. Pais, Proceeding of the Fifth Annual Rochester Conference on High-Energy Physics (to be published) for a review of these analyses.

[2] Fowler, Shutt, Thorndike, and Whittemore, Phys. Rev. **93**, 861 (1954).

[3] M. Gell-Mann, Phys. Rev. **93**, 933 (1953).

Further Observations of Negative K Mesons*

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CONTINUED examination of the emulsions for which observations of negative K mesons have been reported[1] has revealed 22 such particles producing stars at the end of their range. Measurements of the masses of those particles are presented below.

The experimental arrangement was like that sketched earlier,[2] but with the following differences: the proton energy was 2.8 Bev, the collimator aperture was narrowed to 1 inch, the mesons incident on the emulsions were emitted at $(4\pm1)°$ to the proton beam, and a magnet M (10 000 gauss) was interposed between the collimator and the stack of emulsions. The masses of the K^- mesons have been determined from their initial momenta and their ranges in the emulsions.

The mean momentum p of the meson beam was established in two ways. One way depended on measurements of the Cosmotron's magnetic field and the locations and orientations of target and collimator. This gave (310 ± 4) Mev/c for p; the error is due mainly to uncertainty in the value of the Cosmotron's field strength. The other way depended on the deflection of the negative pion beam by the magnet M; for this the collimator was narrowed to $\frac{1}{4}$ inch and the deflection was measured by locating the displaced pion beam in the emulsions. The correlation between p and deflection was established by the wire method to an accuracy of 0.5 percent. This procedure gave (316 ± 4) Mev/c for p; the error is due mainly to the statistical uncertainty in locating the beam's center in the emulsions.

An average of the two methods is taken, namely $p=(313\pm3)$ Mev/c. The average spread in momentum is ±8 Mev/c.

The emulsions were conditioned before packing in an atmosphere of 60 percent relative humidity. The spread in K^- ranges is entirely consistent with a unique mass value and the average spread in momentum. The average range of the K^- mesons is (45.8 ± 0.8) mm, a figure that includes a small allowance for packing material and a correction for distortion. Masses were computed with the range-energy relationship of

Baroni, Castagnoli, Cortini, Franzinetti, and Manfredini corrected for the different type and density of our emulsions.[3]

The average value of the K^- mass is found to be $(931\pm24)m_e$. The stated error is a standard deviation, calculated from the following contributions: from uncertainty in momentum, 16 m_e; from uncertainties in range, due to (a) statistical uncertainty in average range, 8 m_e, (b) emulsion distortion, 10 m_e, (c) uncertainty of moisture content, 7 m_e; from inaccuracy of range-energy relation, 9 m_e.

Clearly, the value is not accurate enough to decide whether the mass of these K^- mesons is or is not the same as the τ mass 965.5 m_e.[4] It is consistent with the recent $K_{\mu2}$ mass, 941 m_e.[5]

Besides these K^- mesons coming to rest, five making stars in flight have been identified, giving a collision mean free path of 20 cm, in approximate agreement, as noted previously,[1] with the geometrical mean free path (27 cm). Although tracks possibly due to ρK mesons (K particles that stop without producing visible products[6]) have also been observed in these emulsions, they do not appear numerous enough to alter that agreement significantly.

We take pleasure in acknowledging our indebtedness to the Cosmotron staff, to R. M. Sternheimer for computing the Cosmotron trajectories, to W. L. Homer for surveying the relevant positions, to J. W. Quinn for help in the experiments, and to M. Bracker, B. M. Cozine, A. C. Lea, J. D. Leek, and E. R. Medd for microscopy.

* Work performed under the auspices of the U. S. Atomic Energy Commission.

[1] J. Hornbostel and E. O. Salant, Phys. Rev. **98**, 218 (1955).
[2] J. Hornbostel and E. O. Salant, Phys. Rev. **93**, 902 (1954).
[3] Baroni, Castagnoli, Cortini, Franzinetti, and Manfredini (unpublished); preprint circulated by CERN, Geneva.
[4] Report of Committee on τ Mesons, Nuovo cimento **12**, Suppl. 2, 419 (1954).
[5] L. Leprince-Ringuet, Proceedings of the Fifth Rochester Conference on High Energy Physics, 1955 (to be published), p. 105.
[6] Report of Committee on K Particles, Nuovo cimento **12**, Suppl. 2, 433 (1954).

PHYSICAL REVIEW VOLUME 99, NUMBER 1 JULY 1, 1955

Proceedings of the American Physical Society

Minutes of the 1955 Spring Meeting of the Ohio Section at Ohio Wesleyan University, Delaware, Ohio, April 22 and 23, 1955

THE regular spring meeting of the Ohio Section of the American Physical Society was held at Ohio Wesleyan University, Delaware, Ohio, on Friday and Saturday, April 22 and 23, 1955. Friday morning was spent in viewing and judging the projects prepared by high school students of the state for the Junior Ohio Academy of Science. About one-third of the projects were in the field of physics. It is hoped that this attention will encourage these students to follow this interest in college.

The subject for discussion on Friday afternoon, "Recent Developments in the Application of Nuclear Energy," proved of such wide interest that the sections of physics and chemistry of the Ohio Academy of Science joined in our meeting. This gave us large numbers for the following invited papers: "Principles of Reactor Operation" by R. J. Stephenson, College of Wooster; "Disposal of Radioactive Wastes" by F. C. Mead, Jr., The Monsanto Chemical Company; "Radioactive Isotopes in Medicine" by G. W. Callendine, Jr., Ohio State University Medical Center; and "Food Sterilization by Radiation" by R. F. Robinson, The Battelle Memorial Institute, Columbus, Ohio.

On Saturday morning, eleven contributed papers were presented. No abstracts were provided for the following three: "Radio Detection of Meteors Using Standard Laboratory Equipment" by Horace T. Castillo, Wright Air Force Development Center; "A Study of the Spectroscopic Binary 5 Lacertae" by Philip C. Stanger, Ohio Wesleyan University; and "The Air Force Institute of Technology Engineering Curriculum" by William J. Price, U. S. Air Force Institute of Technology.

This being the annual business meeting of the Ohio Section, the following officers were chosen for the year 1955–1956; Chairman, Richard N. Thayer, Lamp Development Laboratory, General Electric Company, Cleveland, Ohio; Vice-Chairman, Edward S. Foster, Jr., University of Toledo, Toledo, Ohio; and Secretary-Treasurer, Leon E. Smith, Denison University, Granville, Ohio.

Abstracts of eight contributed papers follow.

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The Ohio Section
American Physical Society
Granville, Ohio