distribution,

$$f(\epsilon) \propto \exp[-(\epsilon/\epsilon_0)^2], \qquad (2)$$

which would result if scattering by acoustical phonons dominated both energy and momentum relaxation.[6] Apart from the fact that such an $f(\epsilon)$ predicts $\overline{\mu}_l \propto E^{-1/2}$, which is not observed, it also implies a constant value of θ/θ_0 equal to 0.925. The fact that the observed θ/θ_0 decreases smoothly to values lower than 0.925 shows that the change in $f(\epsilon)$ is not simply a transition from a Boltzmann to a Pisarenko distribution.

Our thanks are due to T. N. Morgan and P. J. Price for helpful discussions, and to J. C. Owens, J. F. Reid, and J. L. Staples for aid in the experimental work.

[1]P. J. Price, IBM J. Research Develop. 3, 191 (1959).
[2]T. N. Morgan, J. Phys. Chem. Solids 8, 245 (1959).
[3]M. A. C. S. Brown and E. G. S. Paige, Phys. Rev. Letters 7, 84 (1961).
[4]Energy relaxation noise is described, although not under that name, by the second term of Eq. (19) of reference 1.
[5]P. J. Price, J. Appl. Phys. 31, 949 (1960).
[6]J. Yamashita and M. Watanabe, Progr. Theoret. Phys. (Kyoto) 12, 443 (1954). The same results were obtained earlier by N. L. Pisarenko, Izvest. Akad. Nauk S.S.S.R., Ser. Fiz. 3, 631 (1938).

PION-PION RESONANCES IN A PURE $T=1$ STATE*

B. Sechi Zorn
Brookhaven National Laboratory, Upton, New York
(Received March 14, 1962)

Proton-proton interactions, in which a deuteron is formed leaving the created pions in a pure $T=1$ isospin state, have been studied in pictures taken in the BNL 20-inch hydrogen bubble chamber exposed to a 2.05-Bev proton beam at the Cosmotron.[1]

The deuterons were identified by momentum-bubble density measurements.[2] Each event in which a deuteron was identified was measured with a digitized microscope. The events were analyzed using reconstruction programs TRED I and TRED II, and were kinematically fitted to particular reactions with the program GUTS. In this way, 149 events corresponding to the reaction,

$$p+p \rightarrow d+\pi^+ +\pi^0, \qquad (1)$$

and 75 events corresponding to the reaction,

$$p+p \rightarrow d+\pi^+ +\pi^+ +\pi^-, \qquad (2)$$

have been observed out of 53 000 p-p interactions.[3]

Reactions (1) and (2) are particularly suited to the study of π-π interactions as the effect of nucleon isobars is strongly suppressed,[4] and as the pions are in a pure isospin state. Possible π-π interactions have been studied by determining the Q values, i.e., the kinetic energy in the rest system of the two and three pions produced in these reactions.

In Fig. 1 the frequency distribution of Q values for the $\pi^+\pi^0$ mesons of reaction (1) plotted in 25-Mev intervals is presented. In order to eliminate fortuitous fluctuation due to the choice of the particular Q-value interval used in constructing the histogram, an ideogram normalized to the same area was plotted, and it is indicated by a dashed line. The long dashed curve represents the Q-value distribution determined from a three-body phase-space calculation[5] normalized to the total number of events. The disagreement between this phase-space curve and the experimental data is apparent. A very narrow peak is observed at $Q \cong 285$ Mev, and within the experimental errors of ±15 Mev, its width is consistent with zero width. Barloutaud et al.,[6] Erwin et al.,[7] and Peck et al.[8] reported the presence of a peak at about the same position, and attribute it to a "dipion" called ζ of $T=1$. Another broader peak can be observed at about 450 Mev, but given the effect of a rapid decrease in available phase space beyond 475 Mev, it is difficult to determine the exact position of the peak or to establish its width. It is certainly in good agreement with the ρ particle having a Q value of 420 Mev, reported by many authors,[9] and with the reported full width of ~120 Mev.

In Fig. 2 the experimental Q-value distributions for the $\pi^+\pi^+\pi^-$ mesons of reaction (2) are presented in a plot similar to that of Fig. 1. The long dashed curve represents the Q value according to covariant four-body phase space as calculated by Hoang and Yung[10] and is normalized to the total number of events. No striking deviation from the phase-space curve is seen, but there is an indication of a narrow accumulation of events at a Q value of ~235 Mev. Due to poor statistics and to the lack of an exact four-body phase-space cal-

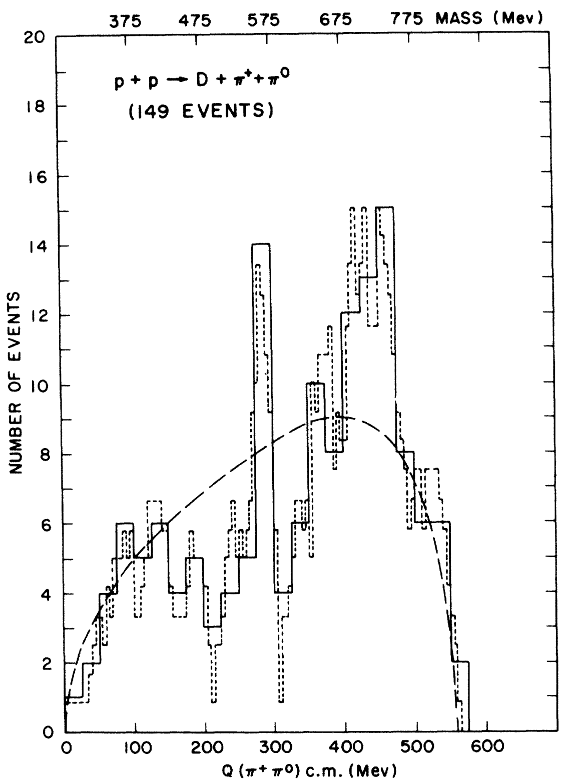

FIG. 1. $Q(\pi^+\pi^0)$ value distribution. Histogram in 25-Mev interval (full line). Ideogram obtained assuming the average experimental error of ±15 Mev and summed in 5-Mev intervals (dashed line). Predictions of statistical model (long dashed curve). A corresponding mass scale is also shown.

culation, these data are difficult to interpret.

Experimental details, cross sections for the different reactions, and an analysis of deuteron formation will be given in a paper to be published.

The author is indebted to Dr. G. T. Zorn for stimulating discussions and continuous help and to Dr. E. O. Salant for his encouragement and his interest in the problem. She would like to express her gratitude to Mrs. B. Cozine and Mr. J. Greener for their intelligent scanning and accurate measuring, to Mrs. V. Austen for her efficient aid in data handling, and to Dr. D. K. Robinson for his help in using the computer program.

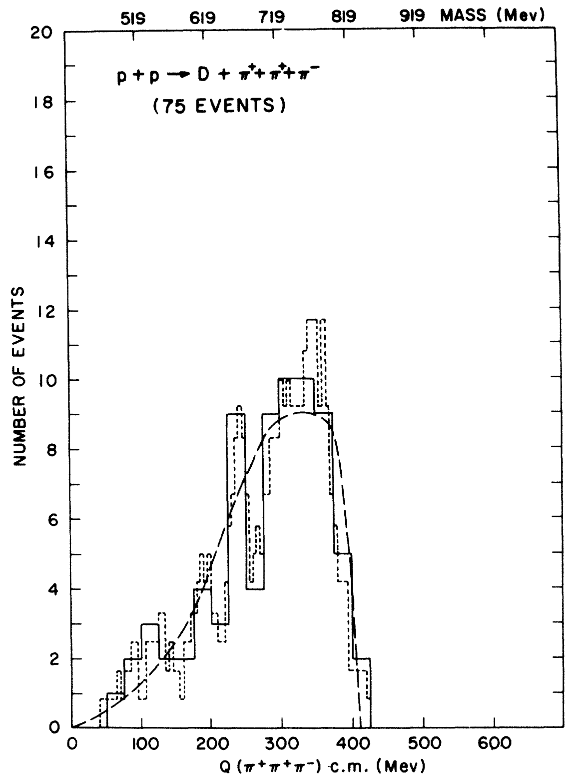

FIG. 2. $Q(\pi^+\pi^+\pi^-)$ value distribution. Histogram in 25-Mev interval (full line). Ideogram obtained assuming the average experimental error of ±15 Mev and summed in 5-Mev intervals (dashed line). Predictions of statistical model (long dashed curve). A corresponding mass scale is also shown.

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

[1]The exposure was made by E. Pickup, D. K. Robinson, and E. O. Salant [Phys. Rev. 125, 2091 (1962)] to whom the author is grateful for putting the pictures at her disposal.

[2]B. Sechi Zorn and G. T. Zorn, Brookhaven National Laboratory Report BNL-5866 [Nuovo cimento (to be published)].

[3]See B. Sechi Zorn, Bull. Am. Phys. Soc. 7, No. 4 (1962), for total and partial cross sections for deuteron formation.

[4]L. I. Schiff, CERN Report 60-32, Theoretical Study Division, 1960 (unpublished), and R. E. Peierls (private communication).

[5]M. M. Block, Phys. Rev. 101, 796 (1956).

[6]R. Barloutaud, J. Heughebaert, A. Leveque, J. Meyer, and R. Omnes, Phys. Rev. Letters 8, 32 (1962).

[7]A. R. Erwin, R. March, W. D. Walker, and E. West, Phys. Rev. Letters 6, 628 (1961).

[8]C. C. Peck, L. W. Jones, and M. L. Perl, Technical Report No. 4, University of Michigan, 1962 [Phys. Rev. (to be published)].

[9]See Barloutaud *et al.* (footnote 6), references 1 to 8.

[10]T. H. Hoang and J. Yung, University of California Radiation Laboratory Report UCRL-9050, 1960 (unpublished).