The relation between the sense of the polarization of a domain and its extinction position, or the arrangement of the optic axes, can be determined by observing which of the two extinction positions a specimen possesses after it has been turned into a single domain by the effect of a field applied in one sense. The result is illustrated in Fig. 2, in which the crystallographic axes of domains which are parallel, or almost parallel, to the *a*, *b*, and *c* axes of a large pseudorhombic crystal are called *a*, *b*, and *c*, respectively, for simplicity.

Further investigations are in progress.

The authors are grateful to Dr. H. Kawai for supplying the rochelle salt crystals, and are also much indebted to Mr. Y. Katsui who has given much valuable help and many suggestions in the course of this work.

[1] B. Matthias and A. von Hippel, Phys. Rev. **73**, 1378 (1948). P. W. Forsbergh, Jr., Phys. Rev. **76**, 1187 (1949).

The γ-Ray Spectrum Resulting from Capture of Negative π-Mesons in Hydrogen

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August 8, 1950

PRELIMINARY results concerning the γ-ray spectrum resulting from the capture of π^--mesons in hydrogen have been reported in a previous letter.[1] The purpose of this note is to present more conclusive data and to indicate the resultant mass values for the neutral meson. A more detailed report is in preparation.

The apparatus and geometrical arrangement used are similar to the instrumentation previously reported.[1] The principal improvement is the use of a 32-channel pair spectrometer (Fig. 1). Two sets of spectra are shown: one (Fig. 2) taken with the spectrometer set at 100 Mev and one (Fig. 3) with the center set at 70 Mev. Figure 2 clearly shows that both processes discussed previously coexist, namely:

$$\pi^- + p \rightarrow n + \gamma, \quad (1)$$

$$\pi^- + p \rightarrow n + \pi^0. \quad (2)$$
$$\downarrow$$
$$2\gamma$$

Figure 3 permits a fairly accurate determination of the π^0-mass. We obtain from Fig. 3 and the kinematics pertaining to Eq. (2):

$$M_{\pi^-} - M_{\pi^0} = 10.6 \pm 2.0 \text{ electron masses.}$$

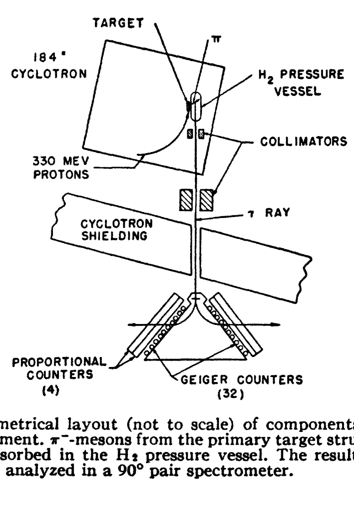

FIG. 1. Geometrical layout (not to scale) of components of the π^--absorption experiment. π^--mesons from the primary target struck by 330-Mev protons are absorbed in the H_2 pressure vessel. The resultant γ-rays are collimated and analyzed in a 90° pair spectrometer.

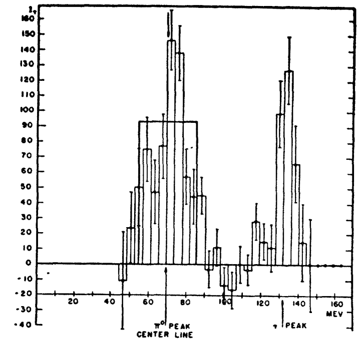

FIG. 2. Gamma-ray spectrum from the absorption of π^--mesons in H_2 with center of spectrometer set near a γ-ray energy of 100 Mev. The center line of the π^0-peak and the γ-peak as computed from a π^--rest energy of 141 Mev are marked. Also the theoretical π^0-spectrum (rectangular contour) is shown to correspond in area to the observed constant and in width to the curve of Fig. 3.

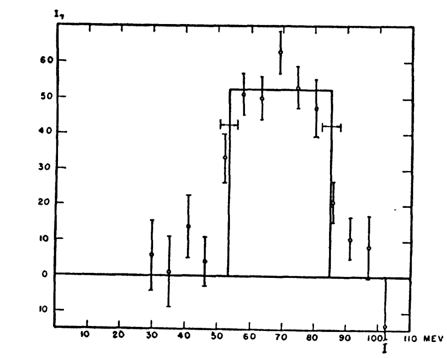

FIG. 3. Gamma-ray spectrum with center of spectrometer set near 70 Mev. The best fit of rectangular contour is shown and the estimate of the probable error of the lower and upper limit of the spectrum is indicated.

Figure 2 permits an estimate of the branching ratio between processes (1) and (2). The result is

$$\Gamma_{\pi^0}/\Gamma_\gamma = 0.96 \pm 0.20$$

and the available momentum space for the π^0 is

$$p/M_{\pi^0}C = 0.23 \pm 0.03.$$

The authors are greatly indebted to Dr. Herbert F. York for cooperation during the early parts of the experiment.

[1] Panofsky, Aamodt, and York, Phys. Rev. **78**, 825 (1950).

Atomic Positions and Vibrations in the Ferroelectric $BaTiO_3$ Lattice

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THE integrated reflections (00*h*) and (0*h*0) from untwinned $BaTiO_3$ single crystals were measured up to high orders ($h = 10$) as a function of temperature in the range from 15 to 310°C using MO K_α-radiation and a precision ionization spectrometer.

The influence of extinction could be estimated and taken into account. The investigated crystals were rather perfect and showed considerable primary extinction. Near the transition point of 120°C, fluctuations occur diminishing the primary extinction which lead to a sharp peak of the extinction-sensitive reflections. The transition proper is very sharp and shows a thermal hysteresis of about 2°. Impurities appear to reduce this hysteresis. The primary extinction in the cubic phase is equal to the primary extinction in the tetragonal phase. Thus the parallel and antiparallel domains are identical with the mosaic blocks.

The fact that the corrections for extinction can be evaluated enables one to determine the variation of the structure factor with temperature from the observed variation of the integrated reflection. The decrease of the mean square amplitude of the lattice vibrations with temperature is found to be quite normal in the cubic region. The variation of the structure factor arising at and below the transition point cannot be accounted for by a mere shift of the atomic positions. It is necessary to assume that considerable changes of the thermal vibrations occur in this temperature range. By a trial-and-error method it was possible to find a single solution agreeing within a few percent with the observed variation of the structure factor. The Ti ions and the oxygen ions lying on the same line along the z axis undergo a sudden displacement along this axis in opposite directions at the transition point, this jump being followed by a continuous change as the temperature decreases (Fig. 1).

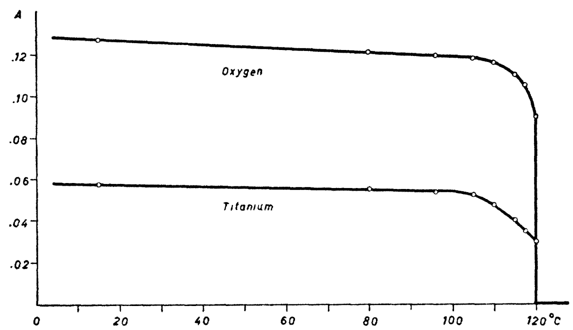

FIG. 1. Variation of the atomic positions (in angstrom units) with temperature.

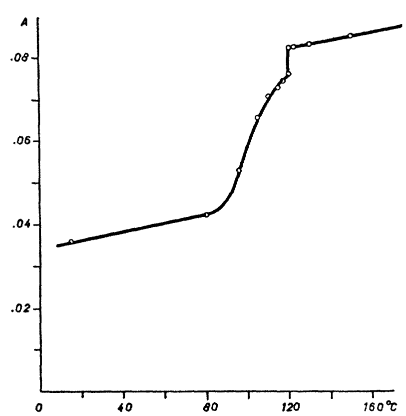

FIG. 2. Variation of the root-mean-square amplitude of the thermal vibration of the Ti ion along the z axis (in angstrom units) with temperature.

The variation of the root-mean-square amplitude of the vibration of the Ti ion along the z axis is shown in Fig. 2. A sudden variation at the transition point is seen to be followed by a continuous rapid decrease below. The Ba ions behave quite normally in the same region. The vibrations in the x direction could not be determined since the reflections ($0h0$) are too strongly influenced by the anomaly in the extinction. A more detailed study of the lattice vibrations through measurements of the diffuse scattering is being initiated.

The full account of the present investigations will appear in *Helvetica Physica Acta.*

Role of Metastable ($^3P_2$) Hg Atoms in Low Current Discharges in Hg Rare Gas Mixtures

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August 7, 1950

A POSITIVE column d.c. hot cathode discharge of about 1 ma in a few millimeters of a rare gas (e.g., A, Kr, Xe) plus a few microns of Hg in a $3\frac{1}{2}$-cm tube has been found to have a positive characteristic and ordinary running striations. As the current increases these striations weaken and disappear at 60 to 100 ma. The voltage (V) goes through a broad maximum at about the same current. Decreasing the temperature (Hg density) raises this maximum and displaces it toward lower currents. No ballast is necessary in the region of positive characteristic.

At 1 ma strong illumination with Hg radiation (transmissible through glass) nearly doubles V (Fig. 1), doubles the 2537 output (B_u), nearly doubles the electron temperature (T_e), as shown by probe measurements, and nearly suppresses the striations.

Irradiation with the light of the rare gas concerned has no effect above about 16°C. Above 25°C, the rare gas lines could be seen only with Xe and apparently even here the role of rare gas excitation is negligible.

Absorption measurements with 5461, 4358, and 4047 show high concentrations ($\sim 10^{11}$ cm^{-1}) of $^3P_2$ and $^3P_0$ even at 1 ma; $^3P_2$ in pure gas is nearly twice as populous as $^3P_0$. These concentrations increase relatively slowly, above about 4 ma; $^3P_1$ reaches an appreciable concentration only at higher currents.

A trace of molecular impurity greatly increases V and B_u and also the visible line output (B_v); it further suppresses the striations and destroys $^3P_2$. Thus 4μ N_2 increases V and B_u fivefold, B_v threefold, T_e twofold, and reduces $^3P_2$ to nearly zero (though scarcely affecting $^3P_0$), while completely suppressing the striations. It was found that

$$B_u \cong KV, \qquad (1)$$

where K is the same for all impurities tried. The addition of N_2 beyond about 4μ precipitates a new intermittent, or flashing form of discharge, described in the following letter.

These results are explained as arising from the destruction of Hg metastables by irradiatiation, the ionization evidently being mainly two-stage. In pure gas $^3P_2$ furnishes most of the ions, but with impurities $^3P_0$ takes over this role (with more difficulty). The

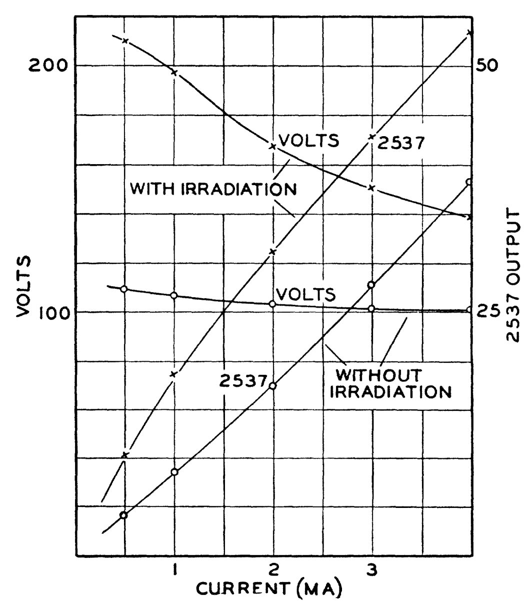

FIG. 1. Effect of illumination with Hg radiation.