expected that these will allow a more accurate determination of α.

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Equilibrium Charge Distribution of Stripped 26-Mev Nitrogen Ions

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THE average equilibrium charge of nitrogen ions as they pass through nickel foils has been measured previously.[1] In order to obtain further information concerning the capture and loss of orbital electrons by fast moving ions, the equilibrium charge distribution of stripped 26-Mev nitrogen ions was measured. The nitrogen beam from the ORNL 63-inch Cyclotron passed through thin foils and was analyzed by the fringing field of the cyclotron into its charge components.

The experimental arrangement was as follows: the triply charged deflected nitrogen beam entered an evacuated chamber 12 inches long through a 0.5 in. $\times$0.001 in. carbon slit and passed through a thin foil of Formvar or aluminum placed directly on the slit. An average fringing field of approximately 2000 oersteds gave a separation of about 4 mm between charge states. The analyzed beam was detected at the end of the chamber with Ilford C-2 emulsions. The deflected beam was parallel enough so that a second collimating slit was not necessary. The foils used for stripping were 0.16 mg/cm^2 Al, and 100, 50, 25, 5 μg/cm^2 Formvar. In all cases except that of the thinnest Formvar, the same ratio of charges was observed, indicating that an equilibrium state is reached in foils thicker than 25 μg/cm^2.

The lines on the photographic plates were scanned with a photodensitometer. Several scans were made across each set of lines in order to obtain an average density ratio. Some lightly exposed plates were scanned with a microscope and the nitrogen tracks per unit area counted. The track counting results were in agreement with the photodensitometer data.

The relative abundance of charge states for 26-Mev nitrogen ions after passing through a thin foil is $N^{7+}=0.38$, $N^{6+}=0.46$, $N^{5+}=0.16$, $N^{4+}=<0.01$. The estimated error is 0.02 in each case. The average charge thus obtained is $6.2e$, in agreement with the average charge measured previously.[1]

The experiment is being extended in order to determine the charge ratios as a function of energy. A measurement of the charge ratios after passing through a foil which is thin enough so that equilibrium is not reached, will permit an evaluation of the capture and loss cross sections for the K shell electrons.

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Limits on π^- Meson Mass from Mesonic X-Rays*

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IN a previous Letter,[1] we have reported that the energies of π^- mesonic x-rays, as determined with a multichannel pulse-height selector and a NaI detector, agree within 10 percent with the result of an elementary computation. More accurate energy measurements of selected mesonic lines are now being made by using the critical x-ray absorption technique. The primary aim of this work is the investigation of possible specifically nuclear interactions between the π^- meson and various nuclei. The results of this work will be described in a later communication. Here, we will report on an upper and lower limit for the π^- mass, obtained in the course of these experiments.

For the critical absorption measurements the absorbers were inserted between the target producing the mesonic x-rays and the NaI detector; the transmission of the mesonic line was measured as a function of the absorber Z. The absorbers were thin-walled Lucite cells, 1 cm thick, containing an aqueous solution of a salt of the absorbing element. The concentration (for a given absorber) was adjusted so that x-rays of energy immediately below its K-absorption edge would be transmitted four times more intensely than x-rays of

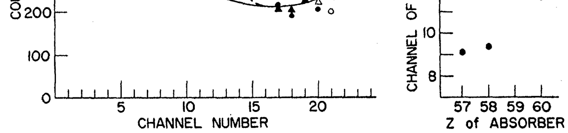

FIG. 1. Pulse-height distribution for the M line of π^- mesons in phosphorus. Absorbers: $Z=57$, 58, 59, and 60. Also shown as a function of Z are the transmitted intensities and the positions of the peaks.

energy immediately above the edge. The cells were placed in contact with the NaI counter, and, as a consequence, one could detect about 30 percent of the fluorescent radiation following the photoelectric absorption process.

The results of a typical run are plotted in Fig. 1. This shows the pulse-height distributions obtained when the π-mesonic M line of phosphorus is observed with the sequence of absorbing cells, $Z=57$, 58, 59, and 60. In each case the data are reduced to 2×10^6 stopping mesons. A transmission discontinuity is apparent between $Z=58$(Ce), and $Z=59$(Pr), indicating that the phosphorus mesonic line lies between the K edges[2] of these two elements. The peaks observed for

TABLE I. Comparison between theory and experiment.

	Line studied	P $4f\rightarrow3d$		Al $4f\rightarrow3d$		K $4f\rightarrow3d$
Theoretical	Klein-Gordon energy (kev) (for $m_\pi=272.5m_e$)	40.39		30.31−		64.90
	Vacuum polarization correction[a] (kev)	0.100		0.065		0.190
	Computed energy (kev)	40.49		30.37		65.09
Experimental	Absorbers bracketing transmission discontinuity	Ce(58)	Pr(59)	Sn(50)	Sb(51)	Hf(72)
	K edges[b] (kev)	40.45	42.00	29.19	30.49	65.35
	Meson mass limits	$\geq 272.2m_e$		$\leq 273.6m_e$		$\leq 273.6m_e$

[a] See reference 3. [b] See reference 2.

$Z=57$ and 58 are due, in part, to the fluorescent x-rays of the absorption cells, as evidenced by their magnitude and by their displacement to lower energies.

The absorption discontinuity of this line is due to the $4f\rightarrow3d$ transition. Higher lines of the M series, such as $5\rightarrow3$, $6\rightarrow3$, etc., would appear at higher energy and thus be strongly absorbed by all the cells used. Other transitions between the total quantum numbers 4 and 3 (such as $4s\rightarrow3p$ etc.) should be much less probable than the $4f\rightarrow3d$ because of statistical considerations.

For the purpose of comparison with the experimental results the energies of the lines investigated were computed with the Klein-Gordon equation (including reduced mass correction, using a point charge potential and $m_\pi=272.5m_e$) and corrected for vacuum polarization.[3] Corrections for finite nuclear size, fine structure, nuclear polarization,[4] electronic screening, etc., were estimated, but found to be smaller than 10 ev in all the cases considered. A specifically nuclear interaction of the meson corresponding to a potential up to 100 Mev over the nuclear volume would introduce negligible corrections for the M lines studied.

The comparison between theory and experiment is shown in Table I.

As one can see, from this experiment one obtains the following limits for the mass of the π^- meson:

$$272.2m_e \leqslant m_{\pi^-} \leqslant 273.6m_e.$$

(This value is in good agreement with the determination at Berkeley,[5] but does not agree well with a recent publication from Columbia.[6]) The greatest error in these limits is due to the uncertainty in our knowledge of the electronic K edges (which we hope to have remeasured) and of the vacuum polarization correction.

* Supported in part by the U. S. Atomic Energy Commission.
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Decay Scheme of Pb^{204m}

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IN the course of investigating the angular correlation of the gamma rays of the 68-min isomer of Pb^{204}, we have found that the decay scheme consists of three, rather than two, gamma rays in cascade [Fig. 1(a)].

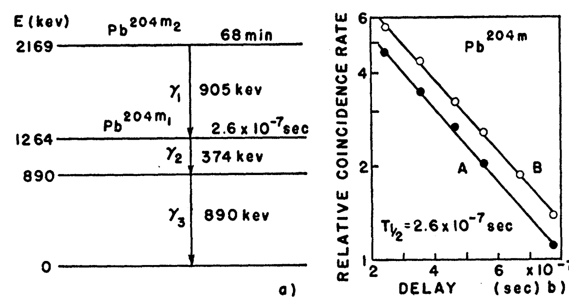

FIG. 1. (a) Proposed decay scheme for Pb^{204m}. (b) Decay of the intermediate state of the 905–890-kev cascade (curve A) and the 905–374-kev cascade (curve B).

The order of the two gamma rays following the 2.6×10^{-7} second state has not been determined experimentally.

Part of our study of the decay scheme was performed with apparatus which used two NaI(Tl) scintillation crystals together with a fast-slow coincidence scheme. The fast coincidence circuit had a resolving time of 10^{-7} second and the slow ($\sim2\times10^{-6}$ second) triple coincidence circuit received the output of the fast circuit plus pulses which had passed through discriminators operated as either differential or integral pulse-height analyzers. 1500-ohm delay lines were inserted as desired ahead of the fast coincidence unit.

The pulse-height distribution of the gamma rays following the 2.6×10^{-7} second state of Pb^{204m} was