or in the free state direct capture by the nucleus must be concluded to have negligible probability ($\sigma = 2\times10^{-32}$ cm^2 ev/(energy of meson)).

In the K-orbit of another nucleus of charge Z the probability of nuclear capture may be expected to be greater (a) by the factor (Z/Z_0) for the larger number of protons presumably capable of being transformed into neutrons and (b) by the volume concentration factor $(Z/Z_0)^3$ based on the expression $(\hbar^2/\mu Ze^2)$ for the effective radius of the Bohr orbit. Combination of factors gives for the expected decay constant for negative mesons stopped in matter, $1/\tau = (1/\tau_0)[1+(Z/Z_0)^s]$, and for the fraction which send out decay electrons the expression,

$$f = [1+(Z/Z_0)^s]^{-1}.$$

An appreciable dependence of the mechanism of dissipation of energy upon atomic number will be expected to alter the value of the exponent, $s=4$, deduced above.

A significant fraction of the moderated negative mesons will arrive at the $2s$ orbit and might be expected to remain in a metastable state with a decay probability lower than that calculated above. However, the finite extension of the nuclear charge inverts the normal order of $2s$ and $2p$ terms (by $\sim$3000 ev in Al) and gives the $2s$ state a short life with respect to radiation ($\sim 2\times10^{-9}$ sec. for Al). Also direct transitions from $2s$ to $1s$ may occur *via* transfer of energy to a $1s$ electron (4×10^{-10} sec. in Al). Consequently only nuclear capture from the K-orbit need be considered.

The Auger electrons given out in $2s \rightarrow 1s$ and $2p \rightarrow 1s$ transitions (0.7 Mev in argon, 1.4 Mev in iron) offer an independent means to determine the mass of the meson. For nuclei of charge $Z>23$ pair production is also possible in the $2s \rightarrow 1s$ transition but has negligible probability.

For a nucleus provided with 100 Mev of excitation by meson absorption, evaporation of 6–15 nucleons (nuclear "star") will be expected to have a probability $\sim 10^6$ times greater than the probability of electromagnetic radiation. Stars at mountain altitudes are too frequent for all to be accounted for by meson absorption. Whether conversely all negative mesons stopped at sea level ($\sim$400 observed per m^3 of air per day) can be assumed to produce stars ($\sim$300/m^3 day as deduced from photographic plates) appears an open question in view of existing experimental uncertainties. Neither experimentally nor theoretically can one exclude the possibility of some other process for dissipation of the mass energy of the meson.

Straightforward application of the law of microscopic reversibility gives $10^{-40}(Z/Z_0)^{s-2}$ cm^2 as upper limit for the (γ, μ) reaction produced by γ-rays in the 100-Mev range, and a correspondingly low probability for production of mesons by heavy particle bombardment.

A more detailed article is being prepared.

[1] See also J. A. Wheeler, same title, Bull. Am. Phys. Soc. **22**, No. 1, Abstract No. A4 (1947).
[2] M. Conversi, E. Pancini, and O. Piccioni, Phys. Rev. **71**, 209 (1947). The author is indebted to Dr. Piccioni for preliminary communication of these results.
[3] T. Sigurgeirsson and A. Yamakawa, preceding letter.
[4] E. Fermi, E. Teller, and V. Weisskopf, this issue, give an explicit formula for the rate of loss of energy by Auger transitions between orbits of large quantum number. The author is indebted to these authors for the opportunity to see their letter before publication.

Gamma- and Beta-Ray Energies of Some Radioactive Isotopes as Measured by a Thin Magnetic Lens Beta-Ray Spectrometer*

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A THIN magnetic lens beta-ray spectrometer, similar to that developed by Deutsch[1] and his co-workers, was constructed by the authors for the purpose of measuring radioactive isotopes produced at the Clinton pile. The instrument was designed primarily for the study of beta-radiations between the energies of 0.1 to 3.0 Mev. The momentum of the focused electrons is determined by the relation $P=kI$, where I is the current through the lens coil and k is a constant depending on the geometry of the coil. Since the electron paths are quite complicated, no attempt is made to use the spectrometer as an absolute instrument; i.e., k is determined experimentally. To determine k, the F conversion line of thorium B ($H\rho = 1385$) and the photoelectron line due to annihilation radiation from positron emitters (0.511 Mev) are used. Agreement between the two calibrations is obtained to about 0.1 percent. Half-intensity widths between 2 and 4 percent are obtained for conversion lines, and between 4 and 6 percent for photoelectron lines. Beta- and gamma-sources as weak as 0.005 and 0.1 mc, respectively, have been successfully used.

Table I lists the results of most of the investigations. The values given for the gamma-ray energies are accurate to about 2 percent. The estimates of the relative intensities of the gamma-rays are only approximate and the values for the smaller components should be taken as indications only.

TABLE I.

Element	Half-life	Max. beta-ray energy (Mev)	Gamma-ray energy (Mev)	Relative intensity
*Sr^{89}	55*d*	1.5±.1		
*Cb^{95}	37*d*		†.75	
Ag	225*d*	0.59±.05	†.66	44
			.90	47
			1.40	9
Sb^{122}	2.8*d*		†.57	
Sb^{124}	60*d*		1.72	
$Te^{122,124?}$	30*d*?		.61	
*Te^{129}	1.2*h*	1.8 ±.1		
*Ba^{140}	12.5*d*	1.05+.05	†.54	
*La^{140}	40*h*	1.45±.1	.335	2
			.49	5
			.87	10
			1.65	77
			2.3	6
Ta^{182}	120*d*	0.53±.03	†.15	2
			.22	4
			1.13	37
			1.22	57
Pb^{209}	3.3*h*	0.68±.03		

* Fission product.
† Internal conversion of the gamma-ray noted.

* This document is based on work performed for the Manhattan Project, and the information covered therein will appear in Division IV of the Manhattan Project Technical Series as a part of the contribution of the Clinton Laboratories.
[1] Deutsch, Elliot, and Evans, Rev. Sci. Inst. **15**, 178 (1944).