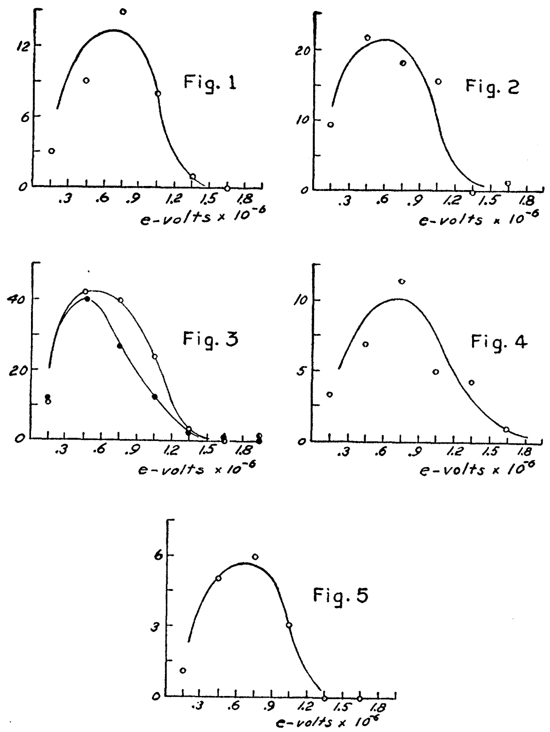
TABLE I.

Target	Projectile	Type of disintegration	Energy distribution
Be	Deutons	Positron	See Fig. 1
B_2O_3	"	"	" " 2
C	"	"	" " 3
Al	"	"	" " 4
C	Protons	"	" " 5

19,000 gauss showed that a large percentage of the tracks originated in the gas in all parts of the chamber. After the removal of the source the gas remained active and several tracks per expansion were obtained. This showed that the active element was present as a gas and diffused from the target throughout the chamber. Lauritsen and Crane have subsequently found evidence that the gas in this case is CO or CO_2, in which the carbon is the radioactive C^{11}.

Though these targets, because of the short range of the impinging deutons or protons compared with those of the ejected positrons should be in all cases essentially thin targets, the diffusion of the active material deeper into the target may in some instances introduce an absorbing layer for the positrons to penetrate before they emerge into the chamber for energy measurement. The energy distributions obtained by using a thick carbon target and those obtained using a very thin layer of paraffin as target are very much the same and show that in no case can the energy distribution be markedly affected by energy loss of the positrons before observation. See Fig. 3.

From all targets the positrons emerged with a wide distribution in energy similar to the β-particles from natural radioactive substances. It is, however, not possible on the basis of our present data to make an accurate comparison between energy distributions for the two types of disintegrations. As in ordinary β-disintegration there is here no indication that the disintegration probability is different in different parts of the energy spectrum. All the distribution curves show a striking similarity with one another with the possible exception of Al. The Al data suggest a higher energy limit and Al has a shorter half life than the lighter elements, B and C. To find whether a relation exists between the maximum energy of the bombarding projectiles and the maximum disintegration energy the writers plan to study targets activated by higher or lower energy protons or deutons. This together with an investigation of the neutrons emitted during bombardment may throw light on such questions as the difficulties of energy conservation in β-disintegration, and the mass of the neutron.



Numbers of positrons in 300,000 volt intervals plotted as a function of energy. The general shape of the smooth curves was obtained by plotting the track counts in overlapping energy intervals but only one set of points is shown.

FIG. 1. Be target bombarded with deutons.

FIG. 2. B target with deutons.

FIG. 3. ●, Very thin paraffin target with deutons; o, C target with deutons.

FIG. 4. Al target with deutons.

Fig. 5. C target with protons.

In the case of Be it is possible that the activity was due to carbon contamination, but this is not likely because of the large activity shown by the Be target.

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The Spectrum of Singly Ionized Europium

The main energy levels of Eu II are found to result from the addition of an electron to the common parent term, $4f^7(^8S°)$, of Eu III. The basic levels are $6s\ ^9S_4°$ and $6s\ ^7S_3°$, which result from adding a $6s$ electron to the parent term. The frequency difference of 1669.27 cm^{-1}, which is now shown to be the separation between $^9S_4°$ and $^7S_3°$, was found by Paulson[1] to occur several times among the prominent lines. The metastable $5d$ terms are at about 10,000 cm^{-1}. $^7D°$ was not found probably because most of its combinations with ^9P and ^7P lie beyond the observed region in the red. The height of $5d$ above $6s$ indicates $4f\ ^76s^2$ as the normal configuration of Eu I. The locating of the $7s$ levels enables the calculation of an ionization potential of 11.4 volts for Eu II. Three levels

[1] Kayser, Handbuch der Spectroscopie **7**, no. 1.

near 37,000 cm^{-1} of unknown origin combine with the 6*s* and 5*d* levels.

The transition 6*p* to 6*s* accounts for all the very intense Eu II lines in the blue and ultraviolet, while the 6*p* to 5*d* transition explains most of the intense lines in the orange and red.

Table I contains a list of the terms with their energies expressed in wave numbers.

Table II contains the wave-lengths, intensities, temperature class, wave numbers, and combinations. The wave-lengths are from three sources: those without temperature class and intensities without parenthesis are from Eder[1]; those with temperature class from King[2]; and those with intensities in parenthesis are from Exner and Haschek.[3] King's intensity scale is considerably greater than either Eder's or Exner and Haschek's.

TABLE I.

Designation	Level	Designation	Level
6*s* $^9S_4^\circ$	0.00	6*p* $^9P_5$	26,172.82
$^7S_3^\circ$	1,669.27	$^7P_4$	26,838.44
		$^7P_3$	27,104.15
5*d* $^9D_2^\circ$?	9,923.02?	$^7P_2$	27,256.33
$^9D_3^\circ$	10,081.68		
$^9D_4^\circ$	10,312.80	$1_{3,4}$	36,627.9
$^9D_5^\circ$	10,643.45	2_4	37,010.6
$^9D_6^\circ$	11,128.49	3_4	37,223.9
6*p* $^9P_3$	23,774.27	7*s* $^9S_4^\circ$	49,127.87
$^9P_4$	24,207.82	$^7S_3^\circ$	49,646.73

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[2] King, Astrophys. J. **72**, 1 (1930).

[3] Exner and Haschek, *Wellenlangen Tabellen, Funkenspektren.*

TABLE II.

λIA	Int.	ν(vac)	Designation	λIA	Int.	ν(vac)	Designation
7370.25	−4	13,564.34	$^9D_5^\circ-{}^9P_4$	4129.734	−500*R* III	24,207.83	$^9S_4^\circ-{}^9P_4$
7301.16	−5	13,692.69	$^9D_3^\circ-{}^9P_3$	4011.71	−25*V*	24,920.01	$^9P_4-{}^9S_4^\circ$
7217.55	−8	13,851.31	$^9D_2^\circ-{}^9P_3$	3971.989	−400*R* III	25,169.21	$^7S_3^\circ-{}^7P_4$
7194.80	−8	13,895.10	$^9D_4^\circ-{}^9P_4$	3943.10	−12*V*	25,353.61	$^9P_3-{}^9S_4^\circ$
7077.13	−8	14,126.13	$^9D_3^\circ-{}^9P_4$	3930.504	−300*R* III	25,434.85	$^7S_3^\circ-{}^7P_3$
6645.19	−20	15,044.33	$^9D_6^\circ-{}^9P_5$	3929.88	−(2)	25,438.89	$^9P_4-{}^7S_3^\circ$
6437.64	−15	15,529.36	$^9D_5^\circ-{}^9P_5$	3907.113	−300*R* III	25,587.12	$^7S_3^\circ-{}^7P_2$
6303.42	−10	15,860.02	$^9D_4^\circ-{}^9P_5$	3864.11	−(2)	25,871.87	?$^9P_3-{}^7S_3^\circ$
6173.03	−10	16,195.03	$^9D_5^\circ-{}^7P_4$	3819.66	−(50) III	26,172.94	$^9S_4^\circ-{}^9P_5$
6049.55	−8	16,525.59	$^9D_4^\circ-{}^7P_4$	3799.02	−(2)	26,315.1	$^9D_4^\circ-1_{3,4}$
5966.09	−5	16,756.76	$^9D_3^\circ-{}^7P_4$	3791.53	−(1)	26,367.1	$^9D_5^\circ-2_4$
5953.90	−2	16,791.07	$^9D_4^\circ-{}^7P_3$	3765.95	−(2)	26,546.2	$^9D_3^\circ-1_{3,4}$
5873.02	−5	17,022.31	$^9D_3^\circ-{}^7P_3$	3761.15	−(3)	26,580.1	$^9D_5^\circ-3_4$
5820.91	−2	17,174.69	$^9D_3^\circ-{}^7P_2$	3744.15	−(1)	26,697.9	$^9D_4^\circ-2_4$
5818.75	−5	17,181.07	$^9D_2^\circ-{}^7P_3$	3724.95	−(20)	26,838.39	$^9S_4^\circ-{}^7P_4$
4539.29	−2*V*	22,023.72	$^7P_3-{}^9S_4^\circ$	3714.90	−(2)	26,911.0	$^9D_4^\circ-3_4$
4522.602	−200*r* III	22,104.99	$^7S_3^\circ-{}^9P_3$	3688.42	−(20)	27,104.19	$^9S_4^\circ-{}^7P_3$
4485.17	−6*V*	22,289.47	$^7P_4-{}^9S_4^\circ$	3683.26	−(1)	27,142.2	$^9D_3^\circ-3_4$
4464.94	−10*V*	22,390.45	$^7P_2-{}^7S_3^\circ$	2859.68	−(2)	34,958.7	$^7S_3^\circ-1_{3,4}$
4435.602	−400*r* III	22,538.55	$^7S_3^\circ-{}^9P_4$	2828.70	−(3)	35,341.5	$^7S_3^\circ-2_4$
4434.81	−8*V*	22,542.57	$^7P_3-{}^7S_3^\circ$	2811.73	−(2)	35,554.8	$^7S_3^\circ-3_4$
4383.14	−15*V*	22,808.31	$^7P_4-{}^7S_3^\circ$	2729.36	−(3)	36,627.8	$^9S_4^\circ-1_{3,4}$
4355.10	−30*V*	22,955.16	$^9P_5-{}^9S_4^\circ$	2701.13	−(3)	37,010.6	$^9S_4^\circ-2_4$
4205.046	−600*R* III	23,774.28	$^9S_4^\circ-{}^9P_3$	2685.64	−(2)	37,224.0	$^9S_4^\circ-3_4$

Collision Problems and the Conservation Laws

Recent correspondence in the *Physical Review** suggests that a rapid means of recognizing the implications of the laws of conservation of momentum and energy in collision problems is desirable. Let x_4 be the coordinates of an event in space-time, x_α being the relative spatial coordinates, and $x_4=ict$, where t is the relative time; here (as in what follows) Roman suffixes have the range 1,2,3,4, and Greek suffixes have the range 1,2,3. The momentum-energy 4-vector M_r of any entity has components

$$M_\alpha=\mu_\alpha/c, \quad M_4=iE/c^2,$$

where μ_α are the components of relative momentum and E is the relative energy. In the case of a particle we have

$$M_\alpha=m_0\gamma u_\alpha/c, \quad M_4=im_0\gamma, \quad \gamma=1/(1-u^2/c^2)^{\frac{1}{2}},$$

where m_0 is the proper mass and u_α the relative velocity. For a photon we have

$$M_\alpha=h\nu l_\alpha/c^2, \quad M_4=ih\nu/c^2,$$

where h is Planck's constant, ν the relative frequency, and l_α the relative direction cosines of the direction of propagation.

* Cf. A. L. Hughes and G. E. M. Jauncey, Phys. Rev. **45**, 217 (1934).