From Eq. (1), we can find the experimental value of $P\sigma_{3/2}$. Using Eq. (1) and the Breit-Wigner resonance formula for the meson-nucleon system in the $T = 3/2$ state:

$$P_{\sigma_{3/2}} = 2\pi P \lambda\!\!\!^{-2} (2J + 1) \frac{(\Gamma/2)^2}{(\varepsilon - \varepsilon_0)^2 + (\Gamma/2)^2}, \qquad (2)$$

(where $\lambda\!\!\!^{-} = 2.4 \times 10^{-13}$ is the wave length of the π meson in the center-of-mass system, J is the total angular momentum), we obtain $J = 3/2$, $P = 0.1$, $\Gamma = 82$ Mev, $\epsilon_0 = 110$ Mev, in satisfactory agreement with the parameters of the isobar.[5]*

*Some of the difference of ε_0 from the corresponding resonance energy in reference 5 may arise from the fact that we did not consider the velocity of the virtual π mesons in the meson clouds surrounding the nucleon cores.

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RANGE-ENERGY DEPENDENCE OF C_{12}, C_{14}, AND O_{16} IONS IN ALUMINUM, COPPER, AND GOLD IN THE ENERGY INTERVAL FROM 50 TO 110 Mev.

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FOR detailed study of nuclear reactions caused by multiply-charged ions, data must be obtained on the range-energy dependence of the heavy ions in various substances. For ions with $Z > 3$ it is difficult to obtain the range-energy curves by calculation, since the multiple charge exchange of such ions during the slowing down process introduces a substantial indeterminacy into the quantities that enter into the equations.[1]

We have consequently set up experiments on the direct experimental determination of these relationships for ions of carbon, nitrogen, and oxygen in aluminum, copper, and gold.

The ions C_{12}^{+4}, N_{14}^{+5}, O_{16}^{+5}, and O_{16}^{+6} were accelerated in a 150-cm cyclotron with an exit system having a focusing magnet, intended for the production of a narrow beam of deuterons in a specially shielded cabin 12 meters away from the center of the cyclotron. Experience has shown that it is possible, without substantial changes, to use the same exit system to obtain in the cabin a sufficiently intense beam of ions of carbon, nitrogen, and oxygen. This is apparently due to the fact that part of the ion beam passes, as a result of scattering, through the exit channel in the field of the focusing magnet, which focuses the ions on the entrance diaphragm of the receiver of the recording apparatus. This mechanism for obtaining a working beam has insured an intensity on the order of $10^5 - 10^6$ ions/cm^2-sec at the receiver, with the current at the terminal radius of the cyclotron being on the order of 0.1 microamperes.

The ions were registered by a photomultiplier with a ZnS crystal, deposited in the form of a thin layer on glass, so as to insure a sufficient sensitivity of measurements in an ion beam on the order of $10^2 - 10^6$ ions/cm^2-sec. With the beam thus extracted from the cyclotron, the ions entering the field of focusing magnet had an energy spectrum (50 — 110 Mev). Narrow beams of practically-monoenergetic ions were gathered from this spectrum by a suitable choice of the intensity of the focusing magnetic field. A focusing magnet could be used as an analyzer because the experimentally-obtained relationship between the magnetizing current and the induction of the magnetic field in the gap was linear over the entire range of the field employed. The analyzer was calibrated with a beam of accelerated deuterons, whose energy was determined from the known range-energy curve in aluminum.[2]

The ions accelerated in the cyclotron passed through a specially installed two-micron aluminum foil on their path to the focusing magnet, and acquired in this foil an equilibrium charge corresponding to their velocity. The ions were then deflected in the magnetic field, entered the recorder in front of which foils of various thickness of aluminum, copper, and gold were mounted on a rotating disk. Thus, the ion energy was determined from the current in the windings in the magnetic analyzer, while the ranges of ions at a given energy in the selected substance were determined from the decrease in intensity with in-

creasing absorber thickness. Since it is much easier to vary smoothly the ion energy than the thickness of the absorber, the actual measurements were performed as follows: the energy of the ions, whose intensity was decreased to one half the initial value by passage through a given absorber, was determined for each foil by varying the magnetic field of the analyzer. Each such operation yielded one point on the range-energy curve. To exclude errors due to uncontrollable variations in the intensity of the initial beam, a proportional counter, placed in tandem with the entrance diaphragm, was used as a monitor.

It is obvious that with the measurement method described, the sensitivity threshold of the registrator can introduce a substantial error in the range. This method was therefore used, in special experiments, to measure the range in nickel of doubly-charged oxygen ions with energies 9.7 Mev, for which data obtained by other registration methods are available. The agreement between our data and those found in the literature,[3-6] indicates that the sensitivity threshold of the system comprising the ZnS and the photomultiplier is so low, that it can increase substantially the error in the determination of the range-energy curve, an error due to the finite resolving power of the analyzer magnet, to inaccuracy of the determination of the thickness of the absorber, etc. By our estimate, the total error in the determination of the values of the range does not exceed 2%.

The results of the measurements of the mean ranges of the ions of carbon, nitrogen, and oxygen in aluminum are shown in the figure. Data on ranges in copper and gold are given in the table.

Our data are in good agreement with the semi-empirical calculation curves made by Papineau (private communication), and lie somewhat lower than the experimental curves for the ranges of nitrogen and oxygen ions in photoemulsions in the energy interval from 0 to 130 Mev, obtained in our laboratory.[7] This discrepancy was apparently due to inaccurate calibration of the magnetic analyzer in the investigation of reference 7.

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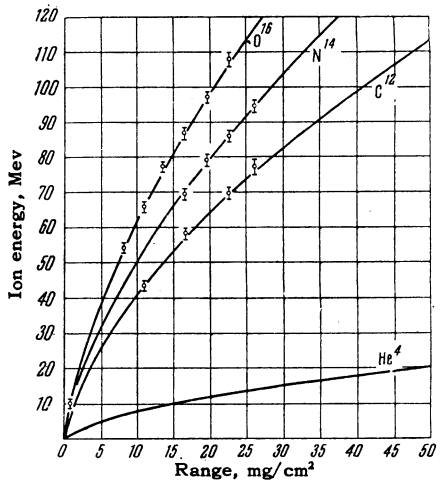

Range vs. energy for C^{12}, N^{14}, and O^{16} in aluminum. Solid line – Papineau's calculations. Points – data of present work.

Substance	Ion	Range, mg/cm²	Energy, Mev
Copper	C^{12}	18.9	52.0
		27.1	66.0
		32.0	69.5
	O^{16}	18.8	75.2
		27.1	96.5
Gold	C^{12}	22.3	36.0
		30.0	50.5
		37.6	56.0
		47.2	66.5
	O^{16}	30.0	73.0
		37.6	85.0
		40.2	90.3

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Translated by J. G. Adashko
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ERRATA TO VOLUME 9

Page	Reads	Should read
115, Col. 2, line 18 from top	R. Gatto and M. A. Ruderman, [Nuovo cimento 8, 775, (1958)]	T. Goto, Nuovo cimento 8, 625 (1958)
294, Col. 2, line 4 from bottom	$N = N_{exp}(p, \theta)\, F(p, \theta)$	$N = N_{exp}(p, \theta) 1 + F(p, \theta)$
462, Col. 1, line 8 from top	which are approximately 13Z ev	and approximately equal to 13Z ev
646, Col. 1, line 3 from top	$<j_1' t_1' \alpha \| R^{J_2} \| j_1 t_1 \alpha_1>$	$<j_1' t_1' \alpha \| R^{J_1} \| j_1 t_1 \alpha_1>$
661, Col 1, line 6 from top	$\lambda\!\!\!^{-} = 2.14 \times 10^{-13}$	$\lambda\!\!\!^{-} = 1.04 \times 10^{-13}$