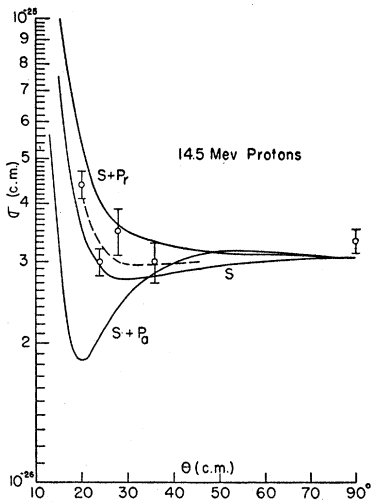

FIG. 1. The absolute scattering cross section per unit solid angle as a function of the angle. Both coordinates refer to the center of mass system.

cable, a standard condenser, and a quadrant electrometer; the whole system being calibrated.

The pulsed nature of the beam from the synchro-cyclotron made the correction for accidental coincidences appreciable. The background counts were due partly to protons and partly to neutrons. Since the pulse width of the neutrons was larger than that of the protons, it was necessary to use the rather complicated correction formula

$$n_a=\frac{2\tau}{R\delta}\left[n_1n_2+\left(\frac{1}{f}-1\right)n_1{}^Pn_2{}^P\right],$$

where n_a is the number of accidentals per second, n_1 and n_2 the total counting rate in each channel, $n_1{}^P$ and $n_2{}^P$ the counting rate in each channel due to protons only, τ the resolving time of the coincidence system, R the repetition rate, δ the width of the neutron pulse, and f the ratio of the width of the proton pulse to that of the neutron pulse. The formula was derived on the assumption of square pulse shape. The lumped constant $2\tau/R\delta$ was determined to be 0.99×10^{-5} sec. by counting the neutron background counts only; i.e., proton beam cut off by a shutter. The fraction f was determined to be 0.25 by misaligning the proportional counters so that no true coincidences should occur.

The number of background counts due to protons was determined after each ten-minute run by subtracting from the total counting rate the neutron rate found by a blank run during which the proton beam was shuttered off. The average accidental correction amounted to about twenty-five percent of the observed coincidences. At the smallest angles of scattering, i.e., 10°, and 12° (laboratory system), it was necessary to add a calculated correction of 8 and 3 percent, respectively, because some of the scattered and recoil protons were geometrically unable to enter both counters.

TABLE I. Scattering cross sections of 14.5-Mev protons on protons.

θ	n	σ	ϵ
20°	12	4.4×10^{-26} cm²	$\pm0.3\times10^{-26}$ cm²
24°	20	3.0	0.2
28°	7	3.5	0.4
36°	11	3.0	0.3
90°	34	3.34	0.2

The final results obtained are given in Table I where θ is the scattering angle measured in the center of mass system, n is the number of ten-minute cyclotron runs at each angle, σ is the absolute scattering cross section per unit solid angle in the center of mass system, and ϵ is the experimental mean-square error determined from the deviations of the values given by each ten-minute run from the mean.

In Fig. 1 the experimental values of σ are compared with theoretical calculations made by L. L. Foldy[4] on the assumption of a square well of depth 10.5 Mev and width (e^2/mc^2), both for S wave scattering alone and for S plus P wave scattering with the potential for the P wave attractive (lower curve) and repulsive (upper curve). The data are definitely inconsistent with any P wave attractive effects. They are not inconsistent with pure S wave scattering or with an admixture of repulsive P wave effects. Perhaps the dotted curve of Fig. 1 is indicated; it corresponds to an admixture of P wave effects due to about one-third the repulsive interaction of the upper curve. This would be consistent with the result found at 10 Mev.[3]

We wish to express our appreciation to Professor E. O. Lawrence for making the facilities of the Radiation Laboratory available to us.

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Neutron Cross Sections for Mercury Isotopes

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ONE hundred twenty-five milligrams of α-phase mercuric sulfide were submitted to long bombardment by neutrons in a graphite pile. To liberate the mercury, the sample was placed in a closed system and heated while oxygen was flowing through the system. The free mercury obtained was collected at −40°C in a glass sample tube and then transferred to the sample system of a Nier type mass spectrometer.[1] The isotopic composition of the bombarded sample was then compared with that of normal mercury. The data obtained are summarized in Table I.

Each of the values in this table is the average of 50 results. The comparative values of the cross sections as listed in the table are better than the absolute values. This is due to the fact that with a fixed neutron energy distribution the former depends only on the accuracy of the mass spectrometer measurement while the latter depends on a knowledge of the magnitude of the integrated flux.

These data show that there are two big neutron absorbers

in mercury, the isotopes at masses 196 and 199. Since the 199 is 110 times as abundant as the 196 most of the neutron absorption in normal mercury is due to the isotope of mass 199.

TABLE I. Isotopic composition of neutron irradiated mercury.

Mass No.	% Abundance normal	% Abundance bombarded	Net change	Isotopic cross sections in 10^{-24} cm²	Contribution to total section in 10^{-24} cm²
196	0.155	0.120	-0.035 ± 0.002	3100	4.8
197	<0.001	<0.001	—	—	—
198	10.12	10.17	$+0.05\pm0.05$	—	—
199	17.01	13.78	-3.23 ± 0.07	2500	425
200	23.21	26.52	$+3.31\pm0.03$	<60	<15
201	13.15	13.11	-0.04 ± 0.07	<60	<8
202	29.66	29.63	-0.03 ± 0.15	<60	<18
203	<0.001	trace	+trace	—	—
204	6.69	6.68	-0.01 ± 0.03	<60	<4
205	<0.001	<0.001	—	—	—

In the cases of the isotope of mass 198, 200, 201, 202, and 204 it was possible only to assign upper limits to the cross sections. The upper limits in the Table I were deduced by assuming only $(n-\gamma)$ reactions. There are some indications at masses 199 and 201, however, that reactions other than $(n-\gamma)$'s took place; in particular $(n-2n)$'s. The occurrence of such a reaction in this sample was possible since there was a considerable flux of fast neutrons in the pile. A much heavier flux, or a different flux distribution, would be necessary to prove this point.

No peak was detected at mass 197 so that all the mercury 197 formed by $(n-\gamma)$ reaction on mercury 196 decayed by K capture to gold 197. Thus 35 micrograms of gold were formed from the 100 milligrams of mercury.

The weak peak at mass 203 was probably caused by a long-lived $(n-\gamma)$ induced activity in mercury as it was not observed in the normal sample. This is probably the 51-day β-activity known to exist in mercury.[2]

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Fine Structure of H_α

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THE fine structure of H_α has been again examined with a Lummer plate and with a Fabry Pérot étalon. The source was a hydrogen discharge tube submerged in liquid air. Trials were made under various conditions of pressure and current density. The separation of the apparent doublet resulted in an average value of 0.310 ± 0.007 cm^{-1}. The results relative to a particular series of spectra have been examined with great care and compared with the results of Dirac's theory. The apparent doublet has been reconstructed by assigning to every theoretical component an intensity curve $\exp[-k(\nu-\nu_0)^2]$ and to k a value derived from the experimental curve.

The "reconstructed" doublet differs from the experimental one in regard to the intensities and to the distance between the two maxima, which for the "reconstructed" doublet has a value of 0.327 cm^{-1}. We have tried to establish whether these disagreements may be ascribed only to the fact that the experimental intensities of the components are not exactly in agreement with the values calculated by Dirac's theory. In order to fit well the reconstructed doublet to the experimental one without changing the separations of the components, we should triple the intensity of the third component, keeping for the others about the theoretical intensities. But such a change of intensity, affecting almost exclusively the third component, would disagree with Sommerfeld's and Unsöld's[1] suggestion according to which the deviations from the theoretical intensities are due to the fact that the $2S$ level is metastable.

The observed deviations of the separation between the two maxima of the experimental and reconstructed doublet can certainly not be attributed to the overlapping of lines of the molecular spectrum, as Drinkwater, Richardson, and Williams[2] suppose, because the intensity of the molecular spectrum near H_α under our experimental conditions was practically zero.

If in the experimental measurements a mysterious systematic error does not occur, we should conclude, in accord with C. R. Williams' observations,[3] that the separations between the components do not correspond exactly to the calculated ones on the basis of Dirac's theory. As Sommerfeld[4] has shown, using Dirac's theory also, the deviations from the coulombian field in the neighborhood of the nucleus cannot explain the deviation observed by C. R. Williams. However, it is not certain that the formalism of the quantum mechanics maintains its validity for problems involving distances of the order of the nuclear radius. Therefore, we may hope that, when a suitable formalism is found, the small observed deviations may be justified.

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A Microwave Spectrograph*

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WE have constructed a microwave spectrograph of the wave-guide absorption cell type[1] which appears to be somewhat more sensitive than others which have been described. The basic principle is the use of a radiofrequency Stark effect field[2] which modulates the absorption by the gas so that a radio receiver can be used for detection purposes. The apparatus consists of the usual $2K33$ K-band klystron oscillator tube, attenuator, a $5\frac{1}{2}$-foot length of K-band wave guide, and a crystal detector, the output of which goes to a narrow-band communication receiver. The amplified output of the receiver is displayed on an oscilloscope screen. The wave guide is fitted with a central electrode insulated from the walls in the form of a brass strip inserted parallel to the broad sides of the wave guide[3] and is made gas-tight with mica windows. An oscillator supplies