the particles were carefully measured. For a small interval, the range-momentum relation is well represented by a power law: $R/m=c(p/m)^q$, where R is the range, m the particle mass, p the momentum, and c a constant of the emulsion. We have used the exponent $q=3.50$ derived from the range-energy relation[3]; the results, however, are insensitive to the value of q chosen. The utilization of protons with velocities distributed about the average meson velocity enabled us to evaluate c, and only momentum and range ratios entered into the determination of the mass ratios. Since all the particles are stopped in the same body of nuclear emulsion, the stopping power of the emulsion is eliminated. The momentum ratios are independent of the absolute value of the magnetic field intensity.

Other statistical errors are small in comparison to the range-straggling error of an individual observation. We have observed that for monoenergetic (π-μ-decay) particles the straggling of ranges has closely a normal distribution. The most probable mass is therefore obtained by averaging the individual observations of that function of the mass in which the range occurs linearly (i.e., $R/p^{3.5}$).

We find the following mass ratios:

$$(\pi^+/\text{proton})=0.1511\pm0.0006,$$
$$(\pi^-/\text{proton})=0.1504\pm0.0007.$$

If the proton to electron mass ratio is 1836.1, these figures correspond to 277.4 ± 1.1 and 276.1 ± 1.3, respectively, in units of the electron mass.

Particles[4] which were presumed to be μ^+ mesons originating from the decay of π^+ mesons stopping in the target were measured in the same experiment. The dispersion of apparent masses in this case, however, exceeds that to be expected if the particles were representatives of a single mass group, all of which comes from the target. μ^+ mesons which arise from decay of π^+ mesons in flight doubtlessly contribute to the distribution found, and we therefore must defer quoting a new μ^+ mass measurement until a better separation of the groups is obtained.

We wish to acknowledge the assistance we have received from numerous individuals of the Radiation Laboratory staff.

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† Dr. Gardner died on November 26, 1950, as a result of beryllium poisoning contracted while working on the Manhattan Project in 1942.

[1] F. M. Smith, *et al.*, Phys. Rev. **78**, 86 (1950).
[2] W. H. Barkas, Phys. Rev. **78**, 90 (1950).
[3] H. Bradner, *et al.*, Phys. Rev. **77**, 462 (1950).
[4] Burfening, Gardner, and Lattes, Phys. Rev. **75**, 382 (1949).

Erratum: Energy Dependence of Proton-Proton Scattering, 18.8 to 31.8 Mev

[Phys. Rev. **80**, 321 (1950)]

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THE value given in row 8 of column 5 of Table I for the normalized triple should be 14.45 millibarns rather than 25.45 millibarns. The values given in Table IV are correct.

Recombination and the Helium Afterglow Spectrum

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JOHNSON, McClure, and Holt[1] have recently made some important observations on the spectrum of a helium afterglow. They find that it consists of He_2 bands and that it does not contain He lines; they find also that the intensity of the luminosity is high, and over a considerable period is proportional to $[n(e)]^2$, the square of the electron concentration. These results might seem to be contradictory to the view[2] that electrons in such an afterglow disappear by dissociative recombination,

$$He_2^+ + e \rightarrow 2He. \quad (1)$$

However, in fact this is not necessarily the case. The absence of lines is to be expected: For the energy available from (1) is only about 21.4 ev, so that the atoms formed are limited to the 1^1S, 2^1S, 2^1P, 2^3S, 2^3P levels and in consequence do not radiate in the λ2000–8000A region studied.[3] Collisions involving them might, however, give rise to excited helium molecules and hence to band emission. Their rate of formation through (1) is proportional to $[n(e)]^2$ during the period in which He_2^+ is the principal ion, and, therefore, the intensity also follows this law. It is only necessary that their removal should be mainly due to the process suggested in order that a high photon yield should ensue. Phelps[4] finds that the rate of destruction of helium metastable atoms is proportional to the square of the gas pressure. The natural inference is that three-body collisions are the predominant cause of the destruction. These are likely to result in the production of molecules; it is not known whether they lead to the required excitation.

[1] Johnson, McClure, and Holt, Phys. Rev. **80**, 376 (1950).
[2] D. R. Bates, Phys. Rev. **77**, 718 (1950); **78**, 492 (1950).
[3] Although all the levels listed can be reached energetically, this does not mean that all are necessarily populated since other factors besides energy considerations enter. It would be of value to determine whether λ10,830A (2^3P-2^3S) is emitted.
[4] A. V. Phelps, *Conference on Gaseous Electronics* (American Physical Society, Division of Electron Physics, New York, October, 1950). Unfortunately the abstract of the paper read at the conference does not give the pressure range covered.

The Disintegration Scheme of I^{131}

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COINCIDENT scintillation spectrometers have been applied to the study of 8-day I^{131}. Gamma-gamma and beta-gamma-coincidence spectra show that a consistent decay scheme can be made including the 720-kev gamma-ray recently found by Zeldes, Brosi, and Ketelle.[1]

The gamma-gamma-coincidence spectra were obtained using NaI-TlI phosphors and 5819 photo-multipliers. A thin sample was placed in a central hole in a 3-mm lead diaphragm between the two crystals, as shown, approximately to scale, in Fig. 1A. The lead absorber reduces the back scattering of photons by the Compton process from crystal to crystal. Curve A, Fig. 2 shows the gross gamma-ray spectrum. The positions of the six known gamma-rays[1,2] are indicated by arrows.

The spectrum of pulses that have a coincident pulse of any energy in the other spectrometer is shown in Fig. 2, curve B. This curve has been corrected for random coincidences which are shown in curve C. The random coincidences were measured by delaying one spectrometer pulse with respect to the other until immediate coincidences were impossible. The peak due to the 364-kev gamma-ray, as well as the bulge due to the 720-kev transition, is absent from the coincidence spectrum. The x-rays, the 80-kev, 284-kev, and 638-kev gamma-rays remain, showing that each is in coincidence with at least one other.

When the second spectrometer is set to count only pulses representing 525-kev energy or greater, the coincidence spectrum is that shown in Fig. 2D. The peak due to the 284-kev gamma-ray and, of course, the 638-kev peak are now absent. This result shows that the 284-kev transition is not in cascade with the 638-kev transition, and since it does appear in the total coincidence curve, it must be in cascade with that of 80 kev. The presence of the 80-kev peak (and the x-rays) in Fig. 2D shows that the 638-kev transition is in cascade with the 80-kev transition. The coincidence count at two points, with the second spectrometer set to count 675 kev and over, are shown at the bottom of Fig. 2 without subtracting the accidentals, together with the accidentals corresponding, showing that only a few x-ray coincidences remain.

These coincidence results lead to the decay scheme shown in Fig. 3. This is essentially that of Kern, Mitchell, and Zaffarano,[3] except for the 720-kev transition, which they did not see.