agreement with the classification of Gieseler[1] on Pb II and Smith on Pb III[2] and Pb IV.[3]

Of these spectra, Pb III is the most interesting, since we have the possibility of checking the Houston[4] theory of intermediate coupling. In the case of the $6s7p$ configuration, ($^3P_0$, $^3P_1$, $^3P_2$, $^1P_1$) the g-sum of $^3P_1+^1P_1$ yields a value slightly higher than the 5/2 it should be according to Pauli's g-sum rule, while the $^3P_2$ level, which should be unaffected by coupling (to first order terms) yields a g-value of about 1.35 instead of 3/2. This might be accounted for by incorrect assignment, but there is no other level in the neighborhood that would fit. It seems then, that the abnormal g-value must be attributed to perturbations caused by the proximity of $6p^2$ and $6s7d$ configurations.

The work was done with the aid of the new 30,000 line 21-ft. grating in the Paschen-Ruage mounting, and the Weiss-type magnet recently completed at this laboratory, with fields of about 41,000 gausses. A complete report will appear in the late summer.

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May 4, 1932.

[1] Gieseler, Zeits. f. Physik **42**, 265 (1927).
[2] Smith, Phys. Rev. **34**, 393 (1929).
[3] Smith, Phys. Rev. **36**, 1 (1930).
[4] Houston, Phys. Rev. **33**, 297 (1929).

Attempts to Induce Temporary Radioactivity in Matter

The experiments of Pokrowski,[1] which report the excitation of feeble radioactivity in heavy elements by irradiating them with x-rays, are of such an astonishing nature that they seem to warrant careful repetition. Gingrich[2] did not find the ionization effects, on repeating the work with detecting apparatus of higher sensitivity and with harder x-rays and irradiating the materials for longer times. This naturally casts doubt on the existence of the effect, although Pokrowski seems to have taken such careful precautions in his experiments that it is not easy to see where consistent error could have been introduced. Pokrowski found measurable ionization produced as long as 90 minutes after exposure of the specimen to x-rays, and suggested that the energy was released from nuclei by trigger-action of the photons. Even if this dubious process is admitted as possible, one might expect that the emission would only last for a very small fraction of a second after irradiation of the specimen ceased. On the other hand, if nuclei have definite eigenstates, similar to those involving extranuclear electrons, it seems reasonable to believe that the absorption of suitable gamma-radiation might cause transitions which would subsequently result in nuclear fluorescence, even from non-radioactive atoms.

I have recently completed several series of experiments in which *long-time fluorescence* was sought from various materials that had been irradiated with gamma-rays and x-rays of different wave-lengths. No such fluorescence was detected, although the intervals between irradiation and detection ranged from 7×10^{-5} sec. to an hour. A Geiger counter was used as a detector. Its approximate sensitivity was found from the increase in the counting rate due to a known amount of radium at a known distance. The "accidental" count was 110 per hour, with the shielding used, while the rate with 1 mg of radium at 4 meters was 700 per hour. From this it is deduced that the accidental counting rate would be increased 50 percent by 2.3×10^{-6} mg of radium 2 cm from the counter, or that 4.6×10^{-8} mg would give a 1 percent increase. The sensitivity, expressed as the minimum detectable radium equivalent, depends on the distance of the material from the counter and the total number of impulses counted, hence the length of time over which the count is made.

In the first gamma-ray tests, various metals and crystals were irradiated for intervals up to an hour with gamma-rays from 1 mg of radium, at 3 mm distance, and transferred to the counter in about 30 sec. No increase in the counting rate was observed; the sensitivity of the counter was about 10^{-6} mg. The substances tried included aluminum, copper, lead, calcite, rocksalt, potassium bichromate, zinc sulphide, and quartz. The lead was a container for the radium, so had been exposed to gamma-rays for more than a year.

To test for fluorescence lasting for much shorter times, a beam of gamma-rays from 1

[1] G. I. Pokrowski, Phys. Rev. **38**, 925 (1931); also, Ann. d. Physik **9**, 505 (1931).
[2] N. S. Gingrich, Phys. Rev. **39**, 748 (1932).

mg of radium was allowed to pass through a hole in a thick lead block and strike a rotating aluminum disk. As the disk turned in the anti-clockwise direction, the irradiated spot went past a second lead tube leading to a Geiger counter, in 7×10^{-5} sec., so that fluorescence persisting that long might be detected. The corresponding time for clockwise rotation was 3.3×10^{-2} sec. Extended counts, made with the disk alternately rotating clockwise and anti-clockwise, agreed within the limits of statistical error, indicating that there was no fluorescence detectable by the means used. In addition to aluminum, beryllium (sulphate), carbon (paraffin), and lead (litharge), were successively waxed onto the disk and the experiment repeated, always with negative results. The sensitivity of the arrangement was sufficient to detect the gamma-ray equivalent of 1.2×10^{-5} mg of radium on the disk.

In another series of experiments, thick sheets of lead, molybdenum, tungsten, tantalum, and bismuth were placed 25 cm from the target of a tungsten x-ray tube, operated at 5 m.a. and 50 to 100 k.v.p., and irradiated for periods of 30 min. to an hour. After each exposure, the specimen was placed as near as possible to the counter, within 10 sec., and the subsequent counting rates were recorded at intervals of 5, 15, 30 and 60 min. There was no evident change of the counting rate with time, although the sensitivity was at least 2×10^{-6} mg. The tests were repeated under the same conditions until a sufficiently large number of impulses were recorded to make the statistical error in each interval small.

Long-time fluorescence of two x-ray tube targets was also investigated. The intense radiation incident on the targets of the tubes seemed to be a promising source of the fluorescence. A molybdenum tube was tried many times with a counter of about 44 cc volume, after running at 25 m.a. and 30 k.v.p. Lately, a tungsten tube was used with the small counter previously mentioned (volume 0.32 cc), after operation at 5 m.a., 50 to 100 k.v.p. The tubes were run for intervals of 5 sec. to an hour before each test. It was found that the counters recover their usual characteristics of response in about 0.02 sec., after being paralyzed by the intense radiation. The sensitivity of the small counter was about 5×10^{-5} mg, but no fluorescence was detected in any of the tests.

The small Geiger counter used here is a special one which also responds to ultraviolet light. A full description of its construction and operating characteristics will be published very soon. It was found that the intense discharge produced in the counter by strong x-rays temporarily sensitized it to visible light, so that it responded to the light from the x-ray tube filament, unless an opaque screen was interposed.

Clearly, the tests described here do not exclude the existence of induced gamma-ray emission, or nuclear fluorescence. But they indicate that if these effects do exist, their intensity, or duration, or both, must be below the limits of detection by the methods I have used.

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May 7, 1932.

A Comparison of the Theoretical Results of Sugiura and Sommerfeld on the Production of X-rays

Recently A. Sommerfeld[1] has treated the theoretical problem of the production of x-rays by a method somewhat different from the usual quantum mechanical method used by Oppenheimer[2] and Sugiura,[3] which considerably simplifies the analytical treatment. The basic model is the same in both cases, namely an electron, whose original velocity and direction are known, is retarded and deflected by a positive nucleus, the problem being the determination of the intensity of the radiation resulting from this process. From the results of Sugiura's calculations and those of Sommerfeld, it is not immediately evident whether or not their results are in agreement, and therefore at Professor Sommerfeld's suggestion, the following comparison has been made.

The only explicit formula given by Sugiura

[1] Sommerfeld, Ann. d. Physik. **11,** 257 (1931).

[2] Oppenheimer, Zeits. f. Physik **55,** 725 (1929).

[3] Scientific Papers of the Institute of Physical and Chemical Research **17,** 99 (1931).