ends the observed masses seem to vary somewhat more rapidly. This may perhaps be ascribed to the approximate character of our calculations and the lack of good mass estimations for more than perhaps thirty stars.

The stars of the giant class are distributed in H–R diagram in a very peculiar way, very different from the main sequence. The line (heavy line in Fig. 1) representing the geometrical place of maximum population shows a rapid increase of luminosity towards lower temperatures. If we suppose that the energy source of giants is of the same kind as for the stars of main sequence (i.e. ordinary thermonuclear reaction), differing only by the values of exponent n and the numerical coefficient in the formula (33) the giants should be distributed along a line running almost parallel to the main sequence.

The fact that it is not so leads us to the conclusion that the energy source in giants must be entirely different. It may be due for example to a resonance phenomenon for nuclear transformations playing a main role in these stars or, since all giants have the masses larger than the critical mass of Chandrasekhar and Landau,[4] to the beginning of the formation of a dense neutron core in the centers of these stars.

G. Gamow

The George Washington University,
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May 5, 1938.

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On the Nature of the Penetrating Cosmic Rays

The data obtained from an experiment in a copper mine[1] indicated that there are two types of very penetrating cosmic rays; one with a maximum range of about 250 meters water equivalent, and one with a much greater range; and that both types are capable of producing showers. It was suggested that the first of these consists of "heavy electrons" and the other of "neutrinos." One would expect the "heavy electron" to be a strongly ionizing ray and the "neutrino" to be weakly ionizing and detectable only by the ionizing secondaries which it produces. At the suggestion of Professor A. H. Compton, an experiment similar to those of Rossi[2] and Hsiung[3] has been performed to determine the type of the first group. Four Geiger-Mueller tubes were arranged according to the diagram in Fig. 1. One meter of lead could be piled between the second and third Geiger-Mueller tubes.

If all the penetrating rays at any particular depth are ionizing rays, then the absorption curve with the lead between the Geiger-Mueller tubes should be the same as the curve with the lead above all four tubes. If all the penetrating rays are nonionizing rays and are detectable only by the ionizing secondaries produced, then the absorption curve with the lead above all four tubes should depend upon the absorption coefficient of the primary and secondary rays; whereas, the absorption curve with the lead between the tubes should depend only upon the

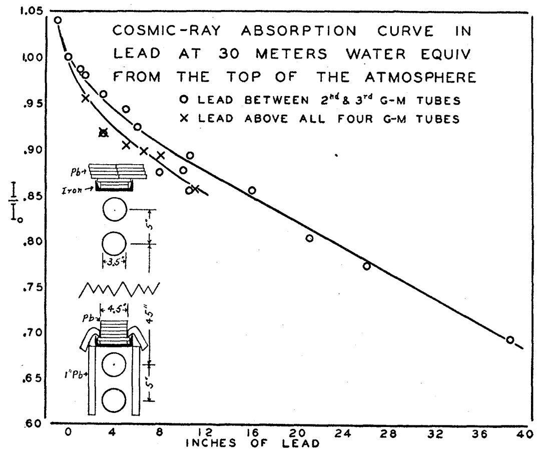

Fig. 1.

absorption coefficient of the secondaries entering the first Geiger-Mueller tube. (The nonionizing primaries and the secondaries produced in the lead will not be detected by the two upper tubes and so will not be recorded.) Evidently, then, the ionizing rays will show the same absorption curve whether the lead is above or between the tubes; whereas the nonionizing secondary producing ray will show much more absorption when the lead is placed between the tubes.

Figure 1 shows the data obtained in a tunnel of the Chicago Tunnel Company at a depth of 30 meters water equivalent from the top of the atmosphere. Except for the point at the extreme left, one inch of lead was kept around the second and third tubes to shield them from weak shower particles. Within the probable error (about 1.5 percent) the two curves agree, indicating that the great majority of the rays are of the ionizing type. To measure the showers, the second tube from the top was moved down 20 inches and to the right 8 inches. The shower counts with the lead shield were about 3 percent of the vertical counts, and without the shield, about 4 percent.

If one makes allowance for the smaller solid angle subtended by this apparatus as compared with that[1] used for the absorption in rock, the absorption curve in lead and rock agrees very well, thus identifying the ray observed with the first group mentioned above. One is led to conclude, therefore, that this first group of rays (maximum range 250 meters water equivalent) is an ionizing ray—probably the "heavy electron."

Nielson and Morgan[4] have recently completed a similar experiment at 75 feet of rock, in which, however, lead was placed only between the tubes. They conclude: "The penetrating component is to be associated with a charged particle." In an earlier report, Barnóthy and Forró say: "At great depths, about 800 meters water equivalent, the ionizing part of the cosmic radiation consists only of shower particles produced by a nonionizing radiation." They conclude that this nonionizing radiation consists of "neutrinos" created as described by Heisenberg.[6] This conclusion is the result of a comparison of the shower coincidences with the linear coincidences at various angles from the vertical. Such evidence is much less direct than the evidence for the ionizing character of the primary rays present at lesser depths that is presented in this report. Nevertheless, the three experiments support the original hypothesis that the first group consists of "heavy electrons" and the second of "neutrinos." It is felt that more work should be done along this line and plans have been made to repeat the above experiment at other depths.

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University of Chicago,
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May 2, 1938.

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On the Structure of "Built-Up" Films on Metals

Holley has described[1, 2] some x-ray and optical measurements on barium stearate and barium-copper stearate films. At the request of Professor Rideal and Dr. Bikerman I have examined some barium stearate films of the X type[3] with the use of the same apparatus that was employed in the study of the long spacings of tobacco mosaic virus protein.[4, 5] This consisted essentially of a "condensing" monochromator[6] and a slit system to isolate the $K\alpha$ component of the reflected radiation. The measurements were made in air, with copper $K\alpha$ radiation ($\lambda = 1.539$A) and the distance from the specimen to the photographic film was up to 40 cm. It is quite unnecessary to employ vacuum cameras for long spacing measurements with monochromatic radiation. Fig. 1 shows 5 orders of the Bragg reflections from 100 X layers of barium stearate rolled continuously on to a chromium plated ring 7.5 cm in diameter. (See following letter.) This gives a value of 51.5 ± 0.5A for the grating spacing. This agrees with Dr. Holley's results for X type films in giving an x-ray spacing similar to that of the Y films and to those obtained in the crystal. A 95 layer X type calcium stearate specimen gave a pattern which was substantially identical with the barium stearate insofar as intensities and spacing were concerned. The very long angle diffuse scattering is caused by the specular reflection of the x-rays by the chromium.

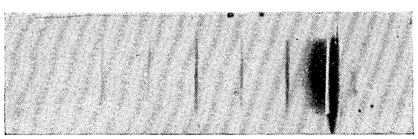

FIG. 1. Five orders of Bragg reflections from barium stearate multilayers. $\lambda = 1.539$, specimen to film distance 20.1 cm.

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May 6, 1938.

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On the Structure of "Built-Up" Films on Metals

The results of Fankuchen,[1] as well as those of Holley and Bernstein,[2] and of Holley,[3] which show the identity of the spacings in X and Y films, presumably admit of a simple explanation. The primary difference between X and Y films lies in the manner of their formation (Blodgett[4]); that they—even after the preparation—have different properties was first demonstrated by E. F. Porter and J. Wyman,[5] who have found that an X film affects the potential of the underlying metal much more strongly than a Y film of the same thickness. We are able to confirm (qualitatively) Porter's and Wyman's results although we have measured the potentials in a different manner. We have measured by a compensation method the potential difference in air between a radioactive needle and a metal slip coated with the multilayer. In addition we have found that the originally high potentials of X films gradually decay, and that the rate of decay is greatly accelerated by irradiation with x-rays or with α-particles of Po. The influence of the x-rays is complex since they also cause an electron emission from the multilayer; and we have as yet been unable to separate quantitatively both effects. At any rate, even after allowance for the photoelectric effect, the fact remains that the X films change their electric properties when irradiated by x-rays and that the direction of the change would correspond with the transformation of X into Y films. It is therefore certain that patterns produced by irradiation of X films are those of *transformed X* films, and it is not improbable that the transformed X films have the molecular arrangement of the Y films. Then the agreement between the spacings of the transformed X films and the Y films would be self-explanatory.

The barium stearate film measured by Fankuchen has been produced with a new technique. Instead of metal strips which are dipped in, and withdrawn from, the solution[4] we have used a metal ring (short cylinder) suspended by and rotating round a horizontal axis. About one-third was immersed in the solution. When the surface of the solution was covered with a monolayer on both sides of the ring, the ring after a complete rotation was coated by one "Y film." But, when the contaminated surface was separated from the clean surface by a floating barrier which was placed inside the ring, it was possible to let the ring go downwards through a monolayer and upwards through the clean water surface, so that the film was only picked up on the downwards journey similar to the usual X films technique. The film measured by Fankuchen consisted of 100 such "artificial X films." By placing the floating barrier inside the ring and covering the surface to the right and to the left side of the barrier with different monolayers, it is hoped that a complete rotation of the ring may produce a mixed film two molecules thick or a penetrated mixed monolayer.

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Colloid Science Department,
University of Cambridge, England,
May 6, 1938.

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