Production of Mesotrons up to 30,000 Feet at a Magnetic Latitude of 22° North

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(Received October 23, 1946)

The production of mesotrons by non-ionizing radiation in a lead thickness of 2 cm was measured in an airplane at a magnetic latitude of 22° North. In general the results are in agreement with those obtained by Schein, Jesse, and Wollan. In addition it was found that mesotrons passing through 8 cm of lead exhibit in the intensity *vs.* altitude curve a marked hump in the neighborhood of a pressure of 530 millibars.

IN 1939, Schein and Wilson[1] studied the production of mesotrons in lead by non-ionizing particles at higher altitudes. They reached a height of 25,000 feet in an airplane at Chicago (54°N) and found that at these altitudes mesotrons were produced by non-ionizing radiation. Schein, Jesse, and Wollan[2] extended these measurements to considerably higher altitudes by means of balloons. In 1945 the author studied the production of mesotrons in 2-cm lead up to an elevation of 30,000 feet at the latitude of Lahore (22° magnetic North). The equipment used was similar to that used by Schein and Wilson[1] and is shown diagramatically in Fig. 1. The apparatus consisted of four Geiger-Müller tubes placed one above the other in a vertical line. Slabs of lead 2 cm thick were placed between the upper two tubes and between the lower two tubes, while a block of lead 6 cm thick was inserted between the second and the third tubes. The upper G-M tubes constituted a cosmic-ray telescope with a lead absorber 8 cm in thickness. The lower three G-M tubes constituted the second telescope with a lead absorber of 10-cm thickness. The third tube from the top was shielded from the sides with one-cm lead in order to reduce effects of soft side showers. The cone of both telescopes was 22° 38′ in the vertical and 65° 48′ in the lateral plane. The efficiency of the two coincidence sets was exactly the same. The apparatus was placed in the nose of a R.A.F. Mosquito aircraft and was supported by double gimbles so that it remained vertical in spite of the tilting of the plane.

The results of the flight made on December 4, 1945 are shown in the curves of Fig. 2. Curve A represents the coincidences from the upper telescope and curve B those of the lower one. For both curves the number of triple coincidences per minute is plotted against the pressure in millibars. The minimum pressure reached during this flight was 300 millibars above sea level. Records were made throughout the flight beginning at the

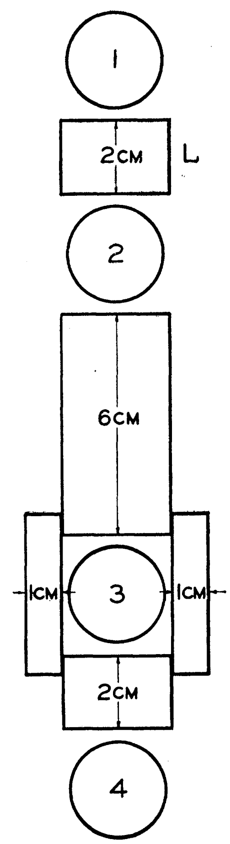

FIG. 1. Arrangement of counters.

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[1] M. Schein and V. C. Wilson, Rev. Mod. Phys. 11, 292 (1939).

[2] M. Schein, W. P. Jesse, and E. O. Wollan, Phys. Rev. 57, 847 (1940).

ground at an altitude of 600 feet above sea level. At the ground level very little difference between the counting rates of the two telescopes should be observed. Ordinarily the lower telescope should give a slightly lower number of coincidences per unit time than the upper one because of (a) the absorption of mesotrons in the additional 2-cm lead block and (b) the scattering of these particles in the same block of lead. Curves *A* and *B* show that up to a height of 17,000 feet the average number of coincidences from the lower set of G-M tubes is somewhat less than from the upper set as is expected because of the two above-mentioned effects. Above this height the lower telescope begins to show a very marked increase in the number of coincidences per unit time over the upper one. The average difference between the counting rates of the two sets between the elevations of 17,000 feet and 30,000 feet is about 33 percent. This large difference is in accordance with the findings of Schein, Jesse, and Wollan[2] from their balloon data. As already pointed out by them, the production of mesotrons in a 2-cm lead block does take place abundantly at higher elevations and in this small thickness of lead such a large difference definitely indicates that the mesotron producing radiation is strongly absorbable in lead and hence should most probably consist of photons.

The accuracy of each point given in the curves is approximately 8 percent. This follows from the fact that the duration of flight at a particular height was between 25 and 35 minutes. These data seem to confirm in general the results obtained by Schein, Jesse, and Wollan.[2] However, because of the fact that considerably more data were collected in these experiments, the curves of Fig. 2 give much more detailed information at intermediate altitudes where the production of mesotrons by photons just sets in. Schein, Jesse, and Wollan[2] sent their equipment up by using balloons which usually ascend to much higher altitudes and therefore pass through these regions of the atmosphere in a very short time. As a result their data in these altitudes were not sufficiently accurate to show all the details of the curves obtained here.

The curves shown in Fig. 2 reveal some interesting information not only regarding the production of mesotrons by photons but also regarding the intensity *vs.* altitude curve (*A*) for mesotrons passing through 8 cm of lead. As seen from the figure, Curve *A* shows a distinct hump at a pressure around 530 millibars. The nature and magnitude of this hump presumably depends on the geometry of the cosmic-ray telescope and the lead thickness interposed. This point needs further investigation. It is, however, quite clear that the mesotron intensity *vs.* altitude curve is not a smoothly increasing curve as is generally assumed but shows a break in the neighborhood of 500 millibars pressure. This might mean that either a group of softer mesotrons produced at higher layers of the atmosphere are not able to penetrate more than one-half of the atmosphere or that some non-ionizing radiation responsible for the production of softer mesotrons is abundantly present in the upper atmosphere only. It is interesting to note that at practically the same pressure (530 millibars) where the hump in curve *A* occurs, curve *B* crosses curve *A*. Since the lower telescope registers in addition to the mesotrons passing through 10 cm of lead those produced by non-ionizing radiation in 2 cm of lead, no pronounced hump was found to be present in curve *B* at 530 millibars. The rapidly increasing production of mesotrons with altitude in 2 cm of lead smoothes out curve *B* sufficiently that no definite inflection could be detected

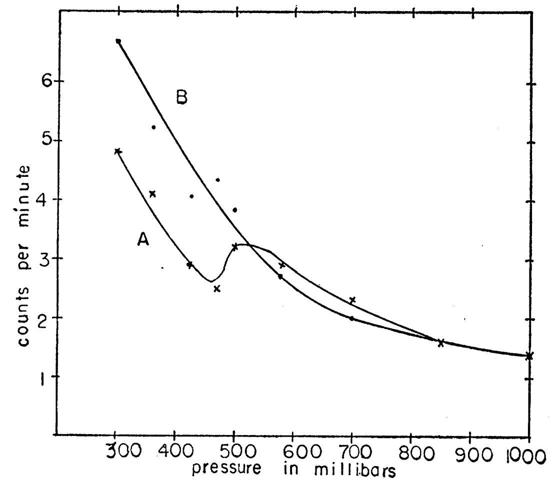

FIG. 2. Mesotron intensity as a function of altitude. Curve *A* (crosses) represents coincidences for upper telescope and curve *B* (solid dots) represents coincidences for lower telescope.

within the experimental precision. This, however, does not rule out the possibility of its existence which could only be established by more precise measurements.

The comparison of the present data with that of Schein, Jesse, and Wollan[2] shows that the curves A and B at 22° North magnetic latitude are consistently lower at the higher elevations, thus exhibiting a definite latitude effect on mesotrons passing through 8 cm of lead. This is in agreement with recent measurements of Bhabha and his collaborators[3] who also found a latitude effect of the same order of magnitude on the mesotron component.

The author acknowledges with thanks the valuable suggestions and criticism given by Professor Marcel Schein. The author also wishes to express his thanks to the R.A.F. for putting at his disposal one of their Mosquito aircraft in which the flights were made.

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PHYSICAL REVIEW VOLUME 71, NUMBER 2 JANUARY 15, 1947

X-Ray Absorption Structure of $GeCl_4$ and $AsCl_3$*

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(Received October 31, 1946)

The fine structure on the short wave-length side of the K x-ray absorption edges of Ge and As in $GeCl_4$ and $AsCl_3$ has been measured with a double crystal spectrometer having resolution sufficient to resolve all structure predicted by theory. The results are compared with the theory and with previous measurements made with spectrographs of lower resolving power. Structure is obtained closer to the edge than that resolved heretofore, which structure is not altogether in agreement with the theory.

INTRODUCTION

THE fine structure to be found on the short wave-length side of the x-ray absorption edge of a molecular gas was explained by Kronig[1] in terms of the scattering of the ejected electron by neighboring atoms in the molecule. The probability of the ejection of the electron, and consequently the absorption coefficient, is found to be dependent upon the energy with which the electron leaves the parent atom. Kronig's general arguments have been summarized by Snyder and Shaw[2] and applied to the Br_2 molecule which had been shown to have a pronounced structure.[3–5] The theory was in agreement with the experimental structure near the edge in so far as position was concerned but not as regards the intensity. Structure which was predicted for positions further from the edge was not observed.

Perhaps the most detailed theoretical calculation of the fine structure for a gaseous molecule is that made for the germanium edge in $GeCl_4$ by Hartree, Kronig, and Petersen.[6] $GeCl_4$ has been studied experimentally by Coster and Klamer[7] and by Drynski and Smoluchowski.[8] Agreement between theory and experiment was acceptable at an energy separation of 50 volts and more from the main edge. Unfortunately, the experiments were carried out using a photographic spectrograph of low resolving power; consequently, the several pronounced structures nearer to the edge than 50 volts which were predicted by theory could not be checked experimentally. $AsCl_3$ was also considered by Hartree,

* This work was carried out as part of Contract N6ori-167, Task Order II with the U. S. Navy Office of Naval Research.

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