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Observation of High Intensity Radiation by Satellites 1958

Alpha and Gamma

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Introduction

This is a preliminary report of results obtained concerning radiation intensities measured with a single geiger tube carried by the artificial earth satellites 1958 α and 1958 γ.

The counting rate of the counter in 1958 α was transmitted continuously, and the data were recorded only when the satellite was quite near one of the 18 receiving stations distributed over the earth.

The data collected by 1958 γ were also telemetered continuously. In addition, a small magnetic tape recorder stored the data obtained during each entire orbit. Then, as the satellite passed near one of the receiving stations, a radio command from the ground caused the data to be read out.

A preliminary study of the data obtained from 1958 α and several interrogations of 1958 γ has been carried out, with the following results.

Reasonable cosmic ray counting rates have been obtained for altitudes below about 1000 km. In particular, we have obtained a plot of omnidirectional intensity vs. height in the vicinity of California for the first two weeks in February. This curve, extrapolated down to altitudes previously reached by rockets, agrees with earlier data.

At altitudes greater than about 1100 km, very high counting rates were obtained. This conclusion is the result of a somewhat lengthy analysis. Geiger tube output rates up to about 140/see have actually been observed. In addition, periods have been found during which the geiger tube put out less than 128 pulses in 15 min. (We have a scaling factor of 128.)

The considerations detailed in section 3 cause us to conclude that this is not due to equipment malfunction, but is caused by a blanking of the geiger tube by an intense radiation field. We estimate that if the geiger tube had had zero dead time, it would on these occasions have been producing at least 35,000 counts/sec.

We surmise that the radiation we have found is closely related to the soft radiation previously detected during rocket flights in the auroral zone.

The radiation intensity necessary just to blank the geiger tube is equivalent to 60 mr/hr. In this connection the recommended permissible dose for human beings is 0.3 r/week.

The present radiation is 0.3 r in 5 hr or less.

Several geophysical effects of this radiation seem possible. It is very likely closely related to aurorae and geomagnetic storms. In addition, a rough calculation suggests that the radiation may be sufficiently intense to contribute important heating to the upper atmosphere. It will be important to investigate the amount of atmospheric ionization, light and radio noise which would be produced, under various assumptions as to the nature of the radiation.

1 Instrumentation for 1958 α and 1958 γ

The instrumentation for 1958 α consisted essentially of a single Geiger Mueller tube, a scaling circuit for reducing the number of pulses to be worked with, and telemetry systems for transmitting the scaler output to the ground receiving stations. The system contained in 1958 γ was identical, with the addition of a miniature tape recorder for storing the data for the duration of each orbit and a command system to cause the telemetry of the stored information over a ground receiving station (Fig. 1).

Identical G.M. counters, scaler input circuits and scaling circuitry were used in the two cases. The G.M. counters were Anton halogen quenched counters having approximately 0.050 in. thick stainless steel walls. In addition, the counters were surrounded by the stainless steel cases of the payload, which were 0.023 inch thick. Thus the total absorption was approximately 1.5 cm em$^{-1}$ of stainless steel (approximately 1000 m of water).

![Fig. 1 Block diagram of 1958 γ instrumentation](image)

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6 These satellites are sometimes called Explorer I and Explorer III, respectively.


were reset, the transmitter turned off, and the next recording begun.

The information thus telemetered to the ground was the train of pulses emanating from the inhibitor circuit, except that it was much compressed in time. It can be seen then that scaler input pulse rates between 0 and 128 per sec were properly passed on, and that all rates above 128 per sec appeared as a rate of 128 per sec, that is, all pulses missing.

2 Summary of Preliminary Observations

Table 1 is a list of the stations receiving data and reporting them to us. The stations labeled JPL are operated under the auspices of the Jet Propulsion Laboratory at Pasadena, Calif. Those labeled NRL are operated by the Naval Research Laboratory in Washington, D.C. Data were obtained from 1958 only when it was reasonably near one of these stations, since it had no provision for storing data for a later readout. We have already analyzed most of the data from the JPL stations, and some of that from the NRL stations as well. This work is continuing.

A small magnetic tape recorder in 1958 stored the cosmic ray information for an entire orbit, and then played it into a transmitter on command from the ground. Data from nine of these orbits have been reduced in a preliminary way. We already have on hand many more of these passes, and are reducing the data from them in a routine way.

It is evident from the above summary that the present report is a very preliminary one. The nine cases from 1958 occur during the last four days of March, and we expect ultimately to have data obtained during several weeks after those days. In addition, we have so far reduced the data from 1958 only in a rather rough way, as explained in the following paragraphs. Finally, we do not yet have highly accurate data on the satellites' orbits. We do have the position of 1958 as a function of time tabulated in 1 min intervals as supplied by the Vanguard Computing Center for the month of February. These data seem to be in error by several minutes in time, but apparently are sufficiently accurate for the purposes of the present report. So far for 1958, we have only a set of orbital elements for March 29 and position vs. time for one orbit on April 1, together with estimates of the various perturbations. This information, supplied to us by the Vanguard Computing Center, has made it possible for us to estimate the orbit during the last days of March with reasonable accuracies. In particular, we estimate that our error in determining the time of passage through perigee is not more than about 5 min on March 31, and is less on earlier dates. Our errors in estimating latitude and longitude may amount to 10 deg in some cases.

Accurate orbital data will ultimately be supplied to us by the Vanguard Computing Center.

Table 1  Receiving stations

<table>
<thead>
<tr>
<th>Station</th>
<th>JPL</th>
<th>NRL</th>
</tr>
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<tbody>
<tr>
<td>Blossom Point, Md.</td>
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<tr>
<td>Fort Stewart, Ga.</td>
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<td>Antigua, Br. W. Ind.</td>
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<td>Havana, Cuba</td>
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<tr>
<td>San Diego, Calif.</td>
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<tr>
<td>Quito, Equ.</td>
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<tr>
<td>Lima, Peru</td>
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<tr>
<td>Antofagasta, Chile</td>
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<tr>
<td>Santiago, Chile</td>
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<tr>
<td>Woomera, Aus.</td>
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<tr>
<td>Patrick Air Force Base, Fl.</td>
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<tr>
<td>Earthquake Valley, Calif.</td>
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<tr>
<td>Singapore</td>
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<tr>
<td>Ibadan, Nigeria</td>
<td></td>
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<tr>
<td>Temple City, Calif.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasadena, Calif.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

September 1958
We discuss first the data obtained from 1958 α.

Fig. 3 is a plot of height against counting rate near the California coast. All of the passes recorded by JPL stations in California are included in this graph. There is some variation in latitude, which presumably accounts for some of the scatter of the points. In addition, as explained above, the orbital data are not yet known with good accuracy, and this presumably contributes significantly to the scatter. A linear extrapolation down to a height of 100 km yields a value of omnidirectional intensity of 1.22 (cm²·sec⁻¹), in adequate agreement with values we have previously obtained from rocket flights, considering the crudity of the extrapolation. The data shown in this figure were nearly all taken before Feb. 11.

The data obtained by the NRL stations in South America during the first two weeks of February are altogether different from those just discussed. The passes fall into two classes. In the first case, one obtains a counting rate of about 30/sec, a roughly reasonable value. In the second case, the telemetered signal fails to show a single scaler output pulse during the approximately 2 min of clean signal. This represents an input rate to the scaler of less than about 0.1/sec. There are, in addition, a few cases showing a strong change in counting rate during the pass.

For reasons discussed in section 3, we believe that the extremely low output rate of the scaler is caused by very intense radiation which "jams" the geiger tube so that it puts out pulses even at the lowest level that they are below the threshold of the counting circuits. Laboratory tests show that this first happens for the present equipment when the radiation reaches such an intensity that a counter of the same effective dimensions and efficiency as the present geiger counter but with a zero dead time would produce 35,000 counts/sec.

Fig. 4 is a plot of height vs. geographic latitude in the vicinity of 75 W longitude. The positions of 1958 α during reception of its telemetering signal by various of the NRL stations are marked. A code designates the kind of information received. It is at once evident that the extremely low counting rates observed all occur at a high altitude, while the more or less normal rates occur at a low altitude. Transitional cases occur at a low altitude. Transitional cases occur at intermediate altitudes.

Quite similar behavior is observed near Singapore, and probably also Laotian. In these two cases no thorough study has been made, mostly because of the lack of trajectory data for the dates on which extremely low telemetered counting rates occur. In the one case at Singapore where such a rate occurred on a date for which orbital data were available, the extremely low counting rate observed occurred at an altitude of about 2000 km.

Fig. 5 is a plot of geographic latitude vs. geographic longitude for various orbits. Only the high altitude cases are plotted on this figure. The fact that the segments of data do not correspond to positions of closest approach to the interrogating stations is due to our so far inaccurate knowledge of the trajectory.

These data already suggest a picture of the geophysical phenomenon being measured. The data from 1958 γ are much more explicit. Fig. 6 is a plot of the scaler output as a function of time as given by the tape recorder readout for the pass ending near San Diego on March 28, 1748 UT. Since the tape recorder can only record one scaler output pulse each second (see section 1) the maximum indication on the tape recorder output corresponds to 128 counts/sec for the geiger tube output rate. (Our scaling factor is 128 in this case.) It is evident from the figure that reasonable counting rates occur near the two ends of the pass. These ends correspond to the most northern latitudes and the lowest heights above the earth. The section where the counting rate indication is zero corresponds to a portion of the magnetic region where no tuning fork pulses were missing, and hence no scaler output pulses occurred. This condition lasted 15 min, and 128 pulses were fed to the scaler during this time. This is an}

The tape recorder has three 15,000-dash memories, and these are the usual pulse times of the effect. An explanation will be presented at the meeting.

The geiger effect was also observed to occur in the satellite's orbit. As the satellite shut down due to a battery problem, the temperature dropped, but the effect continued for several hours. This suggests that the effect may be related to the satellite's mechanical structure.
average counting rate for the interval of 0.14/sec, to be compared with the usual cosmic ray rate for a geiger tube of this sort of about 50/sec. The counter goes through the transition from putting out essentially no counts to putting out a great many very quickly, and we presume that most of the 128 counts observed during this 15 min interval occurred near the ends of the interval. There is, of course, no real evidence for this.

As discussed in detail in the next section, we believe that if we had had a detector with zero dead time, and a storage mechanism of unlimited capacity, Fig. 6 would begin where it does now, and at about 13 min would have begun rising rapidly to a peak near 25 min at which point the counting rate would have been greater than 35,000 counts/sec. After this time, the rate would gradually have subsided, returning finally to about the value actually recorded near the end of the pass.

Fig. 7 is a plot of geographic latitude vs. geographic longitude of those orbits for which the tape recorder readout data have so far been analyzed. We have simply identified the transition points between portions of the record where no tuning fork pulses are missing, all tuning fork pulses are missing, or some tuning fork pulses are missing. These three different kinds of regions are identified on the graph as >15,000/sec, 128 to 15,000, and <128, respectively. The dashed portions of the various curves represent regions where the identification as to counting rate range is uncertain. Since these passes all occurred during March 28 through March 31, the orbit did not have time to precess appreciably. Since perigee was near the most northern latitude, a given latitude corresponds closely to a given altitude. It is evident that at high altitudes and low latitudes, mostly in a certain range of longitude, the counting rate is very high. Near perigee the counting rate is low. Elsewhere intermediate counting rates occur. Possible interpretations of this result will be discussed in section 3.

3. Interpretation of Observed Data

We now propose to justify our claim that when essentially no scaler output pulses occur, the apparatus is, in fact, exposed to very intense radiation.

Three possibilities are immediately evident. The apparatus may have some simple malfunction. This possibility can immediately be rejected except for the scalers, geiger tubes, and geiger tube voltage supplies, since the subsequent treatment of the information is completely different in the 1958 α and 1958 γ. Some effect of temperature seems the only reasonable possibility here. The temperature of the geiger tube was measured in 1958 γ and telemetered continuously to the operating transmitter. The observed temperatures range from zero to about 15 C. As discussed in section 1, the operating range of the circuitry is 25 to 85 C. In addition, the frequencies of the continuously telemetering channels which carried the cosmic ray information are significantly temperature sensitive. These showed that no extreme temperatures occurred at the location of the corresponding subcarrier generators.

Another possibility might be that the satellite passed through regions which very few cosmic rays could reach. This is extremely unlikely. A magnetic field of the order of one gauss extending over thousands of kilometers and remaining unbelievably free of local irregularities would be required to exclude a sufficient fraction of the cosmic radiation.

The possibility that we firmly believe is correct is that the geiger tube encountered such intense radiation that dead-time effects reduced the counting rate essentially to zero. In order to explore this possibility, we have carried out the following experiments.

A spare flight unit for 1958 α was placed in an X-ray beam which was hardened by a ½ in. thick, brass absorber. The voltage on the X-ray tube was varied between 50 and 90
Flame Stabilization in the Boundary Layer of Heated Plates

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This paper describes studies conducted with flames stabilized in the boundary layer of a heated flat plate. A graphical analysis of boundary layer flame stabilization is proposed and verified by an experimental investigation of propane-air flames. The free stream flow was laminar with a turbulence intensity of 0.4 per cent, and the approach mixture velocity was 25 and 50 ft per sec. The maximum Reynolds number encountered, based on the length of the heated plate, was 122,000. Surface temperatures up to 2925 R were investigated.

Introduction

In TURBOJET afterburners and ramjets, it is necessary to anchor the flame and prevent it from being blown out by the high velocity gases. One method which has been suggested is the stabilization of the flame on a high-temperature surface. Such a surface may have the form of a circular cylinder or a flat plate, aligned parallel with the flow. The phenomenon whereby a flame anchors itself within the boundary layer of the surface as a result of boundary layer configuration and surface temperature is called boundary layer flame stabilization. No flow separation occurs, and, in addition, the surface upon which the stabilizing boundary layer is created need not obstruct the flow stream. No turbulence is created by the body other than that from the transition from the laminar to the turbulent regime.

Previous Investigations

Probably the use of heated bodies to stabilize flames was first proposed in 1950 by Tien (1) who suggested a flameholder in the shape of a streamlined body. Such an airfoil would first be internally heated until combustion was initiated. Once the flame was started, it would be stabilized on.

Acknowledgments

We owe a large debt of gratitude to many individuals and agencies. We are indebted to the Jet Propulsion Laboratory, Los Angeles, Calif., for the high-speed rocket cluster and for assembly of the satellite payload. The Army Ballistic Missile Agency at Huntsville, Ala., supplied the booster stage and conducted the launching. Project Vanguard of the Naval Research Laboratory assisted in the early design phases of the instrumentation. They also set up and operated the minitrack tracking and telemetering stations, with cooperation and assistance from the countries in which the stations are located. They supplied us with orbital information for both satellites. The Jet Propulsion Laboratory set up the microlock stations for telemetry reception and operated all of them except those at Ibadan and Singapore. These last two were operated by students at University College, Ibadan, and the University of Maylays, Singapore, as a part of the British IGY effort.