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ENHANCEMENT OF THE X-RAY INTENSITY AT BALLOON ALTITUDES IN THE SOUTH AMERICAN ANOMALY*

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Several years ago, Cladis and Dessler[1] predicted the possibility of detecting bremsstrahlung x rays at balloon altitudes in the region of the Cape Town anomaly, originating in electron precipitation from the outer radiation belt. Later, satellite measurements by Vernov et al.[2] located a region over the east coast of Brazil and adjacent Atlantic Ocean with high radiation intensity, attributed to particle precipitation from the inner radiation belt. These measurements were confirmed by Discoverer 29 and 31 flights[3] indicating the "South American anomaly" to be located mainly over the Atlantic Ocean between 0 and 70°W longitude with maximum fluxes at about 30-35°S latitude. Finally, measurements on trapped electrons from project Starfish showed that their maximum approach to the earth's surface occurred in a region centered at about 35°S and 40°W.[4]

Bremsstrahlung flux estimates, using the Discoverer 29 electron *C* spectrum,[3] indicated that an x-ray intensity enhancement might be detectable at balloon altitudes in the South American anomaly. A series of balloon experiments was carried out between 7 and 13 December 1963, over the Atlantic Ocean, about 900 miles east of Buenos Aires. The principal aim was to verify the existence of such an additional x-ray flux, and to determine its atmospheric absorption. Six successful launchings were performed from aboard the oceanographic ship "Comodoro Laserre." Three flights carried x-ray equipment. This included a three-channel scintillation counter, a Victoreen 1B85 Geiger-Müller counter, and pressure and internal temperature transducers. Energy losses in the $1\frac{1}{4}$-in. $\times\frac{1}{2}$-in. NaI(Tl) crystal were in the nominal ranges 20-60 keV, 60-150 keV, and >150 keV. The Geiger-Müller counting rate provided an accurate estimate of the atmospheric depth at high altitudes. The total payload weight, including gondola and parachute, was 2.8 kilograms. Each payload was carried by a single neoprene balloon (Darex J11-2400) with valve stabilization of altitude.[5] Floating altitudes up to 38 000 m were attained. Flight duration was limited to a pre-fixed interval by a cut-down mechanism. Three flights, carrying standard Geiger telescopes, were performed to monitor the cosmic-ray background.

Details of the three x-ray flights are summarized in Table I. Flight No. 31 descended shortly after reaching maximum altitude. Flight No. 32

Table I. Details of the three x-ray flights.

Flight No.	Balloon launch (Local time)	Geographic position at launch	Cutoff rigidity (GV)	Minimum atm depth (g/cm^2)
31	1250, 10 December 1963	35.5°S 40.0°W	10.6	8.5
32	1620, 11 December 1963	35.5°S 36.7°W	10.4	4.5
35	1324, 13 December 1963	37.7°S 47.0°W	10.5	4.0

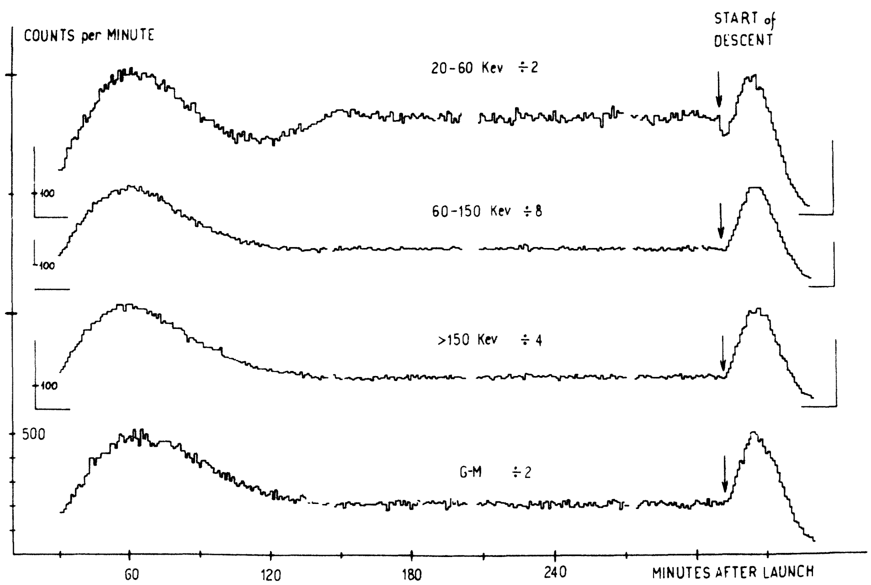

FIG. 1. Counting rates vs time for flight No. 35.

was launched in the late afternoon reaching the highest point shortly before sunset, in order to obtain good intensity vs altitude data during the very slow descent due to balloon cooling. Flight No. 35 stayed at a fixed level of about 4 g/cm^2 for several hours. This flight was launched where Discoverer 29 detected the highest flux in the anomaly. Figure 1 shows counting rate vs time for flight No. 35. After having passed through Pfotzer maximum, the 20- to 60-K channel counting rate increases again during the last part of the balloon ascent. This process appears in a reversed way during the first minutes of parachute descent. The other two x-ray flights showed a similar behavior.

Figure 2 shows intensity vs depth plots for the high-altitude range. Counting rates taken during descents are marked with crosses; for these, a correction was applied in order to take into account the influence on the discrimination levels of the temperature, which towards the final parts of the flights was decreasing to very low values, specially in flight No. 32. Higher energy channel counting rates corresponding to flight No. 35 are added for comparison. There is some indication for the 60- to 150-keV channel to show a small additional flux too, below 10 g/cm^2. In Fig. 3 we have represented the x-ray enhancement in the 20- to 60-keV interval, i.e., the difference between the measured x-ray flux and the linearly extrapolated atmospheric secondary photon flux

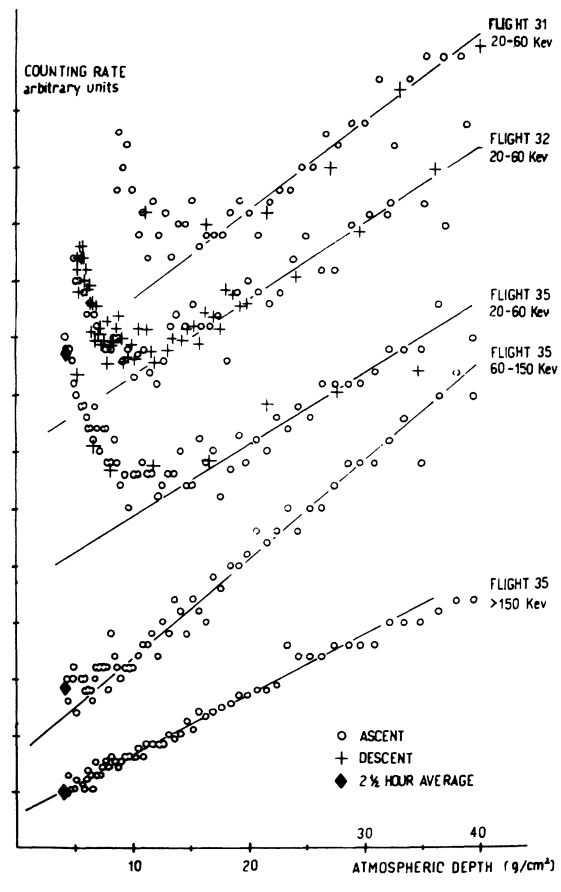

FIG. 2. Counting rates vs atmospheric depth in the high-altitude range.

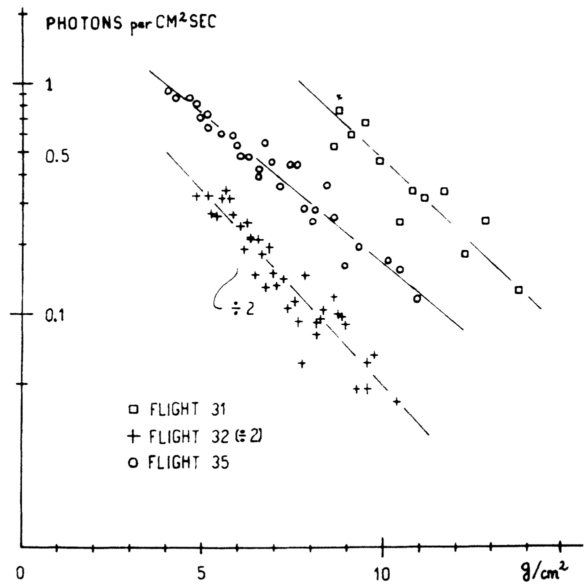

FIG. 3. Additional x-ray flux in the 20- to 60-keV interval, for flights Nos. 31, 32, and 35.

(solid lines in Fig. 2). A geometrical factor of 7.13 cm^2 was used. Apparently, flight No. 31 showed the strongest effect, although it reached only 8.7 g/cm^2 atmospheric depth. Only the knowledge of the energy spectrum of the additional flux will enable us to decide whether the differences between the three flights are due to a geographic dependence or to small differences in the channel widths. The mean absorption length for the additional flux is 3.0 ± 0.5 g/cm^2.

In summary, there seems to be no doubt about the existence of an additional flux of low-energy x rays in the region of the South American anomaly, detectable above 30-km altitude. We suggest that this x-ray flux enhancement originates in electron bremsstrahlung. These electrons might precipitate from the inner radiation belt, or from the remainder of the "Starfish" fission electron belt. A more detailed interpretation of data in order to estimate the precipitating electron flux and spectrum is under progress.

The fact that secondary effects of the electron precipitation in the South American anomaly can be detected at balloon altitudes makes it possible to study in a rather simple way the behavior of electrons trapped in low L shells as a function of time.

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SURFACE STATES ON THE (111) SURFACE OF DIAMOND

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A calculation of the surface states on the (111) surface of the diamond crystal has been made, based on the linear combination of band orbitals (LCBO) model. The interaction integrals between the localized orbitals have been evaulated in the same approximation used in the *a priori* LCBO volume-state calculation of Cohan, Pugh, and Tredgold,[1] so that the surface-state spectrum fits consistently into the volume-state energy bands of that model.

The volume-state calculation was based on an expansion in terms of eight tetrahedrally directed bonding and antibonding orbitals ϕ_1^b to ϕ_4^b, ϕ_1^a to ϕ_4^a, made up from Slater $2s$ and $2p$ atomic orbitals orthogonalized to the $1s$ functions. The orbitals directed along the bond between the near-