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16.Summary/Notes *Studies concerning particle precipitation and atmospheric X-and low energy gamma-rays in the South Atlantic magnetic anomaly by balloons experiments have been made at INPE since 1968.* ~~*This paper presents a brief report on these research activities.*~~ Hot are reported

17.Remarks *This work will be presented in the "First Aeronomy Workshop Brazil-Argentina", to be held at Foz do Iguaçu, Brazil, during 18-20 July, 81.*

PARTICLE PRECIPITATION AND ATMOSPHERIC X-AND GAMMA-RAYS IN THE SOUTH ATLANTIC MAGNETIC ANOMALY BY BALLOON EXPERIMENTS

by

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Various attempts have been made at INPE, since 1968, to observe particle precipitation from the Van Allen belts into the atmosphere of the South Atlantic magnetic anomaly region, with balloon-borne instrumentation. This research has been conducted through the measurements of bremsstrahlung X-rays and low energy gamma-rays as well as the charged particles themselves at the altitude of stratospheric balloons, and also simultaneous measurements of the geomagnetic variations by rapid run ground magnetometers.

Balloon carrying on board charged particle and X-and gamma-ray detectors formed by plastic scintillators, NaI(Tl) crystals and high energy resolution Ge(Li) diodes have been used in this research. Most of the payloads were fully designed, constructed, tested and calibrated at INPE laboratories. The Ge(Li) diodes were used under an international cooperation program with the Centre d'Étude Spatiale des Rayonnements of Toulouse, CESR, France, and the Centre d'Études Nucléaires de Saclay, CENS, France.

The balloons were launched from São José dos Campos ($23^{o}14'S$, $45^{o}51'W$) and Guaratinguetá ($22^{o}50'S$, $45^{o}12'W$) except for few recent ones which were launched from the new INPE balloon launching facilities at Cachoeira Paulista ($22^{o}42'S$, $45^{o}01'W$). Very few balloon flights had as their primary objective the detection of particle precipitation, or even the detection of atmospheric X-and gamma-rays. Most of the flights had well

defined astrophysical objectives which of course demanded observations during magnetically quite periods.

Direct evidence of particle precipitation associated with geomagnetic variations were observed only during the two balloon flights conducted on October 17, 1971 and October 20, 1973.

The data for the flight of December 17, 1971 were obtained with a single cylindrical plastic scintillator NE 102A two inch in diameter and two inch high, viewed by a two inch RTC model 53AVP photomultiplier. The charged particle counting rate increased by a factor of about four simultaneously with the occurrence of a sudden commencement in the geomagnetic field intensity. An electron precipitating flux above 7.5 MeV of $\simeq 1.35\ cm^{-2}s^{-1}$ at 40 Km was estimated from these data.

The data for the flight of October 20, 1973 were obtained with a 4" x 4" NaI(Tl) crystal surrounded by a plastic scintillator 1 cm thick as an active anticoincidence. The energy threshold of the detector was such that the minimum energy at the top of the atmosphere of charged particles capable of triggering the detector was 7.0 MeV for electrons and 30 MeV for protons. Charged particle and gamma-ray counting rate increased in association with the high level of geomagnetic activity prevailing during the flight. The power law for the gamma-ray spectrum covering the range of 0.9 - 2.0 MeV, changed from $\simeq E^{-1.1}$ for a magnetically quite time to $\simeq E^{-2.2}$ for the disturbed one.

Theoretical studies have also been conducted in order to help in the analysis of the experimental data and to get a better understanding of the mechanisms responsible for the particle precipitation phenomenon, and the production of X-and gamma-rays in the atmosphere. For the purpose of particle precipitation, a computer simulation was performed with a Monte Carlo code used for the auroral region. The simulation was applied to several types of precipitating electron spectra in order to get the associated X-ray spectra due to atmospheric bremsstrahlung. Another Monte Carlo computer simulation was performed to get the photon spectrum

(0.9 - 18 MeV) from the pulse height gamma-ray spectrum, measured with a 4" x 4" NaI(Tl) crystal surrounded by a plastic scintillator 1 cm thick functioning in anticoincidence.

Recent studies have shown that wave-particle interactions play an important role in the enhancement of electron precipitation in the anomaly, during quite and magnetically disturbed periods, through a correlation analysis of the PC5 type geomagnetic micropulsations recorded at São José dos Campos and the hiss type fluctuations recorded by satellite detectors. Further work is in progress.

Data analysis of the X-ray bremsstrahlung, measured with a 3" x 1/2" NaI(Tl) scintillator flown on board of a balloon on last April 14th from Cachoeira Paulista, during a magnetically disturbed period, are underway.

Two balloon flights with the same X-ray NaI(Tl) detector mentioned above are scheduled for the period November 1981 - April 1982. Simultaneous fine micropulsations recording will be also performed during the flights. Another payload, presently in construction, which uses a Ge(Li) diode as main detector, may allow the detection of peaks in the X-ray spectrum.

Since there is not yet a clear knowledge on how the more energetic component of the precipitating particles can affect the ionosphere D-region and the mesosphere (mainly), it is of great importance to perform simultaneous observations of atmospheric X-and low energy gamma-rays when ionospheric parameters are also being measured. A combined effort might give a more complete knowledge of the particle precipitating fluxes and their effects in the ionosphere.

It seems that due to the scientific importance and the large area of the South Atlantic magnetic anomaly, which includes even part of the territories of two continents, an international coordinated study is in great need at this stage of the space research. Brazil and Argentina of course should carry to play important roles in this study.

PUBLICATIONS

The results of these researches have been reported through the following publications:

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