Stratified regions of high radioactivity in the atmosphere over Hyderabad, India, in April, 1968

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(Manuscript received January 4, 1971; revised version April 20, 1971)

ABSTRACT

In a balloon flight from Hyderabad, India on 28th April, 1968 with an X-ray telescope recording X-rays in the energy band 16–125 KeV, two stratified layers of high radioactivity in the atmosphere were observed at an altitude of 16–20 km. The excess radiation was concentrated in the layers located at 16.4–17.2 km and 18.6–20.1 km separated by a region of normal counting rate. The two distinct layers of excess radiation were recorded in all the six different energy channels and the energy spectrum of the excess radiation was measured. A subsequent balloon flight from the same location with the same instrument on December 22, 1968 did not show any excess radioactivity in the atmosphere. It is concluded that the excess atmospheric radioactivity on April 28, 1968 originated from the global fallout from the nuclear detonation, presumably from the air burst by China on June 17, 1967. The interesting aspect of the present observations is the occurrence of stratified layers of activity in the tropopause region near equator several months after the explosion.

Introduction

In this report we present the observations of two stratified layers of high radioactivity in the atmosphere at an altitude of 16–20 km over Hyderabad, India (latitude 17.6° N, longitude 78.5° E) on April 28, 1968. These observations were made during the ascent part of a balloon flight from Hyderabad in an X-ray astronomy investigation using a telescope which recorded X-rays in the energy interval 16–125 keV. Subsequent balloon flights made from Hyderabad on December 22, 1968 and April 16, 1969 using the same instrument showed only normal cosmic ray induced X-ray background in the atmosphere and did not show any excess atmospheric radioactivity. Therefore it is believed that the localised region of intense radioactivity observed in the atmosphere on April 28, 1968 was of transient nature and was probably related to the global fallout of nuclear detonations. Since these results were obtained as a byproduct of an investigation that was directed for an entirely different purpose, we present in this note only the experimental observations which may be of special interest to those who keep track of such transient radioactivity in the atmosphere.

Observations

The balloon-borne X-ray telescope consisted of a NaI(Tl) crystal of area 97.3 cm^2 and of thickness 4 mm surrounded by cylindrical plastic scintillator in anticoincidence and cylindrical shieldings of lead, tin and copper. The area × solid angle product of the telescope for isotropic radiation was 13.3 cm^2. sr. and the opening angle 12.5°. The telescope was mounted on an oriented platform with its axis at a zenith angle of 25° and it looked at various directions in the sky. The pulse height data from the scintillator extending from 16 to 125 keV were sorted into six channels, and were photographed on a continuously moving 35 mm film along with the aspect information on the orientation of the telescope. An Am^{241} radioactive source having two line emissions at energies of 16.5 and 59.8 keV came in the field of view of the telescope once in every 5 min for 30 sec for the inflight calibration of the detector and the performance of the detector was found to be quite satisfactory during the entire flight. The details of the instrument and results concerning cosmic X-rays are published elsewhere (Agrawal et al., 1969).

The balloon was launched at 23.31 hours

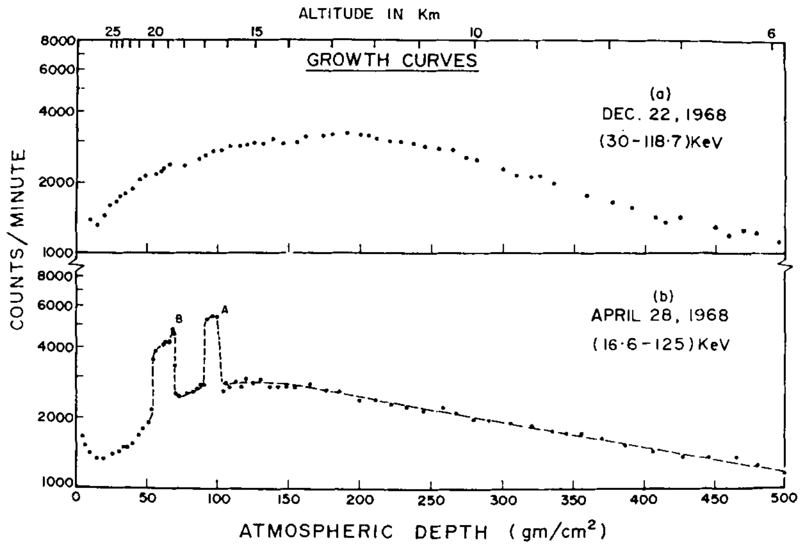

Fig. 1. Growth curves of X-rays in the atmosphere measured in ballon flights from Hyderabad, India on (*a*) December 22, 1968, and (*b*) April 28, 1968, which shows two pronounced peaks, *A* and *B*, due to excess radioactivity in the atmosphere.

I.S.T. (Indian Standard Time) on April 27, 1968 and its rate of ascent was 222 metres/minute up to 15 km and 269 m/min from 15 to 35 km. It reached the ceiling altitude of 36 km (5.4 g/cm^2 of air) at 02.40 hours I.S.T. (April 28, 1968), and floated at this level for 5 hours, 40 min. The altitude measurements were made by photographing a Wallace-Tiernan absolute pressure gauge once every minute, as well as by radar tracking.

In the Fig. 1 the counting rate of the X-ray detector has been plotted as a function of altitude in the energy range 16.6.–125 keV for the flight made on April 28, 1968 and in the energy range 30–119 keV for the flight on December 22, 1968. From the figure the following observations are apparent. In the flight on December 22, 1968 the counting rate of the telescope gradually increased as the atmospheric depth decreased, then went through a broad maximum, after which the counting rate decreased, and attained a constant value at the ceiling. However, in the flight made on April 28, 1968 the behaviour is noticeably different. In this flight the counting rate increased quite smoothly upto 110 g/cm^2 in the atmosphere and then between 105 and 50 g/cm^2 there is clear evidence for two pronounced and distinct peaks in the counting rates. It is seen that the excess radiation was concentrated in two distinct layers A and B located at 16.4–17.2 km and 18.6–20.1 km respectively. These two layers of high counting rates of thicknesses 0.8 km and 1.5 km were separated by a thickness of 1.4 km having a normal counting rate.

A study of the growth curves for different energy channels of the detector for the flight on 28th April 1968 shows that the excess radiation was present in the two layers in all the energy bands. The energy spectrum of the excess radiation in the two peaks at A and B are presented in Fig. 2. It is seen from the figure that the activity is characterised by a rather broad spectrum with a peak around 60 KeV and a sharp fall in the intensity between 80 and 100 KeV. There is evidence, however, for an apparent increase again towards the low energy side. The instrumental cut off occurs at 16 KeV.

The position of the energy peak of the excess counting rate at about 60 KeV coincides with the 59.8 KeV line emission of the Am^{241} calibration source. However, the following arguments establish that the excess counting rate is not due to the calibration source itself being stuck in the field of view of the telescope: (*a*) there was no evidence for the mal-functioning of the sequencing system for the calibration and the contribution of the calibrating source was

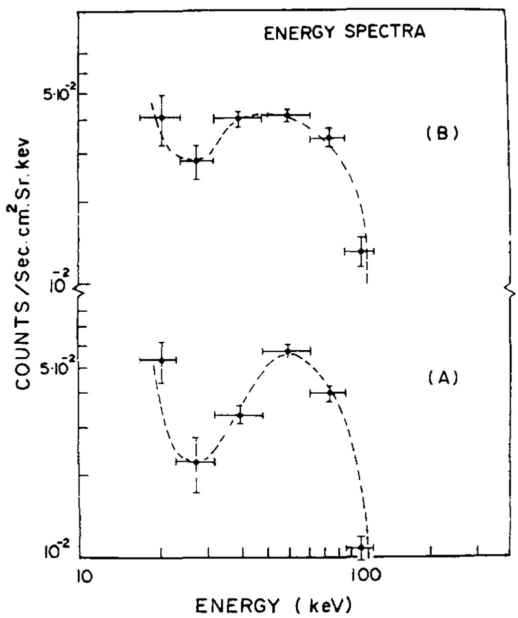

Fig. 2. Energy spectra of the excess atmospheric radioactivity for 16-125 KeV X-rays for the two peaks *A* and *B* shown in Fig. 1.

clearly recorded over and above the excess counting rate in appropriate channels (II and IV) for 30 sec in every 5 min; (*b*) the spectral shape and the intensities of the excess counts were quite different from those of the calibrating source.

Discussion

As the excess activity was confined only in the tropopause region at 16–20 km altitude without any evidence at ceiling altitude, the effect of extra-terrestrial disturbances such as solar activity can be ruled out. Also there was no abnormal geophysical activity on this date. Therefore it is concluded that the excess activity must have originated from the global radioactive fallout from nuclear detonations. This probably originates from the megaton-range air burst by China on June 17, 1967. There is evidence from the U.S.A.E.C. high altitude sampling programme results that the stratosphere in the northern hemisphere contained during the winter and spring of 1967–68, fission products from the 6th Chinese H-bomb test of June 1967 (Hardy and Rivera, 1969). However, the activity had almost disappeared by October 1968 (Hardy, 1970). These essentially support our findings that the activity was observed in the balloon flight of 28th April, 1968 while there was no evidence for any activity in the flight of 22nd December, 1968. Measurements made in India show that the surface air contained fission fragments during the first half of 1968 traceable to the Chinese H-bomb test (Rangarajan & Gopalakrishnan, 1969). It is to be emphasised that the most interesting aspect of the present results is the observation of stratified layers of activity in the tropopause region several months after the explosion. While in the literature there are reports of stratified layers of activity immediately after an explosion, there seems to be no earlier observation of a delayed stratification.

It may be noted that at Hyderabad the tropopause is located at 17–18 km altitude during the spring and the two stratified layers of activity occurred just above and below the tropopause.

The energy spectrum of the excess radiation showed a broad peak at ~ 60 keV. Because of fairly broad resolution of the detector (25%) it is not possible to identify the radioactive isotopes responsible for the excess radiation. A number of long-lived isotopes that can give rise to the observed activity and which can be produced as fission products are Cs-137 (30 yr) Sb-125 (2.71 yr), Ce-144 (285 d) and Ru-103 (39.5 d).

Acknowledgement

The authors are grateful to Dr K. G. Vohra of Health Physics Division, Bhabha Atomic Research Centre, Bombay, for valuable discussions and helpful comments on the manuscript.

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СТРАТИФИЦИРОВАННЫЕ ОБЛАСТИ С ВЫСОКОЙ РАДИОАКТИВНОСТЬЮ В АТМОСФЕРЕ НАД ХАЙДЕРАБАДОМ, ИНДИА, В АПРЕЛЕ 1968 Г

Во время полета стратостата над Хайдерабадом 28 апреля 1968 г. с рентгеновским телескопом, регистрирующим рентгеновские лучи в интервале энергий 16–125 *кэв* были обнаружены два слоя высокой радиоактивности на высотах 16–20 *км*. Повышенная радиация была сконцентрирована в слоях, расположенных на высотах 16,4–17,2 *км* и 18,6–20,1 *км*, разделенных областью с нормальной скоростью счета. Два отчетливых слоя с повышенной радиацией были зарегистрированны на всех шести различных по энергии каналах и был измерен спектр этой радиации. Следующий полет стратостата с того же места и тем же оборудованием 22 декабря 1968 г. не показал какого-либо повышения радиации в атмосфере. Сделан вывод, что повышенная радиоактивность 28 апреля 1968 г. происходила из-за глобального выпадения продуктов ядерного взрыва, предположительно, китайского взрыва в атмосфере 17 июня 1967 г. Интересным аспектом данных наблюдений является обнаружение стратифицированных активных слоев в области экваториальной тропопаузы через несколько месяцев после взрыва.