Small-Scale Spatial Inhomogeneities in X-Ray Fluxes in Auroral Stratosphere

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Synchronous balloon measurements of X-rays in the stratosphere were carried out at Tixie Bay (71.6°N, 128.9°E) in March 1975 and 1976. Typical balloon separation distances were 20-200 km. These X-ray measurements correspond to the high energy tail of the precipitating electron flux ($E_e \sim E_x \sim$ hundreds of keV).

From Fig. 1 it is seen that electron precipitation into the upper atmosphere on March 18, 1975 was present for many hours as determined by the measurement of the ionospheric absorption of cosmic radionoise at a frequency of 32 MHz. The magnitude of the absorption is given in Fig. 1. Maximum absorption amplitude was 3.5 db. Detection of X-rays was carried out from 12 hr 30 min to 12 hr 55 min during the recovery phase of the absorption. X-ray fluxes had small intensities and were not correlated with local magnetic activity. Only a negative magnetic bay with amplitude 400 γ (H -component) was observed, 10 hr after the detection of emission in stratosphere.

In Fig. 1 the simultaneously detected X-ray fluxes are divided into two parts. There is good temporal correspondence of X-ray fluxes at the spaced balloons, during a-b, while the portion b-c has no correspondence. During the incoherent detection of X-ray fluxes the balloons drifted at 25 km altitude and were spaced 30 km from each other. A large magnitude X-ray flux was measured by a detector placed 5 g/cm² below the second detector. In the lower part of Fig. 1 a sketch of the balloon positions (projected on the Earth) during the X-ray measurements for two times 12 hr 35 min and 12 hr 45 min is given. The projection on the Earth of the sensing area of the riometer is also given. Thus, on March 18, 1975, small-scale spatial inhomogeneities in X-ray flux during the period b-c were observed. The difference in X-ray flux amplitude, and the incoherence of their temporal variations, existed at distances of 30 km in the stratosphere. On the other hand, the radiation during the period from a to b is coherent. Some difference in amplitude is due to differing altitudes of balloon flights. This fact can be used to estimate the mean energy of the X-ray quanta on the basis of the well-known Lambert law.

$$\mu f(E_x) = \ln \frac{I_1}{I_2} \cdot x^{-1},$$

Fig. 1. Temporal variations of X-ray flux in stratosphere over Tixie Bay on March 18, 1975 at two observation points.

where μ is a mass coefficient of X-ray absorption in the air, E_x is the energy, I_1 and I_2 are magnitudes of X-ray fluxes at various altitudes in stratosphere. x is the quantity of atmosphere substance between detectors along the vertical. The dependence $\mu f(E_x)$ is taken from GOLDSTEIN (1961). The calculations show that X-ray rigidity in the coherent interval grows with time (Fig. 2).

An example of the existence of spatial peculiarities in X-ray flux at distances 50–100 km is given in Fig. 3. Results of X-ray measurements by a Geiger counter and of the cosmic ray background with a ‘telescope’ on the first balloon are presented in the upper part of Fig. 3. The X-ray flux obtained on the second balloon is in the lower part of Fig. 3. In Fig. 3 are also given: flight altitudes of both balloons in mb, the registration type scale (with point 180.27 and 52.67 min⁻¹ for the Geiger counter and 11.02 min⁻¹ for ‘telescope’ in the first flight; 50.4 and 199.4 min⁻¹ for

Fig. 2. Temporal variations of the energy of X-ray quanta in stratosphere over Tixie Bay on March 18, 1975. Δh : Amount of atmosphere between detectors along the vertical in g/cm^2 . Accuracy of determination Δh : $\pm 1 \text{ g/cm}^2$.

the Geiger counter in the second flight), the sketch of the positions of the balloons $\mathbf{u}1$ – $\mathbf{u}2$ (projected on the Earth) and the riometer measurements. The absorption at the first minute of each hour is given in db. Dark rectangles show the time of measurements in the stratosphere on the two balloons, 'K' is a moment of calibration of the riometers.

The onset of intense precipitation on March 2, 1976 was recorded on the two balloons simultaneously at 12 hr 59 min at an altitude of 25 km. But the growth rate of X-ray counts on the two balloons was different. During 13 hr 03 min–13 hr 13 min the growth rate of X-ray counting on the first detector was 115.4 min^{-1} ; and on the second detector — 1320.62 min^{-1} . Gradients of X-ray growth rate at locations separated from each other by distances 50–100 km became smaller with time. During 13 hr 12 min–13 hr 15 min they were 192 and 465 min^{-1} , respectively, i.e., small-scale spatial features in X-ray fluxes as in the case on March 18, 1975 were less noticeable.

Fig. 3. The X-ray flare registered in stratosphere on separated balloons on March 2, 1976.

REFERENCE

GOLDSTEIN, G., Osnovy zaschity reaktorov. Gosatomizdat, Moscow, p. 135, 1961.