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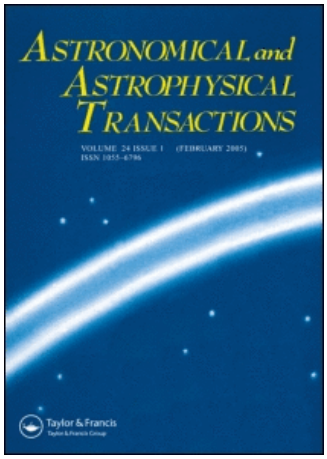

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M. Goshdjanov [a]; A. Muradov [a]; D. Boltaev [a]
[a] Physical-Technical Institute of the Academy of Sciences of Turkmenistan, Ashkhabad, Turkmenistan

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THE POSSIBLITIES OF THE OPERATIVE DIAGNOSTICS OF SOLAR FLARES FROM DOPPLER IONOSPHERIC OBSERVATIONS

M. GOSHDJANOV, A. MURADOV and D. BOLTAEV

Physical-Technical Institute of the Academy of Sciences of Turkmenistan, Gogol Street 15, Ashkhabad 744000, Turkmenistan

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The effect of solar flares on the Earth's upper atmosphere is one of outstanding problems in modern solar-terrestrial physics. The possibilities of solar flare diagnostics from their ionospheric manifestations are of particular importance.

The Earth's ionosphere undergoes essential changes during solar flares resulting even in a complete interruption of the short-wave radio communication on certain radio lines. Therefore, the search for the physical phenomena and processes in the upper atmosphere which precede this event is of obvious scientific and practical interest for their further use for operative diagnostics and short-term prediction of solar flares.

The Doppler observations of the ionosphere with high time, space and frequency resolutions provide such a possibility.[1]

Below we discuss the results of the joint analysis of experimental data of Doppler ionospheric sounding at three frequencies simultaneously and the parameters of X-ray flares during the period of 1988–1991. Wavelike perturbations have been discovered in the Doppler frequency shift (Δf) of the radiowaves reflected from the ionosphere before some X-ray flares. From the 64 cases of X-ray flares, in 44 cases pre-flare wavelike perturbations have been observed. The absence of these perturbations in others 20 cases is explained by the existence of the threshold value of the X-ray flares energy flux. These perturbations preceded the moment of the flares in H_α by $\approx$30–80 min. This time lag depends on the flare power and can be used for the operative diagnostics and short-term prediction of X-ray flares. The spectrum of the variations of Δf during the wavelike perturbations that preceded the X-ray flare 1N/C5.1 happened on 19 April, 1989 at 04.20 UT is given in Figure 1.

As can be seen from Figure 1, where the time scanning step is 1 min, the sharp growth of Δf is observed during $\approx$2 min with a subsequent slow decrease during the period of $\approx$10 min which is determined by the relaxation processes in the ionospheric plasma.

This process repeats at the period within 6–12 min (with the value of $\approx$8 min being observed most often) and stops for 10–12 min before the flare begins in H_α.

Such a sharp increase of Δf during a short period can apparently be stimulated

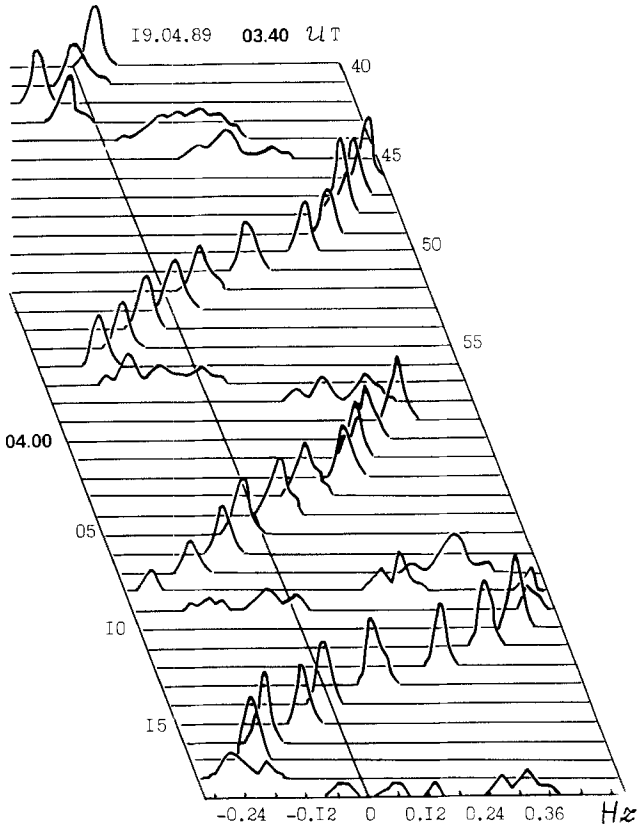

Figure 1 The three-dimensional spectrum of the variations of Δf.

by the corresponding increase of the electron number density due to an external fluctuating UV source of an impulse character.

The widening of the variation spectrum of Δf at the rising branch implies a considerable deformation of the reflection region under the influence of the external radiation source.

When the external radiation stops to act, the ionospheric plasma restores its original structure due to relaxation processes. Therefore, the reflections on the decreasing branch are of a normal nature.

The simultaneous occurrence of the wavelike perturbations of Δf at all sounding frequencies is their distinctive peculiarity that apparently points to the effect of external ionizing radiation on the total reflection region thickness at all used frequencies.

As the intensity of the pre-flare radiation is apparently much less than the flare energy itself, the amplitude of the pre-flare wavelike perturbations on the Doppler records is not large (0.2 Hz), so that they can be observed against the general background not in all cases. But the main reason of the fact that not all X-ray flares are accompanied by pre-flare wavelike perturbations is, as we suggest, the existence of the threshold value of the X-ray flare energy flux that is

equal to $1.5 \cdot 10^{-3}$ erg/(cm^2 · sec). Above this value of the X-ray energy flux of flares, pre-flare wavelike perturbations in the ionosphere F-region are always observed.

The existence of the pre-flare fluctuating sharp increase of UV radiation is apparently confirmed also by the sharp decrease of the ozone number density in the upper atmosphere during these period.[2]

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