X-RAY SPECTRUM
OF A CORONAL CONDENSATION AND A FLARE

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Abstract: The analysed spectrum covers the wavelength range of 8—13 Å and was obtained during the descending part of a solar flare. The absolute intensities of spectral lines and the continuum have been determined. A thermal model of the emitting region was then calculated and compared with the various models of coronal condensations. It has been verified that an exponential function provides a good approximation for the distribution of the emission measure with temperature.

Solar X-radiation was investigated by the rocket Vertikal 2, launched on August 20, 1971. The present analysis concerns the X-ray spectrum in the wavelength range of 8—13 Å, obtained by means of two Bragg spectrometers with KAP crystals. The experiment was prepared and carried out by the Lebedev Physical Institute.

The high sensitivity in the spectral range was a valuable feature of the spectrometers. Owing to this, the counting rates were high and the continuous spectrum was reliably measured.

The bulk of the recorded 8—13 Å radiation came from an intense coronal condensation (McMath region No. 11482) and a flare, which was in progress in the region during the observations. The observations coincided with the descending part of the flare. The flare was not large, but it lasted for about 24 min in H_α and about 40 min in X-rays.

The absolute intensities of spectral lines and the continuous spectrum have been obtained. It is known that there are some serious difficulties in the absolute calibration of Bragg spectrometer measurements, which cause significant differences between the line intensities, obtained by various authors. It is especially difficult to obtain reliable absolute values of the crystal reflectivity. This is why we have used simultaneous measurements of a 8—11 Å broad-band photometer for the calibration of the line and continuum intensities.

The line intensities obtained are in good agreement with the measurements of Walker and Rugge (1969) in the sense that they fall between their values for a non-flare Sun and for a great 3B flare.

The main purpose of the data analysis consisted in computing the thermal model of the emitting region, i.e. in finding the distribution of the emission measure as a function of the temperature.

Following other authors, the distribution has been approximated by the exponential function

$$\varphi(T) = C\,10^{-\alpha T}, \qquad (1)$$

where C and α are constant parameters of the model.

In previous investigations samples of the lines of various elements were taken for adjusting the parameters in Eq. (1). This had the disadvantage that the errors of admitted element abundances entered into the analysis and, in consequence, the validity of the approximation (1) could not be verified comprehensively. An essential improvement in our analysis consisted in adjusting the distribution $\varphi(T)$ for individual elements independently. The errors of the element abundances do not then influence the value of the parameter α.

The obtained distributions of the emission measure are shown in Figure 1. The good agreement of the inclinations of the lines in the figure indicates that the exponential function provides quite a good approximation of the emission measure distribution $\varphi(T)$ in the rather wide temperature range of 2—10×10^6 K.

The relative vertical displacements of the individual distributions $\varphi(T)$ are caused by the errors of the admitted element abundances, as well as by the systematic errors in the calculation of the spectral line intensities for the individual elements (calculation of the ionization equilibrium and excitation rates).

A comparison of our thermal model of the X-ray flare region with the models of coronal condensa-

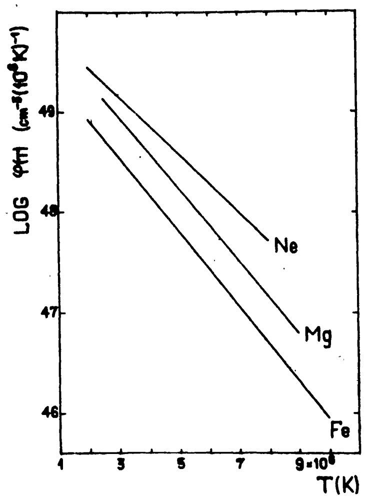

Fig. 1. The distributions of the differential emission measure $\varphi(T)$. Every distribution has been obtained from two lines of the same element: Mg — lines: Mg XI 9.17 and Mg XII 8.42; Ne — Ne IX 11.56 and Ne X 10.24; Fe — Fe XVII 12.26 and FE XX 12.82.

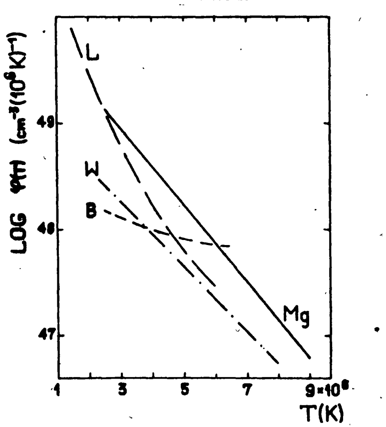

Fig. 2. Comparison of the obtained model of the emitting region (line Mg) with various models of coronal condensations: L — model of Landini and Monsignori Fossi (1971); W — model No. 1 of Walker (1972); B — model of Batstone et al. (1970), for their condensation No. 1.

tions of other authors is given in Figure 2. Here, it must be remembered that our observations and, therefore, also our model, concern the radiation of the large coronal condensation, greatly enhanced by the flare. In particular, it is seen that the Landini and Monsignori Fossi model evidently assigns too large an amount of matter at temperatures $T<3\times10^6$ K.

Figure 3 shows good agreement between the observed and calculated continuum intensities. This provides valuable verification of the above model of the emitting region, as well as of the reliability of the continuum measurements in our spectrum.

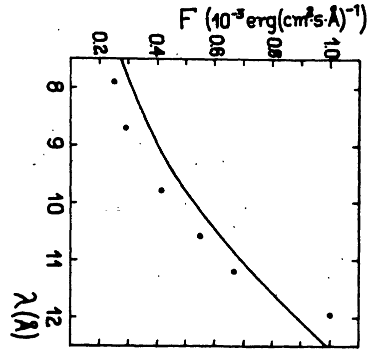

Fig. 3. Comparison between the observed (points) and calculated (line) continuum intensities.

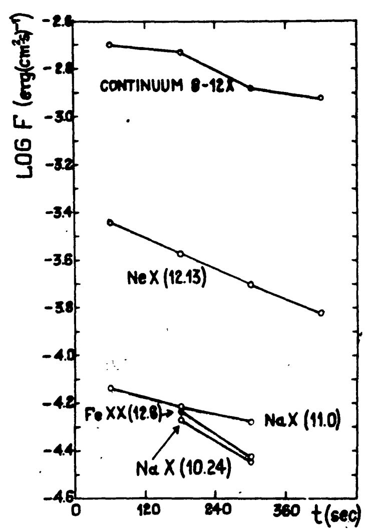

Fig. 4. Examples of the time variation of the spectral lines and continuum.

It is worthwhile to note that the total continuum intensity in the range 8—12 Å prevails appreciably over the total intensity of the lines in the same range,

$$\text{lines/continuum} = 0.32,$$

which is in full agreement with the above calculations.

Figure 4 shows some examples of the time variation of the spectral lines and of the continuum in the course of our observations. We could not establish any reliable time variation of the parameter α of the distribution $\varphi(T)$ from our observations — the variations fall within the limits of observational errors.

A more detailed account of the present investigation will appear in Space Research XIV.

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