INVESTIGATION OF THE Mg xII 8.42 Å DOUBLET IN SOLAR FLARE SPECTRA

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Abstract. The intensity ratio of the components of the Mg xII 8.42 Å (1s 2S 1/2 - 2p 2P 1/2, 3/2) doublet in solar flare spectra has been investigated using observations recorded from the Intercosmos 7 satellite. The observed values of the ratio fall within the interval 0.38–0.66 and have been compared with recent theoretical predictions based on an optically thin collisional-radiative model. It has been found that for the flare plasma the low values of the ratio cannot be explained since they fall below the smallest theoretical value. The highest values on the other hand require that an unacceptably high electron density be postulated. It is suggested that both high and low values may be caused by the resonance line scattering of the Mg xII quanta in the flare volume, provided that the volume is elongated and not spherical.

The intensity of the nearby satellite lines is also investigated. Good agreement between the theoretical and observed intensities is found.

1. Introduction

Beginning from 1970 high-resolution X-ray spectrometers for solar research were constructed at the Lebedev Physical Institute in Moscow. In particular, the spectrometers made it possible to resolve for the first time the fine structure components (1s 2S 1/2 - 2p 2P 1/2 and 1s 2S 1/2 - 2p 2P 3/2) of the Mg xII 8.42 Å resonance line (Grineva et al., 1972, 1973). We will refer to the pair of lines as the Mg xII Lα doublet and denote their intensity ratio by B.

The first observations of the Mg xII doublet showed that the observed values of B may deviate significantly (B ~ 0.6) from the theoretical low-density value of B = 0.5. The only available Solar Maximum Mission record of the Mg xII doublet gives the value B = 0.64 (Phillips et al., 1982). (Note that the value 0.67 given in their paper is a misprint reported to us by Phillips in 1983.) It is clear from the papers of Ljepojevic et al. (1984, 1985) that such high values of B for solar flares can only be explained in terms of unacceptably high values for the electron density.

In the present paper the observations carried out from the Intercosmos 7 satellite are used to investigate the ratio B of the Mg xII doublet and the intensities of nearby satellite lines. In a previous paper (Jakimiec et al., 1975) the observations were used to
investigate the time variation of the intensity of the Mg XII doublet and to discuss the temperature distribution in flare plasma.

In Section 2 we discuss the observational data and their analysis. In Section 3 we compare the observations with recent theoretical predictions. The results are briefly summarized in Section 4.

2. Observational Data and Their Analysis

2.1. Description of the Observations

2.1.1. Spacecraft

The data consist of the high-resolution spectra of the Mg XII Lα doublet measured aboard the Interkosmos 7 (IK 7) spacecraft by means of a Bragg crystal spectrometer designed in the Spectroscopy Laboratory of the P. N. Lebedev Physical Institute in Moscow. The IK 7 spacecraft was operational from 1972 June 30 to 1972 October 5. The important parameters of the orbit were: apogee, 586 km; perigee, 257 km; inclination, 48.4°; orbital period, 92.6 min.

In its normal mode of operation the spacecraft performed several scans through the Sun each 24 hours. During these scans, the main axis of the spacecraft (to which all solar instruments were aligned) moved inertially across the disc of the Sun. The direction of successive scans relative to the solar coordinates rotated slowly (1° per minute). At preselected times of frequency determined by the level of solar activity the scanning action was activated and controlled by gas jets. Before initiating a full scan, the axis was moved to one of the corners of a 1° by 1° (approximately) square centred on the Sun. This motion usually crossed a substantial part of the solar disc and is called the 'pre-scan'. Pre-scan action was aimed to prepare the spacecraft for the full scan which started from one of the corners of the square and traversed the solar disc along a diagonal of the square. This was initiated by the combined actions of two mutually perpendicular gas jets. In conditions of solar flare activity, the frequency of the scans was increased to several per orbit and were grouped in sequences. In any one sequence of scans the scan direction did not change significantly. The scans were either fast (40–60 s duration) or slow (180–400 s), while pre-scans usually lasted less than 30 s. Between scans the main axis of the spacecraft moved randomly within the 1° × 1° square centred on the Sun.

The actual position of the main axis relative to the Sun was constantly monitored by the Optical Sun Sensor (OSS) located within the spectrometer. OSS data was used to identify scans where the scanning velocity changed during the scan and to help to identify pre-scans.

2.1.2. Spectrometer

The instrument was a simple uncollimated Bragg crystal spectrometer without moving parts and fixed with respect to the spacecraft. A natural Quartz crystal, cut along the