OBSERVATIONS OF CORONAL OSCILLATIONS
ABOVE AN ACTIVE REGION

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Abstract. Periodic Doppler width fluctuations have been observed in Fe xIV spectra above an active region. The oscillations have a period of 6.1 ± 0.6 min and a peak-to-peak amplitude of 0.07 ± 0.006 Å. The amplitude of the oscillation increases with height above the limb, and is enhanced at specific heights where we marginally detect line center intensity oscillations. The intensity fluctuations have a period of 6.1 min, an amplitude of 2.0 ± 1.4%, and are 180° out of phase with the width oscillations. A comparison region in the quiet corona showed no evidence of oscillatory phenomena.

1. Introduction

The problem of coronal heating mechanisms and the importance of spectroscopic data in placing limitations on the possible interpretations of coronal emission features has been detailed by Billings (1963). Since that time the copious generation of Alfvén waves in sunspots (Parker, 1974; Beckers, 1976) has been proposed, and the thermalization of these waves was suggested as a heating source for coronal arches (Uchida and Kaburaki, 1974). Beckers and Schneeberger (1977) showed that the heating of coronal arches via non-linear Alfvén waves, as suggested by Uchida and Kaburaki, can be ruled out. Indeed, a scant 0.08% of the missing spot flux can penetrate the corona in the form of Alfvén waves. Thomas (1978) has shown that, if sunspots are cooled by Alfvén waves, these waves must escape downward into the solar interior.

The observational evidence for energy input to the corona above sunspots is not in contradiction to the Beckers and Schneeberger (1977) results. The upper limit to Alfvén wave energy input derived in that work is consistent with the energy necessary to maintain the active region corona. The XUV and X-ray bright points observed above active regions suggest an energy source tied to the properties of active regions. Efforts to detect short period oscillatory phenomena in the corona have not provided compelling results. Observational evidence of wave-like structure in the low corona was reported by Billings (1959). Searches for 5 min coronal

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Intensity fluctuations have been contradictory as pointed out by Tsubaki (1977), who reports a possible short period oscillation in Fe xiv Doppler velocity. Tsubaki's results suggest that there may be certain positions in the corona where wave effects are amplified, thus requiring reasonable spatial resolution.

The recent results of Athay and White (1979) confirm the existence of 5 min type oscillations in the mid-chromosphere. The energy flux from these acoustic waves is too small to account for chromospheric heating requirements.

The difficulties encountered by the Alfvén wave heating mechanism and the confused evidence for short period oscillations in the corona have motivated the present study, an observational search for short period coronal oscillations. The results of Athay and White (1979) which show traveling acoustic waves in the mid-chromosphere suggest the possibility of leakage into the corona. We compare a quiet and active coronal region for periodic phenomena. Our results show strong evidence for oscillatory phenomena in the low corona above active regions.

2. Observations

The Sacramento Peak Observatory 40 cm coronagraph and universal spectrograph were used to obtain time series of Fe xiv coronal emission line spectra above both active and quiet regions. Data from two days with background sky brightness of 10 millionths of the disk center brightness were chosen for further analysis. Data obtained on UT March 31, 1978, PA = 40° was observed above an active region, while the UT Nov. 02, 1977, PA = 112° data are not associated with an active region. The 40 μm wide spectrograph slit was mounted perpendicular to the solar limb, as shown in the Fe xiv slit jaw filtergram in Figure 1. The two fiducial lines were used as height references. A sequence of 85 spectra were observed at 20 s time intervals. Exposure times of 12 s for the March 31 data and 14 s for the Nov. 02 data were used. The dispersion is 2.51 Å mm⁻¹ at λ 5303, and the instrumental resolution is 0.1 Å. Examination of the slit jaw images, observed at 1 min intervals, revealed no apparent change in the coronal intensity structure during the period of spectroscopic observations. The data were analyzed in a strip 570 km wide by 99 000 km long, corresponding to a region from 1.0 to 1.14 R⊙.

3. Data Reduction

Intensity calibration was obtained by a neutral density step wedge, placed across the spectrograph slit and exposed to defocussed solar illumination. The Fe xiv coronal emission line data and step wedges were digitized with the Sacramento Peak Observatory fast microphotometer. The 35 mm high speed film was digitized every 10 μm in the direction of dispersion, and stepped 25 μ in the spatial direction. The digital data corresponds to 0.025 Å/point. Microphotometer noise was studied and found to be negligible compared to the grain noise of the high speed film. Examination of this noise and the noise induced by the density to relative intensity calibration