EVIDENCE FOR THE 300-SECOND OSCILLATION FROM OSO-7 EXTREME-ULTRAVIOLET OBSERVATIONS

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ABSTRACT

Evidence is presented for a 300-second oscillation in the intensity of solar extreme-ultraviolet emission lines of He ii, Mg viii, and Mg ix as observed by OSO-7.

I. INTRODUCTION

In 1962, it was discovered that some photospheric and chromospheric spectral lines show velocity oscillations with a period near 300 seconds (Leighton, Noyes, and Simon 1962; Evans and Michard 1962). An important problem is the role of these oscillating velocity fields in chromospheric and coronal heating. Detection of 300-s oscillations in extreme-ultraviolet lines formed in the transition region or low corona has a direct bearing on this problem. In this Letter, we report on the detection of oscillations in three such lines and discuss the possible significance.

II. THE EXPERIMENTAL CONFIGURATION

The Goddard Space Flight Center extreme-ultraviolet spectroheliograph on OSO-7 has been used for a variety of studies of the solar transition region and corona. The complete instrument has been described by Underwood, Neupert, and Hoover (1971). Here we will briefly summarize the part of the instrument relevant to our present study.

The Goddard extreme-ultraviolet spectroheliograph can make simultaneous observations in several emission lines between 120 and 400 Å with up to 10 × 20 arc second spatial resolution and 1 Å spectral resolution. The spatial resolution is obtained by a Wolter type II (Wolter 1952) grazing-incidence telescope which focuses the extreme-ultraviolet radiation on one of four on-axis entrance apertures—in the present study a 10" × 20" aperture—to the spectrometer. After passing through the aperture, the radiation strikes the grating at glancing incidence. Located behind the focal curve of the grating is a series of three Bendix Magnetic Electron Multipliers with appropriate mechanisms for selecting combinations of interesting lines. This detector system is mounted on a movable carriage which enables the spectrometer to cover the entire spectrum from 120 to 400 Å.

The mode of operation of the instrument in the present study was to point the telescope near the center of the solar disk, stop the spectrometer carriage at selected wavelengths, and measure the line intensities with high time resolution. The number of counts accumulated by each detector in a 125-ms exposure was read out every 160 ms.

III. ANALYSIS AND RESULTS

The data obtained in this manner were summed in blocks of 32 successive readouts, yielding a value every 5.12 seconds. To investigate the possibility of periodic variations in the data, we then calculated the power spectrum of these intensities measured during chosen time interval. One of the best known methods for computing the required Fourier...
The transform of the discrete data is the Cooley-Tukey algorithm (1965) which requires \(2^k\) equally spaced data points, where \(k\) is a positive integer. Here, we choose \(k = 8\), that is, 256 data points. Before the transform was calculated, the average of the 256 data values was subtracted from each value, thereby avoiding a large zero-order Fourier coefficient.

In figure 1, we show the power spectra of the data for three selected lines—the He \(\text{II} 304\) Å line, the Mg \(\text{VIII} 2s^22p^2 2P-2s2p^2 2P\) line at 315 Å and the Mg \(\text{IX} 2s2p^2 1P\) line at 368 Å. In each case, only the power for the first 20 wavenumbers is plotted. The vertical scales have been multiplied by an arbitrary power of 10 to force the curves to the same level for comparison. We indicate the level at which noise occurs at high wavenumbers.

The peak at wavenumber 1 in each graph represents a secular change in the data. This secular variation may be due to fine structure traversing the field of view as the Sun rotates or to a change in atmospheric extinction as the air mass between the Sun and the satellite varies.

The important feature in all three curves is the peak at wavenumber 5, corresponding to a period of \(262 \pm 25\) seconds (the spacing between successive points in the power spectrum at wavenumber 5 is about 50 s). This peak, we feel, is a manifestation of the well known 300-s oscillation discovered by ground-based observers. Because of the low

![Fig. 1.—Power spectra of observations of three extreme-ultraviolet solar spectrum lines showing a peak at wavenumber 5. Power spectra for wavenumbers above 20 have not been plotted.](image-url)
spectral resolution of the instrument, we are undoubtedly observing intensity changes rather than Doppler shifts.

Each plot was chosen as a good example of the power spectrum of the variations of the lines. Several additional examples show similar peaks at the same 262-s period. Several examples which show no peak at wavenumber 5 were found to have been taken near active regions, where the oscillation is not observed from the ground, either.

IV. CONCLUSIONS

The presence of significant power in the observed lines around 262 s is the first reported observational evidence, to our knowledge, that periodic waves in this frequency range persist to heights where local kinetic temperatures are close to $10^6$ °K. It is also interesting to note that the horizontal extent of the wave fronts seems to be at least of the order of 10,000 km, from the spatial resolution element of $10'' \times 20''$. This is much greater than the extent of coherent oscillating elements observed at chromospheric heights.

These observations have important implications for the problem of heating the transition region and low corona. Recent work by Ulrich (1970) and Leibacher (1971) shows that the 300-s oscillations in the photosphere and low chromosphere probably represent evanescent waves which can be interpreted as the chromospheric response, around the temperature minimum, to standing waves in the underlying convection zone. However, these evanescent waves become vertically propagating, gravity-modified sound waves at that height in the chromosphere where the rising temperature admits propagation, by reducing the critical frequency above which propagation is possible. Vertical propagation will occur for temperatures $T_k > 8650°$ K ($6600°$ K) if the period $P$ is 300 s (262 s) (cf. any standard treatment of critical frequencies in the solar atmosphere, such as Kuperus 1965).

Propagating sound waves at these periods are known to develop into strong shock waves over very short distances under chromospheric conditions (Schwartz and Stein 1972), and it has been suggested (Jordan 1970) that these shocks might provide the large dissipation which, from stability considerations, could give rise to the low-lying, abrupt transition from the chromosphere to the corona, observed (Zirin 1966) over the supergranulation cells. The periodic intensity fluctuation we observe could be evidence of the atmospheric response to strong, periodic shock waves high in the transition region or in the low corona. If so, there may be sufficient energy in these shocks at low coronal heights, notwithstanding their rapid growth and dissipation, to heat the low corona and provide a strong conductive flux back to the chromosphere. This picture is completely consistent with a low-lying, abrupt, narrow transition region.

REFERENCES