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AN INTERPRETATION OF THE CORRELATION IN THE INTENSITY FLUCTUATIONS IN H AND K OF Ca II AND b_1 OF Mg I

(Research Note)

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From a study of the intensity fluctuations in the continuum as well as in the lines H and K of Ca II, b_1 of Mg I and Hβ, Evans and Catalano (1972) find that the correlation between the continuum structures and those in the inner wings of the lines of K and b_1 assumes negative values.

Thomas (1972) has suggested an explanation based on the source functions. In this note, we offer an interpretation derived from a study of the intensity oscillations in the continuum and in the Fe I 6358.695 line completed at Kodaikanal from an excellent time sequence around this region. The Rowland intensity of this line is 6 and the lower excitation potential is 0.855 eV. The intensity fluctuations were measured both in the line wings and in the line core. In the line wings the intensity measures are those averaged from the tracings at $+\Delta\lambda$ and $-\Delta\lambda$, to avoid the disturbing effects of the local Doppler shifts. The value of $\Delta\lambda$ is 0.0659 Å and represents the region at which the velocities were also measured on the line to correlate the velocity oscillations with the intensity oscillations. These have been discussed in detail in a separate paper Sivaraman (1973). A cross-spectral analysis is then carried out between intensity fluctuations (1) in the continuum and in the line wings and (2) in the continuum and in the line core.

The contribution functions show that the line wings have a mean depth of formation at $\log\tau_{5000} = -1.2$ and the line core at $\log\tau_{5000} = -1.6$ or -1.8.

The line wing and the continuum show a high coherence reaching a value of 0.95. The wing brightness lags behind the continuum by about 14° or 12 s in the frequency range $\nu = 2.0$ to 4.0×10^{-3} Hz. Between the line core and the continuum brightness, the coherence has an average value of 0.65. The core brightness, however, is seen to lead the continuum over the entire frequency range of analysis ($\nu = 2$ to 6×10^{-3} Hz) by 57°.

It is this phase reversal that manifests itself as a negative correlation coefficient in the analysis of Evans and Catalano. In a collision-controlled line, at the lower levels, i.e. outside the line core, the temperature fluctuations are controlled by the local fluctuations in T_e. This local thermal field is in turn assumed to be coupled to the radiation field of the continuum through collisions. This is confirmed by the observations by the high correlation coefficient of 0.95, if we interpret the brightness

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fluctuations as directly proportional to temperature changes. At higher levels, the thermal fluctuations are the results of the induced pressure and density changes caused by the dissipation of the mechanical energy flux transported by the velocity fluctuations. This is essentially an LTE process in collision-dominated lines. It is the phase lead, of the line core intensity fluctuations over those in the continuum that shows itself as a negative correlation coefficient. The correlation coefficient of the core of K and b_1 with the continuum obtained by them is <0.15. This means the core and the continuum intensities are in quadrature. A phase analysis would perhaps have shown that the core of K and b_1 leads the continuum by a value around 90°.

The cross-spectral analysis of the velocity fluctuations in Fe I 6358.695 line against the intensity fluctuations in the line wing, line core and in the continuum further support this argument. The velocities lag behind the continuum brightness by 36° and the coherence is around 0.6. The velocities also lag behind the line wing intensities by 21°. This strengthens the argument that the changes in the line wing brightness reflect those of the continuum, since the phase lag of 21° is appropriate between the velocity and the continuum with allowance made for the difference in their levels in the solar atmosphere. The core brightness is seen to lead the velocity in Fe I 6358.695 line by about 93°.5, which confirms that the intensity fluctuations are caused by the compressional forces induced by the velocity fluctuations through the standing adiabatic wave motions. In a standing wave, the velocity lags the temperature and density changes by 90°.

We have no explanation concerning the Hβ correlation. The work on an Hβ time-sequence is, however, in progress to measure the phase differences.

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