CHAPTER VI

A REVIEW OF THE RESULTS OF THE PRESENT STUDY

6.1. General

The present investigation has brought out the spatial properties in terms of depth and the temporal behaviour of the velocity and temperature fields in the solar atmosphere based on the study of fourteen spectral lines. The choice of a large number of lines originating in the entire photosphere and the low chromosphere at graded levels has enabled us to achieve a very good insight into the behaviour of the inhomogeneities sampled at close intervals in height in the solar atmosphere. There are a few spectral lines whose mean depth of formation overlap. This gives the advantage of confirming the properties of the oscillations derived from one spectral line by another having nearly the same depth of formation.

6.2. Review of the results

The main conclusions that emerge from this investigation are:
1) The velocity fields observed simultaneously at different levels show vertical oscillatory motion with an average period around 300 sec. The velocity time plots for the various lines, at successive points 1080 km apart on the solar surface show a high degree of coherence in the oscillations at different levels. This is also seen to be so from the results of the cross-spectral analysis between the velocities at two different levels. The "High resolution" analysis enabled the determination of the most probable period of oscillation for each line with an accuracy of 5 seconds. The CI 6587 line formed in the very deep photosphere (mean depth of formation $\log \tau = 0.2$) shows a period of 304 seconds. The weak lines having a mean depth of formation around $\log \tau = -0.6$ have a period ranging from 295 to 300 seconds. The remaining lines originating at mean levels from $\log \tau = -0.8$ to $\log \tau = -1.2$ have a period of 295 seconds. This shows that the period of oscillation decreases with height in the solar atmosphere.

2) In the low frequency range, the presence of the convective overshoots are seen well in all the lines, but the amount of power falls very rapidly with increasing height. This is confirmed by the high coherence of
velocity and intensity fluctuations near the zero frequency range. The low frequency power may not be due to gravity waves, as these waves cannot exist at these levels, due to the relatively small radiative relaxation time (Souffrin 1966). The existence of these waves at higher levels, is, however, not ruled out, as the radiative relaxation time increases fast with height at higher levels (Souffrin 1966) and according to Lighthill (1967) these waves can be generated even beyond the temperature minimum, by the penetrating 'tongues of turbulence' from levels below.

3) The coherence and phase spectra of velocities between pairs of lines show that the high level lines lag behind the low level lines. But the value of the phase lag in the resonance range is very small being of the order of 5 seconds for lines having their mean depth of formation 110 km apart. This suggests that in this range these are primarily standing waves. In the high frequency domain the phase lag increases and the propagation velocity agrees well with the velocity of acoustic waves in the medium. These presumably provide the non-thermal source for heating the corona.
4) The power spectra of the intensity fluctuations in the continuum, line wing and line core, show large power in the neighbourhood of the zero frequency. The high coherence in this frequency range between the three intensity fluctuations should be considered as an additional evidence of the penetration of the convective motions to these higher levels represented by the line wings and line core. Unlike the continuum and the line wing, the core brightness shows clearly the oscillations. In the FeI 6358 line, the intensity oscillation in the line core leads the velocity oscillation by 93°, in the resonance range. This again confirms the standing mode for the oscillations in the 300 sec. period range. The velocity in FeI 6358 lags behind the continuum fluctuations by 33° and lags behind the wing brightness by 21°. Also the wing brightness lags the continuum by 14° and the core brightness leads the continuum by 57°. These give support to the fact, that the line wing fluctuations are caused by the granulation field, while the line core fluctuations are independent of those of the granulation.

6.3. Some problems for future investigation

This field of study, namely, the dynamical characteristics of the macroscopic inhomogeneities have been
engaging the attention of the solar physicists during the past two decades and will continue to be a fertile field for investigations for many years to come.

Our information of the velocity and intensity fields at the high chromospheric levels, is very scanty. These can be obtained using the balmer lines. More observations of the phase relations between the velocity and intensity are necessary both in the photosphere and chromosphere, to help in determining the dynamic characteristics of the oscillations. Another point of great interest is the role of spicules in the heating of the corona. This will primarily rest on the identification of the spicules with disc features. It is known that, at the boundaries of the chromospheric network seen in the Ca$^+$ K line spectroheliograms, there is an excess heating and also that this network boundary bears a good correlation with the boundary of the supergranulation cell. The magnetic fields piled up at the supergranular boundary are presumably responsible for this excess heating along the boundary. We do not know for certain whether these brighter regions along the boundaries of the chromospheric network are really bases of the spicule bushes. It would be of great significance to find out whether the chromospheric and coronal heating is localised in the regions
above these spicule bushes. Whether any relation exists between the small scale velocity oscillations and the supergranulation flow is a problem that can be examined by simultaneous observations of velocity fields in any photospheric or chromospheric line and intensity fields in the Ca\textsuperscript{+} K line. Also a detailed study of the behaviour of the oscillatory velocity fields in active regions would provide information on the extent of influence of magnetic fields on these oscillations.

The transformation of the waves propagated upwards into shock waves is only a hypothesis, put forward, to achieve a suitable energy dissipating agency. It may be interesting to detect these shock waves. The quasi-periodic movements detected in the solar chromosphere and corona by Durasova et-al (1971) by observations at 3.3 cm gives encouragement for further work in this direction. Similar observations carried out at mm wavelength will provide a link between the optical observations and those in the cm wavelengths.

Summing up, it is certain, that only the accumulation of such observations in large quantities on the inhomogeneities obtained through studies of their velocity and
intensity fields at all levels in the solar atmosphere, will offer a basis for the interpretation and understanding of the fundamental problem of the transport of mechanical energy and subsequent heating of the outer layers of the solar atmosphere.