son *et al.*, 1974). Lists of abundances and isotopes ratios have been given by Engvold *et al* (1974). The following list gives the references of recent abundance determinations:

He – Hirshberg (1973); Li – Brault *et al.*, 1975; Muller *et al.*, 1975; Be – Aller, 1973; Chmielewski *et al.*, 1975; Ross and Aller, 1974; B – Wohl, 1974; Hall-Engvold (1975); O – Delone *et al.*, (1973); Si – Holweger (1973); K – De la Reza (in print); Ca – Holweger (1972); Ti – Foy (1975); Mn – Margrave (1972); Fe – Lites (1973); Huber and Tubbs (1973); Ross (1973a, b), Ga – Mutschlecner (1972); Ge – Ross and Aller (1974); Y – Allen and Cowley (1974), Nb – Hauge and Youssef (1975); Ag – Ross and Aller (1972); Ba – Holweger and Muller (1974); Tm – Ross and Aller (1974); Pb, Th – Hauge and Sorli (1973); Bi – Hauge (1974).

Investigations for isotopic composition have been carried out in the case of Rb, Sr, Eu (Hauge 1972a, b, c) and Sm (Ekeland and Hauge, 1975). Some attempts have also been made to detect ^{13}C, ^{17}O, ^{18}O, ^{3}He (Hall, 1973, 1975) and also deuterium (Beckers, 1975).

2. THE CHROMOSPHERE

(M. K. V. Bappu)

A. *Spicules*

Lynch *et al.* (1973) have measured spicule properties on much improved filtergrams obtained with the Sacramento Peak vacuum telescope. The average spicule diameter is 950 km well above the instrumental resolution of 0.6″. The variations of spicule diameter with height, wavelength and time are uncertain and do not confirm earlier reports of rapid spicule expansion. Direct counts referring to off-band filtergrams (Hα ± 0.75 Å; ± 1.0 Å) and to an approximate height of 4000 km give spicule numbers that are three times larger than those reported before. A real decrease in spicule numbers for low heights explains satisfactorily the appearance of the dark band beyond the photospheric limb described by Loughhead (1969) and confirmed by Nikolskii and others. Mouradian (1974) finds from a study of filtergrams that the most probable value of inclination of spicules in relation to the normal to the solar surface is 25° and that nearly 62% of all spicules have inclinations within ± 10° of this value. Escant and Mouradian have in progress a study of spicule spectra on the solar limb in K and D_3.

Moe *et al.* (1975) have compared the spicule-like features well visible in He II 304 Å Skylab spectroheliograms with spicules seen in Hα filtergrams obtained simultaneously. No correspondence between the two is seen. However, this does not rule out the possibility that spicules, like prominences, may have differences in appearance when seen in He II and in Hα.

Banos (1973) has studied some properties of spicules at the limb through a K-filter. He finds these features in K to be inadequately resolved as compared to Hα. The ratio of spicule intensity to background intensity increases with height similar to the Hα behaviour, though less striking. The widths are larger than in Hα, though this needs to be re-examined under better conditions of observation. The lifetimes are of the order of 270 secs; these are the same as the lifetime of the fine bright mottles as determined by Bappu and Sivaraman (1971) and from this aspect alone, both may be the same in identity. The velocity of ascent is similar to the average value derived in Hα.

Alissandrakis (1973) has analyzed simultaneous spectra of spicules in Hα, Hβ and K, obtained with a resolution of 1.5″. A very good correlation in the structure of all three lines is seen. The rotation velocities around the spicule axis must be small. Optical depth effects contribute to the Hα line widths. The broadening of the K line is mostly non-thermal.

Zirin (1974a) has studied K line disc filtergrams and finds that while they produce K absorption, they occur in emission more often than in Hα, especially near the limb. Bright spicules and dark ones are seen over all elements of the K network similar to the Hα case. In a study of spicules and fibrils in Hα and K, Zirin (1974b) finds near the limb, bright Hα features at the bottom of dark spicules. In K both bottom and top of the features are bright. There are also bright vertical features in Hα that are uniformly bright in K too.

Bohlin *et al.* (1975) report a major new characteristic of the Sun's polar cap, which they term polar macro-spicules. In He II 304 Å they appear as long pointed jets ranging in length from 5" to 60". The macro-spicules occur only over the polar cap as defined by the polar coronal hole seen in UV spectra. No counterparts in the visible wavelength are seen and in nearly every characteristic they are substantially different from the spicule seen in Hα.

B. *Supergranulation*

Kubicela (1973) has evaluated spatially the line of sight velocities within a supergranular cell. A tangential component to the horizontal supergranular motion is invoked that can be explained both in direction and magnitude by a Coriolis velocity. Local enhancements of velocity fields, especially of approach, have been observed to give rise to a rearrangement of the new supergranular boundary. The enhanced calcium network that outlines the supergranular boundary follows the velocity changes in time. Kubicela and Karabin have in progress a programme for measurement of these large-scale photospheric velocities. Detailed studies of supergranular dynamics coupled with simultaneous magnetic field and calcium intensity values are needed to understand the evolutionary aspects of the supergranule.

Giovanelli (1974) has found that, over supergranule centres, the Hα chromosphere has a fine structure at line centre of similar scale to the photospheric granulation but having no geometrical correspondence with it. The chromospheric granulation can be seen wherever the fibrils are absent, or where there are gaps between the fibrils, so that it lies below them. There is also a faint diffuse structure visible in the Hα line core and outlining the network; this may well be the interspicular absorbing material postulated by Michard to account for the central reversals seen in spicule Hα profiles.

A first look at the supergranular network from the Skylab scanning UV spectrometer in many wavelengths, that originate from different heights in the solar atmosphere, shows (Reeves *et al.*, 1974) the preservation of spatial identity with changes in contrast, up to excitation temperatures of 3×10^5 K. It diffuses rapidly and becomes unrecognizable at temperatures of 1.5×10^6 K, suggestive of a substantial spread in the magnetic-field configuration at these heights. An interesting feature is that individual bright points are seen unchanged in size through this entire range in height and temperature, indicating a localized channelling of magnetic fields through coronal temperatures. Detailed analyses of Skylab data, pertaining to the chromospheric network, its coronal extension and temporal changes in its structure, are in progress at Harvard.

The association of the supergranule boundary with the formation of an active region finds further support in a recent study by Born (1974). A rearrangement of the network pattern is seen with a new cell surrounding the active region.

C. *The Continuum*

Vernazza, Avrett and Loeser (1975) have reviewed all available observations of the UV solar continuum as part of the development of a model of the photosphere and low chromosphere. Listed in measures of intensities and fluxes in the region 2000–3000 Å are the recent values of Kohl *et al.*, (1975) and of Heath (1973). Since heavy line blanketing occurs in this region one needs to have high-resolution observations to evaluate the continuum level. Tousey *et al.* (1974) have an extensive compilation for the region 2226 Å to 2992 Å. Less extensive lists in the 2800 Å region are those of Greve, McKeith (1973) Greve and McKeith (1974). Recent stigmatic spectra obtained by Samain *et al.* (1975) show a less pronounced decrease at the Al I photoionization edge than did earlier observations. Vernazza *et al.* find fair agreement between their model and the observations, provided line blanketing is adequately accounted for. With the use of improved Al I photoionization cross sections measured by Kohl and Parkinson (1973) they find good agreement between the observed and calculated continuum intensities near 2077 Å.

Bonnet (1975) has reviewed recent progress in understanding the regions of origin for the emission between 1250 Å to 2000 Å. Available flux measures in this region are by Nishi (1973), Samain *et al.* (1975), Rottman (1974), Heroux *et al.* (1975) and by Jordan and Ridgeley (1974). A compilation of low-resolution observations has been completed at the U.S. Naval Research Laboratory and high-dispersion spectra are currently being reduced. McAllister and Smith (1975) also list lines observed at high resolution in the vicinity of the Al I autoionizing lines between 1889 Å and 1969 Å. Line blanketing has to be evaluated carefully to have a good match between theory and observation. This presents the problem of the 'missing opacity'. Vernazza *et al.* (1975) have taken account of line blanketing through the use of the extensive calculations of Kurucz (1974) and Kurucz *et al.* (1974). Line-blanketed models have also been discussed by Petreymann (1974). However, it does appear that some opacity is still underestimated. Landi Degl'Innocenti and Noci (1973) consider negative ions other than H^-, two photon processes, forbidden dissociation of H_2 molecules, photodissociation of molecules and absorption by quasi-molecules, but find them insufficient contributors. However, Drake (1974) has suggested that electron-hydrogen photo-attachment giving rise to the $2p^2\ ^3P$ state of H may be important, and Krishnaswamy and Stecher (1974) have proposed H_2^+ in non-LTE as a possible source.

In the region 1500 Å to 1700 Å where the apparent brightness temperature passes through a minimum value, the recent observations now give agreement around $T_b = 4400$ K. Vernazza *et al.* have shown the importance of non-LTE calculation for the principal opacity source, the Si I continuum. They suggest that non-LTE effects cause the observed brightness temperature to be higher than the electron temperature value of 4200 K derived from infra-red observations. The recent work of Brown *et al.* (1974) in the laboratory and Moore *et al.* (1975) should greatly help extended studies of Si I level populations. Further progress in understanding the opacity sources is needed before differences between observed and theoretical centre-to-limb intensity ratios can be ascribed to departures from the spherically symmetric homogeneous model. However, inhomogeneities will have to be incorporated in future realistic models. Jordan and Ridgeley (1974) find that limb-to-disk observations made with the limb slit 4″ above the limb show that continuous emission from material with $T_b \leqslant 5000$ K extends to heights of between 2000 km to 5000 km beyond the limb, values far in excess of 700 km predicted by HSRA for this temperature. This value is also above the average height of the chromosphere-corona transition region as derived from optically thin emission lines.

Kurokawa *et al.* (1974) have analyzed flash spectra of the 1970 eclipse. Distributions of the surface brightness of the continuum at six wavelengths in the visible region show a shallow dip and a small hump that cannot be reproduced by any of the existing model atmospheres. Linsky (1973) has recalibrated solar microwave flux measurements (1 mm–3 cm) using the Moon as an absolute radiometric standard. This will be useful for comparison with predictions of solar chromospheric models. Foukal (1974) considers a three-component concept to describe present observations of the chromosphere and transition region in EUV, optical and mm wave-lengths. The three components are the interiors of supergranular cells, the hot plagettes overlying faculae, and the cooler transient mottles which surround them in the network boundaries. Van Dessel (1974) points out the improvement made by considering non-LTE effects in Fe I line formation with variation having a height dependence.

D. *Line Profiles and Spatial Inhomogeneities*

The Al I autoionization lines at 1932 Å and 1936 Å have been observed by McAllister (1974) in a centre-to-limb study with 3′ spatial and 0.01 Å spectral resolution. Theoretical calculations by Finn and Jefferies (1974) of these line profiles show the non-LTE formulation to have better fit with either the Bilderberg or HSRA model, than an LTE calculation. However, a greater continuum opacity is needed than what is normally accounted for, in order to fit the limb-to-disk variation of the profiles.

The Mg II lines at 2796 Å and 2803 Å have been extensively studied in recent years. Lemaire and Skumanich (1973) report on profiles observed with 7″ resolution and moderate (0.25 Å) spectral resolution, and show examples of profiles in the supergranulation network, in cell-centres and in plage regions. Current models do not give a good fit to the profiles and it is difficult to deduce unambiguously which specific parameters in the models need to be modified. Gouttebroze and Lemaire (1974) have analyzed these profiles and find that they are incompatible with those produced in a spherically symmetric atmosphere in which the source function is independent of frequency. The observations would suggest the presence of non-thermal motions of between 9–20 km s^{-1}, preferentially, in the vertical direction. Milkey and Mihalas (1974) have made a detailed study of the Mg II profile assuming partial rather than full redistribution in the line profile and improve the fit between observation and theory. They also suggest that a better theoretical value for the van der Waals broadening in Mg II is needed before the line profiles can be used to refine existing solar models. Centre to limb observations including the Al I and Mg II lines have also been reported by Kohl *et al.* (1975).

Observations of profiles of lines of C I, S I, C II, A III, Si II and Fe II have been made by Boland *et al.* (1973), (1975) with a spatial resolution of $\simeq$40″ and high spectral resolution (0.03 Å). Lines that are estimated to be optically thin show approximately Gaussian profiles with widths that correspond to non-thermal velocities of between 4 km s^{-1} and 7 km s^{-1}. Lines which on the basis of current models would be expected to have high optical depths show pronounced self-reversals. The interpretation of these lines is complex because of the large range in height and temperature of the region formation. Jefferies and McAllister (1973) have also reported observations of profiles of Si II lines and Finn and McAllister are currently engaged on a non-LTE analysis of these and other Si II line profiles. Bruner *et al.* (1973) have also obtained line profiles of Ly-α and of the O I lines at 1304 Å and 1306 Å with 0.01 Å and 20″ resolution. These show the correlation of decreased central reversals in these lines with bright regions of the calcium network. Milkey and Mihalas (1973) have also calculated the Ly-α profile allowing for partial redistribution and find again a better fit to the observations than by using full redistribution.

Livingston and White (1974) describe a spectrum obtained in very good seeing in the 5870 Å region that probes the high photosphere through the low chromosphere. The stronger emission lines show up velocity and brightness structures with sizes ranging from 500 to 1500 km. The emission knots in Fe I and Ba II lines coincide with continuum bright streaks. No correlation is evident however, between structure in He I D_3, emission in Na I D_2 and emission in the Fe I and Ba II lines as a group. Differences in line opacity are suggested as the cause of the low correlation between the fine structure in the various lines.

From studies of the infra-red Ca II triplet, Mein (1971) finds a three-column model to describe the steady field of temperature, micro-turbulence and radial velocity fluctuations in the photosphere-chromosphere transition zone.

Gebbie and Steinitz (1974) have investigated patterns in Hα spectroheliograms, and conclude that the Hα line source function in the quiet chromosphere is indirectly controlled by the photospheric radiation fields in the Balmer and Paschen continua. Variations in the shape of the absorption profile are extremely effective compared to changes in the source and sink terms. Mouradian has in progress the simulation of the chromosphere by the Monte-Carlo method. In computing the emergent intensity of chromospheric origin at the limb, energy transfer in an inhomogeneous atmosphere is taken into account with different physical parameters having different distribution functions.

From a study of contrast of bright and dark mottles in Hα as a function of wavelength, Bray (1973) finds it to be in good agreement with Becker's 'cloud' model. The values of source function and optical thickness derived seem consistent with Becker's spicule model. However the spicule model finds little agreement with observations when similar measures of contrast are carried out at the limb (Loughhead, 1973). The bright mottles seen beyond the limb reveal no evidence of a systematic upward or downward motion persisting throughout the mottle lifetime (Loughhead, 1974) though a short period vertical oscillation of low velocity is not excluded.

Mein and Mein (1975) have derived intensity curves at different wavelengths in limb spectra of Hα, Hβ and Hγ. Between 2000 and 6000 km above the limb the average thermal, together with turbulent, velocity of the atoms increases from 20 km s^{-1} to 30 km s^{-1}. The Meins aim to derive an inhomogeneous model chromosphere. Sivaraman and Venkitachalam (1975) have completed a study of intensity fluctuations as seen in the first four members of the Balmer series. The dependence of the rms brightness fluctuations on heliocentric angle and $\Delta\lambda$ positions within the line profile, as well as the contributions, by structures of different sizes, to these fluctuations are estimated.

There has been interest in recent years in the study of the Ca II K line on the solar disc. Punetha (1974a) has studied rms as well as power and coherence spectra of intensity variations. Grossmann-Doerth *et al.* (1974) present results that improve available information on statistical steady-state conditions as inferred from K spectra. In the supergranule interior, the profiles with violet single peak, the double peak and no peak at all dominate; in the cell boundary the double peak is most common. In both locations the red single peak is relatively rare. The comparison of the single peak line profiles with model computation shows the presence of non-uniform large-scale velocity fields in the chromosphere. In discussing the formation of Ca II K, Vardavas and Cram (1974) point out the need to consider the frequency dependence of line source function in quantative models. Ayres and Linsky (1975a) have analyzed the Mg II resonance line profiles as well as those of Ca II with the aid of a partial frequency redistribution formulation. They give strong evidence for a temperature minimum near 4350 K and a top chromospheric pressure of 0.15 dyne cm^{-2}.

Ulmschneider (1974) has on the basis of HSRA evaluated the radiation loss of the solar chromosphere. He considers the short period acoustic wave theory to be a sufficient mechanism to balance the chromospheric radiation loss.

Harvey, Hall and Giovanelli have studied the 10 830 Å helium line, concluding that the anomalous ratio of the strengths of the two components is due, in the weakest regions, to faint uncorrected blends; elsewhere, the relation between the intensity and the anomalous ratio of the two components can be explained only if the absorbing elements are resolved incompletely. In conformity with many eclipse observations, they find that the widths of 10 830 Å, Pγ and Ca II 8542 Å are compatible only if they are effectively non-thermal out to at least 5000 km, the rms velocities being some 20 km s^{-1}. Milkey has found that He II 304 Å photons may provide a reasonably effective means of pumping the He I ionization in the regions where the 10 830 Å line and other observable transitions are formed. Streete and Tandberg-Hanssen (1974) have obtained the helium triplet/singlet line intensity ratio I_{10830}/I_{20581} at the eclipse of 1973, June 30. A lower limit of 60 was found indicating a relative overpopulation of the 2^3P level.

Harvey in collaboration with several ATM teams has examined ground-based observations of helium lines with simultaneous X-ray observations from American Science and Engineering and EUV slitless spectrograms from the Naval Research Laboratory. These support the idea advanced by Goldberg in 1939 that these helium lines are significantly controlled by radiation arising at much higher temperatures than the regions where helium is observed. As a result, it is possible to detect coronal holes and bright points with helium observations. These phenomena appear to be basically magnetic in origin. The exact association of magnetic fields with coronal holes remains elusive. Studies by AS & E of X-ray bright points and by Harvey, Harvey and Martin of short lived bipolar magnetic regions definitely confirm the X-ray bright points to be associated with small magnetic active regions. Harvey's study of 10 830 Å spectroheliograms shows that polar coronal holes remain strong but equatorial coronal holes have nearly vanished as solar activity continues its decline toward sunspot minimum; this is suggestive that coronal holes, except at the poles, are one of the last vestiges of solar activity.

E. *Temporal Variations*

Temporal variations in the K line have been analysed by Punetha (1974b) from a short time series. Nicole Mein is presently analysing a very good time sequence obtained simultaneously of Hα and the Ca II lines (H, K, 8498, 8542) for the study of propagation of waves with a period much less than one minute. Liu (1974) finds intensity perturbations in the K line that propagate from the far wing towards the line core. The perturbation is a local heating in the chromosphere due to an upward propagating disturbance generated in the lower layers. Liu and Skumanich (1974) have synthesized K-line profiles for the different evolutionary stages with physical parameters specified as functions of height. A temperature disturbance matches the observations well, though the mode of heating needs to be established. The disturbance may very well be magnetosonic. The study of evolutionary behaviour (Cram, 1975) of the emission in K and 8542 Å shows the localized enhancement to be associated with an outwardly propagating wave. Beckers and Artzner (1974) have studied the properties of the dark structures seen in the K_1 line wing using those that move outwards in the solar atmosphere with appreciable velocity. These dark features seem related to the bright ones found by Liu, and both may be related to the shocks that heat the chromosphere and corona. Sivaraman and Venkitachalam have a similar study in progress of the bright points as seen in the H line of Ca II. The simultaneous study of the impulse as seen in a neighbouring Fe I line enables the travel of the impulse to be seen with height in the atmosphere. The average lifetime of the bright points is 100 s and at the conclusion of the brightness enhancement a dark streak is seen which also disappears in about the same time.

The type of waves to be observed in the quiet Hα chromosphere has been studied by Giovanelli (1975a) using methods which show their line-of-sight velocities (i) the chromospheric granulation exhibits vertical velocities of a quasi-oscillatory character but without any horizontal propagation, the characteristic periods being upwards of 2.5 min. Adjacent points appear to have quite independent periods. There is a close relation between intensity at line centre and velocity maximum v occurring about $T/4$ after maximum downward v. The correlation is characteristic of a standing wave and suggests that little energy is transferred into the corona. (ii) Non-sinusoidal waves propagate predominantly outwards along mottles and fibrils from as close as 2000 km to the network axis at propagation speed of around 70 km s^{-1}. The line-of-sight component of the displacement velocity is $\simeq 5$ km s^{-1}. The velocities are accompanied by propagating intensity fluctuations. Similar waves have been seen propagating mainly outwards along superpenumbral fibrils. The system appears to be basically of the Alfvén type and carries enough energy up into but not down from the higher regions, where it is presumably dissipated, to account for coronal heating.

F. *The Sun as a Star*

In a programme to measure long-term variability of the solar Ca II K line, White and Livingston have found that the structure of the K line is most symmetrical at solar maximum. To relate this result to new OSO-8 data, White is also searching for correlation between the Ca II K and Mg II K (2796 Å) lines as a function of activity on the Sun's surface. It may then be possible to observe 'solar cycles' on other stars by means of satellite monitoring of stellar Mg II K lines. Bappu and Sivaraman have monitored photographically the K line in integrated sunlight for nearly half a cycle. The K_{2V} emission continues to be greater that K_{2R} during this period. The widths measured by a micrometer, as in the stellar case, are larger than in the case of the bright fine mottles over the centre of the disk (Bappu and Sivaraman, 1971). This is principally due to solar rotation and demonstrates the need to evaluate the rotation characteristic in the stars along with the K-line widths, especially in the calibration with absolute magnitude.

Macris (1974) finds the intensity of K_{232} chromospheric flocculi to background chromosphere at the centre of solar disk, to be 1.482. This value is of interest to those monitoring total K_{232} intensity as a function of solar cycle. Ayres and Linsky (1975b) have studied the formation of Hε in the Sun and in α Bootis. In the Sun, the line is in absorption and the source function is dominated by the Balmer continuum (formed in the photosphere) through photoionization. In α Bootis the Balmer continuum radiation field is formed partly in the chromosphere, producing Hε emission in the wing of the Ca II H line.

3. THE TRANSITION REGION AND INNER CORONA
(C. Jordan)

A. *The Structure and Heating of the Quiet Atmosphere*

The starting point for many models of the temperature and density structure of the transition region and inner corona, when made from EUV observations, is the distribution with temperature of the emission measure $\int_R N_e^2 \, dh$, which can be derived from each spectral line. Further