

Conclusion

9.1: Success of the Parametric Granular Cell Model

A simple parametric model of granulation was developed from observations of the solar granulation. Synthetic spectra calculated using this model closely match observed spectra and, in particular, reproduce the asymmetry observed in spectral lines. The goodness of fit between observed and computed spectra is improved by the use of this model.

9.1.1: Model Parameters and Granulation

The values of the model parameters are shown in table 9-1.

Table 9-1: Model Parameters

Parameter	Upflow U	Transition T	Downflow D	All
A	0.45	0.4	0.15	–
B	1.07	0.97	0.87	–
V_0	–	–	–	0.577 kms^{-1}
V_s	–	–	–	368 km
ξ	1.58 kms^{-1}	3.67 kms^{-1}	3.67 kms^{-1}	–
ΔV	$1.6 \pm 0.2 \text{ kms}^{-1}$	$1.6 \pm 0.3 \text{ kms}^{-1}$	$3.5 \pm 1.1 \text{ kms}^{-1}$	–

Both the microturbulent motions and the large-scale flow velocity decrease exponentially with a scale height of 368 km as the height within the photosphere increases. The model agrees with observations of the solar granulation (from which it was derived).

9.1.2: Horizontal Motions

With the vertical motions known, the horizontal motions associated with granulation can be found. Spectra away from disk centre can thus be calculated. This is a difficult process, but spectra away from, but reasonably close to, disk centre can be readily calculated approximately.

Spectra calculated in this manner show the expected behaviour, except near the limb, where the approximations used to simplify the calculations break down.

9.1.3: Further Use of the Granular Model

Given accurate damping constants and oscillator strengths for spectral lines, the accuracy of the model parameters can be improved. The relationship of the model parameters to the properties of the solar granulation will then yield more accurate data on solar motions. The f -values available are not of sufficient accuracy for this procedure to be carried out. An experiment designed to measure oscillator strengths is described in Appendix B as a first step towards obtaining such data.

The granular model can also be used to determine damping constants and oscillator strengths. As the profiles of spectral lines are accurately reproduced, calculated and observed spectra can be closely matched in order to determine line formation parameters.

A simple model of granulation also offers the opportunity to study convection in other stars via their spectra. A more complex model with a larger number of freely variable parameters would be less useful due the higher probability of non-unique sets of parameters giving a match between observed and calculated spectra.

9.2: Damping

The Brueckner-O'Mara damping theory was found to predict damping constants accurately.

As quasi-static damping is strongly asymmetric, and the usual theory does not adequately deal with simultaneous perturbations by different types of particles (such as ions and neutral atoms), a more correct quasi-static damping theory was developed in chapter 4. This improved theory was used to show that the contribution of damping to the asymmetry of spectral lines is negligible in the solar photosphere. (Under different conditions, it can be a major source of asymmetry.) This removes all plausible non-convective causes of asymmetry of solar spectral lines.

9.3: Solar Abundances

The photospheric abundances of a number of elements (mainly titanium-nickel) determined in this work are listed in table 9-2.

Table 9-2: Photospheric Abundances

Element	Lines	Abundance	Standard Solar	Meteoric
Si	2	6.71	7.55 ± 0.05	7.55 ± 0.02
K	1	5.30	5.12 ± 0.13	5.13 ± 0.03
Ti	15	5.01 ± 0.11	4.99 ± 0.02	4.93 ± 0.02
Ti*	6	4.97 ± 0.03	4.99 ± 0.02	4.93 ± 0.02
V	7	4.10 ± 0.08	4.00 ± 0.02	4.02 ± 0.02
Cr	9	5.73 ± 0.11	5.67 ± 0.03	5.68 ± 0.03
Mn	1	5.49	5.39 ± 0.03	5.53 ± 0.04
Fe	63	7.55 ± 0.04	7.67 ± 0.03	7.51 ± 0.01
Fe*	12	7.46 ± 0.05	7.67 ± 0.03	7.51 ± 0.01
Co	5	4.78 ± 0.06	4.92 ± 0.04	4.91 ± 0.03
Ni	17	6.24 ± 0.15	6.25 ± 0.04	6.25 ± 0.02
Mo	1	2.01	1.92 ± 0.05	1.96 ± 0.02

* Only lines with accurately measured f-values used.

The abundance obtained for iron agrees with the meteoric iron abundance, and the lower photospheric abundances that are obtained, but not with the higher photospheric abundance of 7.67. The value obtained for the iron abundance in this work is well-determined (i.e. the error is quite small) due to the large number of iron lines used. The errors in the abundances for the other elements are higher, as fewer lines were available. A major contribution to the errors is the inaccuracy of the available oscillator strengths.

9.4: Oscillator Strengths

A number of astrophysical f -values were determined in the course of this work. The values obtained are listed in table 9-3. (See table C-2 in Appendix C for full details of the transitions involved.)

Table 9-3: Astrophysical gf -values

Wavelength	Element	$\log(gf)$
5241.450	Cr I	-2.13
6303.466	Fe I	-2.61
6698.671	Al I	-1.90
6862.499	Fe I	-1.44
7001.549	Ni I	-3.77

An experiment designed to measure oscillator strengths of weak lines is described in Appendix B.