Tomography of the Solar atmosphere

L.M. Sarro and B. Montesinos
Laboratorio de Astrofísica Espacial y Física Fundamental, POB 50727, E-28080 Madrid, Spain

C. Jordan
Department of Physics (Theoretical Physics), University of Oxford, 1 Keble Road, Oxford OX1 3NP

1. Introduction

The determination of the structure of the transition region both in the Sun and in other late-type stars has been a topic of great interest since the discovery of this thin layer that separates the chromosphere from the corona. In the general case, the method to model the transition region involves the use of emission lines fluxes to compute a quantity called emission measure, defined as $Em = \int_{\Delta R} N_e^2 dh$ as a function of the electron temperature $T_e$. This method was developed in the context of solar physics by Pottasch (1964) and has been widely applied in the stellar context mainly since the advent of the International Ultraviolet Explorer (IUE) which has provided a wealth of homogeneous data for analyzing the outer atmospheres of cool stars. The emission measure method does not give by itself a picture of the structure of the atmosphere in the sense of providing a representation of $N_e(h)$ or $T_e(h)$. For obtaining these functions some assumptions have to be made as there is not a sufficient number of spectroscopic diagnostics to separate $N_e(h)$ and $\Delta(h)$ in the emission measure expression.

2. Observations and data reduction

The spectra used in the present study were taken on photographic film with the Naval Research Laboratory (NRL) High Resolution Telescope and Spectrograph (HRTS) instrument on board the Space Shuttle Challenger STS 51-F during the Spacelab 2 Mission. The calibration to convert photographic density to relative intensity, was done by determining the film characteristic curve using spectra of the same field made with different exposure times. The method used film density histogram distributions and was described by Cook, Ewing and Sutton (1988).

1Instituto de Astrofísica de Andalucía, POB 3004, E-18080 Granada, Spain
3. Three dimensional information from two dimensional spectra

The current knowledge of the vertical structure of the supergranulation boundaries is based upon a series of observations of the solar atmosphere in the ultraviolet and extreme ultraviolet regions that have given increasing evidence of the highly inhomogeneous (Reeves et al. 1976) and dynamic (Dere et al 1989) nature of the chromosphere and transition region of the Sun. The typical feature of these inhomogeneities as seen in spectral lines formed in the temperature range $3.8 \leq \log T \leq 5.8$ is a cell-like distribution pattern surrounded by bright interstices. The persistence of this cell-like brightness distribution at different temperatures, and therefore heights above the solar surface, indicates the vertical nature of these inhomogeneities. The observations seem to be compatible with bundles of magnetic field lines constrained to the supergranule boundaries climbing through the solar atmosphere up to coronal temperatures. Let us assimilate a supergranulation boundary as a vertical wall-like structure, whose axis is perpendicular to the photosphere. A section of the boundary would be within the field of view of the slit, so we can consider, as an idealized working structure, a column of gas anchored in the photosphere with the characteristic temperature stratification whose mapping with geometric height is the problem we intend to solve. If the supergranulation boundary is placed at a relatively high latitude, the projection effects will make the signature of the ‘cool’ lines, i.e. those arising from neutral atoms or singly ionized species such as O i, Si i, ($T_e$ less than or around $2 \times 10^4$ K), appear at lower rasterlines on the scanned plate than those of ‘hot’ lines, emitted by ions found at temperatures above $8 \times 10^4$ K, such as Si iv, C iv and O iv. This fact can actually be used to derive the thickness of the transition region in the vertical structure observed, provided the latitude of the supergranulation boundary and the height of a reference layer are known.

4. Results

Values obtained with this method for different boundaries range between 2,700 km and 7,100 km (both cases being exceptional; otherwise, 3,400 km and 5,900 km). The mean height of the region of emission of C iv and O iv above the Si i reference layer is 4,500 km with a mean standard deviation of 1,300 km. This mean value is in good agreement with previous measurements made at the limb by other authors (Cook and Brueckner, 1991)

References

Reeves, E.M., 1976, Solar Phys., 46, 45