OBSERVATIONS OF THE PROFILES OF SOLAR UV EMISSION LINES AND THEIR ANALYSIS IN TERMS OF THE HEATING AND PRODUCTION OF THE CORONA

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Abstract. Observations of the solar spectrum have been made between 1200–2200 Å with high spectral resolution. The results were obtained with an all-reflecting echelle spectrograph carried by a stabilized Skylark rocket launched in April 1970. Measurements of the profiles of a number of emission lines due to Si II, C II, Si III and C IV formed in the temperature range 10^4–10^5 K, indicate ion energies which are considerably in excess of the electron temperatures derived from the ionization balance. Since the ion/electron relaxation time is very short the observed ion energies cannot correspond to an ion temperature and hence a non-thermal mechanical energy component exists in the transition zone.

It is postulated that the non-thermal energy component represents the actual mechanical energy responsible for the heating of the corona, and, that, it is propagated as an acoustic wave. On this basis and with a preliminary estimate of the reflection from the transition zone, a flux of 3×10^5 erg cm^{-2} s^{-1} is established as entering the corona. This value is in agreement with estimates of the total energy loss from the corona due to conduction, radiation and the solar wind, thus establishing a gross energy balance.

Theoretical calculations are currently underway to establish the physical nature of the atmosphere which would result from such a propagating flux. At the present time this has been carried out for an atmosphere in hydrostatic equilibrium and the energy balance equation solved. A preliminary temperature structure which results is shown in Figure 1, together with the derived distribution in electron density. This gives a corona of the right temperature and density but the observed structure deviates in detail from those derived from an analysis of the solar XUV spectrum.

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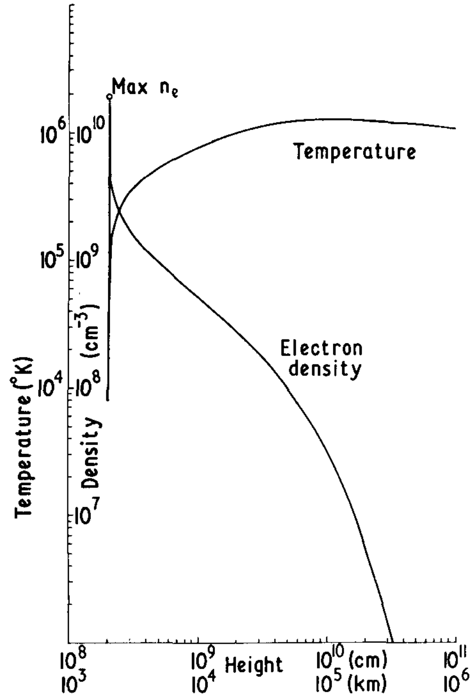

Fig. 1. Theoretically derived model of the coronal structure.

DISCUSSION

M. Kuperus: I think your model calculations based on the observed state of motion of the different atmospheric layers are very much dependent on the assumption of hydrostatic equilibrium. If you abandon the hypothesis of hydrostatic equilibrium, and just let the atmosphere expand, for instance where the heating cannot be balanced by conduction and radiation, you get to a completely different picture of the atmosphere.

R. Wilson: This investigation is still underway and we have started with the simplest case of hydrostatic equilibrium. We do not wish to introduce an expansion in any arbitrary fashion, but to consider the physical consequences of the propagating modes. Hence our next step will be to investigate the pressure contribution of the sound wave, and the extent to which this will affect the equilibrium of the corona. Beyond that, we have to consider expansion effects due to the solar wind, but I confess that I am surprised that this would introduce major changes as far as the lower corona and transition region go.

A. H. Gabriel: If your model predicts the formation of a shock front before it has passed the steep transition region, what reflection coefficient have you used?

R. Wilson: The estimate of the degree of reflection of the sound wave at the transition zone is a preliminary one, based on an idealized model of a temperature discontinuity. This gives a reflection coefficient of about 50%.

A. H. Gabriel: This is I believe rather lower than previous workers have found.

C. Jordan: I am interested to see that your model predicts that a temperature of one million degrees is not reached until a height of 20000 km above the limb. Eclipse data, including that obtained during the 1970 eclipse, show that the emission from lines such as Fe XI, formed at 1.4×10^6 K, originates at heights as low as 7000 km above the limb. The existence of spicules does not affect such coronal line observations.

R. Wilson: The structure I have shown does not represent our final solution, although I do not think that the height of the 10^6 K point will change by the amount you indicate. However, in making this particular comparison, we have to compare the same quantities, and this means that we need to estimate from our theoretical model the distribution of spectral line intensities with height, the maximum of which will occur at a lower temperature than the ionization temperature, because of the density effect. This will reduce, and possibly remove, the discrepancy you refer to.