THE SOLAR TEMPERATURE DISTRIBUTION WITH LATITUDE

(Research Note)

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(Received 13 November, 1972)

To search for a pole-equator temperature asymmetry in the higher layers of the photosphere, I observed the Mg I $\lambda 4571.1$ intercombination line at various positions on the solar disk. This line is especially suitable for temperature measurements because it is purely collision dominated (White *et al.*, 1972).

The line profiles were obtained with the Utrecht horizontal spectrograph (Fokker *et al.*, 1971) with a slit of $0.8 \times 380''$. The new digital spectrum scanner samples the normalized spectrum every 4.5 mÅ on punched paper tape at a rate of 100 8-bit measurements a second. For each position on the solar image a hundred scans were averaged to reduce the rms noise in the continuum intensity to 0.1%.

On 1972 September 24, October 1 and 3 about 50 averaged profiles in total were measured of quiet regions on the solar disk for different position angles at radii $r/R_{\odot} = \sin\theta = 0.7$, 0.8 and 0.9. The slit was kept parallel to the limb with an image rotator. The residual intensities at the line cores were determined relative to the local continuum; their standard error is 0.1 percent of the continuum intensity. The precision is limited at present by excursions of the automatic guider. All systematic errors, such as the spread in $\sin\theta$ due to the straight slit and the degradation of the profile caused by the low resolving power of the spectrograph, are the same for all observations and do not interfere with the differential measurements.

The residual intensity was found to vary about 0.3 percent of the continuum intensity along circles of constant $\sin\theta$. To convert this variation into temperature differences, I used preliminary results of an analysis of the formation of this line by Wijbenga (to be published) that follows the approach described by Wijbenga and Zwaan (1972). The analysis is partly based on new eclipse observations of the line profile at the outer limb (Rutten, to be published). The results show that for the HSRA model (Gingerich *et al.*, 1971) the line core at $\sin\theta = 0.7$–0.9 is formed at an optical depth $\tau_{5000} \approx 3 \times 10^{-4}$. The present observations refer to slightly deeper layers because of instrumental smearing. By changing the model a line core intensity variation of 2% was found to correspond to a 10 K temperature change, which is close to the Planck function difference. To convert the observed relative variation, I assumed that there is no pole-equator asymmetry in the continuous intensity at the observed positions (Altrock and Canfield, 1971b).

The resulting temperature differences are quite small. There is no evidence of a systematic pole-equator asymmetry larger than 3 K; at intermediate latitudes there are slight excesses of up to 5K (Figure 1). However, these are hardly significant since the standard deviation is 3K. The data agree well with the more detailed observations by Altrock and Canfield (1972a) who found a latitude-dependent temperature excess of up to 8K at about the same depth from scans of the solar image in the red wing of Ca II K. Although the present observations are smaller in number and lower in quality the confirmation of the absence of a temperature asymmetry larger than 10K at a depth $\tau_{5000} \approx 10^{-3}$ is of interest since a different spectral line, scanning method and analysis has been used at a different time of observation.

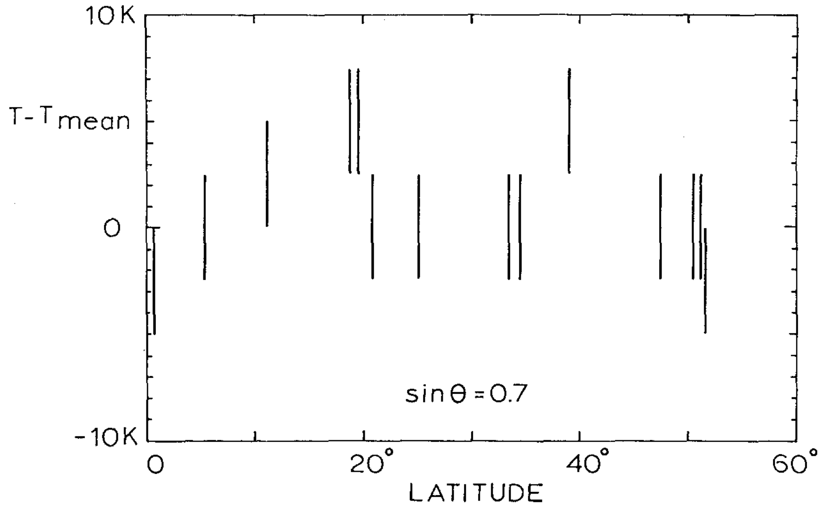

Fig. 1. Relative temperature differences in degrees Kelvin for quiet regions at $\sin\theta = 0.7$ as a function of heliographic latitude.

The present upper limit of 10K is significantly smaller than the ≈40K equatorial excess in the outer photospheric layers that has been suggested by Ingersoll and Spiegel (1971) and Durney and Werner (1971) as an alternative interpretation for the oblateness observations by Dicke and Goldenberg (1967). To find the contribution of the remaining small enhancements to these measurements, their extent in depth and their variation with the activity cycle must be studied.

Acknowledgements

I thank Mr J. W. Wijbenga for the use of his model programs and the preliminary data on the formation of the λ4571 line, Mr H. Spruit and Mr J. L. A. van Hensbergen for assistance with the observations, Mr G. W. Geijtenbeek and Mr E. B. J. van der Zalm for help with the computations and Drs C. Zwaan, O. Namba and E. P. J. van den Heuvel for criticisms.

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