# THE KINETIC TEMPERATURE OF THE SOLAR REVERSING LAYER

PEARL J. RUBENSTEIN

ABSTRACT

A redetermination of the curve of growth for the sun by means of least squares has resulted in a value of the temperature of the solar reversing layer for iron atoms

$$T = 5400° \pm 1300° \text{ (m.e.)}$$

and a value of the damping constant

$$\frac{\Gamma}{\nu} = 1.7 \times 10^{-6} \pm 0.40 \times 10^{-6} \text{ (m.e.)} .$$


In a series of recent papers[1, 2, 3] the theoretical expression for the curve of growth has been derived and compared with Allen's[4] observations of the equivalent widths of lines in the solar spectrum. The present note concerns a further investigation of the same material and of the new tables by Allen,[5] which extend the observations to 3924 A. A least-squares solution gave the theoretical curve which best fits the observational data.

Theory shows that $W/\lambda$ can be given as a function of $X_0$, the optical depth at the center of the line. For small values of $X_0$,

$$\log \frac{W}{\lambda} = \frac{1}{2} \log \pi + \log \frac{v}{c} + \log X_0 + \log \left( 1 - \frac{X_0}{\sqrt{2}} + \frac{X_0^2}{\sqrt{3}} \dots \right) .$$

For intermediate values of $X_0$,

$$\log \frac{W}{\lambda} = \log X_0 \frac{v}{c} \sqrt{\pi} - \frac{1}{2} \log (1 + X_0) - \frac{\frac{1}{2} \log 4\sqrt{\pi} \frac{v}{c} \frac{\nu}{\Gamma}}{1 + 15e^{-2 \log X_0}} ;$$

and for large $X_0$,

$$\log \frac{W}{\lambda} = \frac{1}{4} \log \pi - \log 2 + \frac{1}{2} \log \frac{v}{c} + \frac{1}{2} \log X_0 + \frac{1}{2} \log \frac{\Gamma}{\nu_0} ,$$

1 *Ap. J.*, **84**, 462, 1936.

2 *Ap. J.*, **84**, 474, 1936.

3 *Ap. J.*, **87**, 81, 1938.

4 *Mem. Comm. Solar Obs.*, **1**, No. 4, 1934.

5 *Ibid.*, **2**, No. 6, 1938.

where

$$X_0 = \left[3.510 \times 10^{-12} \frac{N_a}{b(T)} \sqrt{\frac{\mu}{T}} \varphi\right] S \frac{s}{\Sigma s} e^{-X_{J'}/kT} .$$

Since $X_{J'}$, the excitation potential, is essentially constant for lines of a given multiplet, all the lines have been plotted on a single diagram with an arbitrary zero point for log $X_0$. Various multiplets are combined on the diagram by sliding the log $X_0$ zero point until the

TABLE 1

| log $X_0$ | log $\frac{W}{\lambda}$ | $N$ | $\sigma$ | O−C |
|---|---|---|---|---|
| −0.92 | −5.98 | 4 | 0.101 | +0.10 |
| −0.68 | −5.82 | 14 | .242 | + .04 |
| −0.53 | −5.74 | 24 | .121 | − .01 |
| −0.32 | −5.52 | 17 | .142 | + .02 |
| −0.12 | −5.48 | 17 | .148 | − .14 |
| +0.68 | −5.02 | 30 | .132 | − .06 |
| +0.87 | −4.95 | 36 | .149 | − .06 |
| +1.08 | −4.84 | 25 | .117 | .00 |
| +1.26 | −4.81 | 28 | .071 | − .02 |
| +1.44 | −4.75 | 21 | .067 | + .01 |
| +1.65 | −4.71 | 22 | .131 | .00 |
| +1.84 | −4.65 | 29 | .078 | + .02 |
| +2.05 | −4.58 | 20 | .081 | + .03 |
| +2.43 | −4.46 | 25 | .097 | + .08 |
| +2.64 | −4.37 | 8 | .136 | + .07 |
| +2.75 | −4.47 | 4 | .071 | − .09 |
| +3.00 | −4.18 | 7 | .147 | + .08 |
| +3.13 | −4.20 | 2 | .119 | − .01 |
| +3.41 | −4.03 | 3 | 0.050 | +0.02 |

best fit with an assumed master-curve is obtained. The master-curve used in this study was that given by Menzel, Baker, and Goldberg.[3]

The resulting graph was divided into equal parts along the log $X_0$ axis, and all the points in each strip were averaged to give the normal points for the least-squares solution. The first and second columns of Table 1 give the co-ordinates of the normal points; the third column, the number of observations; and the fourth, the mean error obtained from the combined dispersions in the two co-ordinates. The last column gives the difference between the observed and computed values of log $(W/\lambda)$ for given log $X_0$, computed with the least-squares values of the constants. Figure 1 shows the normal points with their mean errors in the log $(W/\lambda)$ co-ordinate and the final theoretical curve.

A least-squares solution was carried out to determine the best values of the constants $v/c$ and $\Gamma/\nu$. An attempt to solve for both $\Gamma/\nu$ and $\Gamma/\nu_0$ separately resulted in values which differed insignificantly from each other, in view of the large mean errors. In the final solution $\Gamma/\nu$ was therefore set equal to $\Gamma/\nu_0$. The curve was

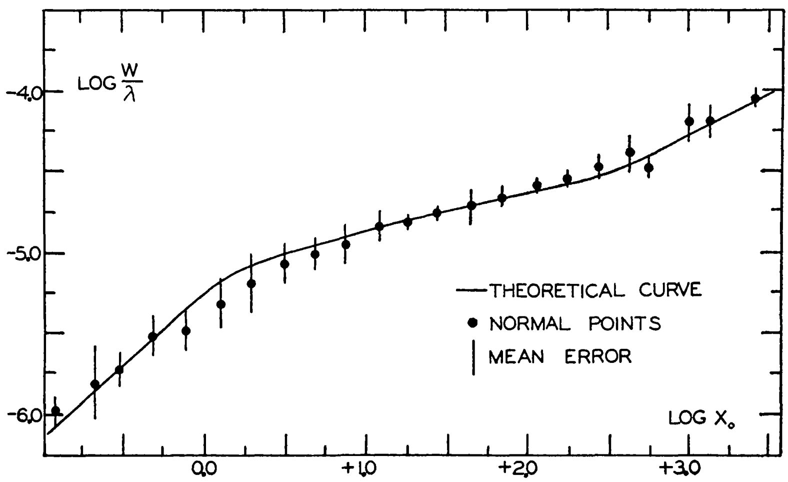


FIG. 1

divided into three parts, corresponding to the three theoretical expressions; and points in the transition regions were omitted.

Using the relation

$$v = 1.289 \times 10^4 \sqrt{\frac{T}{\mu}} ,$$

where $\mu$ is the atomic weight, one arrives at the following value of the temperature for iron atoms:

$$T = 5400^\circ \pm 1300^\circ \text{ (m.e.)} .$$

The solution also gives

$$\frac{\Gamma}{\nu} = 1.7 \times 10^{-6} \pm 0.40 \times 10^{-6} \text{ (m.e.)} .$$

From Figure 1 it is seen that the normal points fit very well on the theoretical curve determined with two constants. The temperature derived in the solution is not the same as that previously found, but the mean error is so large that one can draw no certain conclusions from the differences. One can merely state that the temperature falls within the range of values determined by various other methods. The value of $\Gamma/\nu$ agrees well, within the limit of error, with that found by Menzel.[1]

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