TRANSFORMATION OF THE ABSOLUTE SOLAR RADIATION DATA INTO THE 'INTERNATIONAL PRACTICAL TEMPERATURE SCALE OF 1968'

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Abstract. Corrections are given which transform the Tables of the solar radiation data (Labs and Neckel, 1968) into the 'International Practical Temperature Scale of 1968'. Additionally, for the adjustment of the data of the 'true continuum' and the corresponding line blanketing as well, the veiled line effect mentioned first by Carbon et al. (1968), but studied in more detail by Holweger (1970a), has been considered also.

The corresponding corrections of the solar irradiance result in an improved value of the spectrophotometric solar constant: $S = 1.947 \text{cal cm}^{-2} \text{min}^{-1}$ or $0.1358 \text{W cm}^{-2}$. Two Tables presenting the 'highest (window-) intensities' and the corrected irradiance data have been added.

In connection with a discussion of all the solar radiation measurements available at that time, the authors had published extensive tables of the basic solar radiation data (Labs and Neckel, 1968, 'LN IV'). Only very recently two facts have become known which demand slight corrections of these tables:

1. The 'International Practical Temperature Scale of 1968' (Barber, 1969) is based on the improved value of $c_2 = 1.4388 \text{cm K}$ instead of $c_2 = 1.4380 \text{cm K}$, as it had been used in LN IV. (The 'new' freezing point of gold, 1337.58 K, had already been adopted in LN IV).

2. There is a remarkable depression of the 'continuum' due to many faint, but unseen lines not only at wavelengths below 4000 Å, as it had been supposed already by Carbon et al. (1968, see also LN IV), but also at longer wavelengths, at least up to around 5000 Å. This effect has been analyzed even quantitatively by Holweger (1970a). It modifies, of course, only the data of the 'continuum' and of the line blanketing.

In the following the corresponding corrections are given for Tables 4–7 of LN IV, which deal with the absolute radiation quantities. In a few cases some principal remarks have been added.

For the sake of shortness this paper is thought to be used as an appendix to LN IV. The captions of Tables and Figures quoted in this paper refer to the captions in LN IV except for Table 5a which has no counterpart in LN IV. Those symbols which have been explained in LN IV (p. 3) are not explained again.

With the corrections applied, the Tables are related to the 'International Practical
Temperature Scale of 1968' which is in accordance with the following values of the radiation constants we have adopted:

\[ 2C_1 = 1.1910 \text{ W cm}^{-2} \text{ ster}^{-1} \text{ Å}^4 \]
\[ c_2 = 1.4388 \text{ cm K} \]
\[ \sigma = 5.6698 \times 10^{-12} \text{ W cm}^{-2} \text{ K}^{-4} \]
\[ T_{\text{AU}} = 1337.58 \text{ K} \]
\[ 1 \text{ cal} = 4.1840 \text{ W sec} \cdot \]

To Table 4. Solar radiation data for 20 Å bands and to Table 5. Calibration of the photometric atlases by Brückner and Minnaert et al.*

1. The radiation quantities \( \Sigma_i, \Phi_i \text{ and } \Theta_i \) of Table 4 and \( I_{\lambda}^{100}, I_{C}^{100}, \text{ and } I_{R}^{100} \) of Table 5 have to be corrected for the change of \( c_2 \) alone.

The corrections of Table 4 are given by:

\[
\frac{\Sigma_i^\text{new}}{\Sigma_i^\text{LIV}} = \frac{\Phi_i^\text{new}}{\Phi_i^\text{LIV}} = \frac{\Theta_i^\text{new}}{\Theta_i^\text{LIV}} = 1 - \frac{dc_2}{\lambda T_{\text{AU}}} = 1 - \frac{60}{\lambda [\text{Å}]} + 10^{-8}.
\]

The corrections for Table 5 are given by:

\[
\frac{(I_{\lambda}^{100})^\text{new}}{(I_{\lambda,C,E})^\text{LIV}} = 1 - \frac{dc_2}{\lambda T_{\text{AU}}} = 1 - \frac{60}{\lambda_{B,C,E} [\text{Å}]}.
\]

Relations (1) and (2) result from a combination of the following equations (with \( dT_{\text{AU}} = dC_1 = 0 \) and \( dc_2 = + 0.0008 \text{ cm K} \)):

\[
\frac{d\Sigma_i}{\Sigma_i} = \frac{d\Phi_i}{\Phi_i} = \frac{d\Theta_i}{\Theta_i} = \frac{dI_{BB}}{I_{BB}},
\]

\[
\frac{dI_{BB}^L}{I_{BB}^L} = \frac{dC_1}{C_1} + \chi(\lambda, T_{BB}) \frac{c_2}{\lambda T_{BB}} \left( \frac{dT_{BB}}{T_{BB}} - \frac{dc_2}{c_2} \right),
\]

\[
\left( \frac{dT_{BB}}{T_{BB}} - \frac{dc_2}{c_2} \right) = \frac{\chi(\lambda_0, T_{\text{AU}})}{\chi(\lambda_0, T_{BB})} \left( \frac{T_{BB}}{T_{\text{AU}}} \frac{dT_{\text{AU}}}{T_{\text{AU}}} - \frac{dc_2}{c_2} \right).
\]

Equation (3) considers the fact that the solar radiation data are directly proportional to the intensity \( I_{BB} \) of the black body ultimately used for the calibration of the solar radiation \( T_{BB} = \text{temperature of black body} \). Equations (4) and (5) are direct consequences of Planck's law of radiation \( \chi(\lambda, T) = 1/(1 - \exp(-c_2/\lambda T)) \); \( \lambda_0 = \text{wavelength used for the optical determination of the temperature ratio } T_{BB}/T_{AU} \).

In (1) and (2) the \( \chi \)-terms have been neglected. Their relative contribution is smaller than \( 10^{-8} \).

2. The line blanketing data \( \eta_i \) of Table 4 need, of course, no corrections for the change of \( c_2 \), but they have to be increased for wavelengths shorter than 5500 Å because of the veiled line effect discussed by Holweger. This effect may be taken into account auto-

* The complete corrected Tables 4 and 5 (computer-typed) may be ordered from one of the authors.