Nomogram for the Evaluation of Blackbody Radiancy and of Peak and Total Intensities for Spectral Lines with Lorentz Contour*

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A nomogram has been constructed for the determination of blackbody radiancy and of peak and total intensities for spectral lines with Lorentz contour. The basic equations used for the construction of the nomogram and the use of the nomogram are described briefly.

I. INTRODUCTION

FOR the analysis of infrared spectra from combustion flames, particularly at elevated pressures, it may be of interest to determine peak and total intensities for spectral lines with Lorentz contour. A nomogram has been constructed (see Fig. 1) to facilitate the determination of the desired quantities. The nomogram is useful for temperatures (T) from 1000°K to 20 000°K, semi-half-widths† (b) from 0.01 to 1 cm^{-1}, wavelengths (λ) from 0.5 to 50 microns, and values of SX/c from 10^{-5} to 10^{2} cm^{-1}. Here S/c represents the integrated intensity of the line under study in cm^{-2} atmos^{-1}. The optical density X is expressed in cm-atmos. The blackbody radiancy R_0 is determined by the Planck distribution law.

The peak intensity of radiation $I \equiv I_{\max}$ emitted by

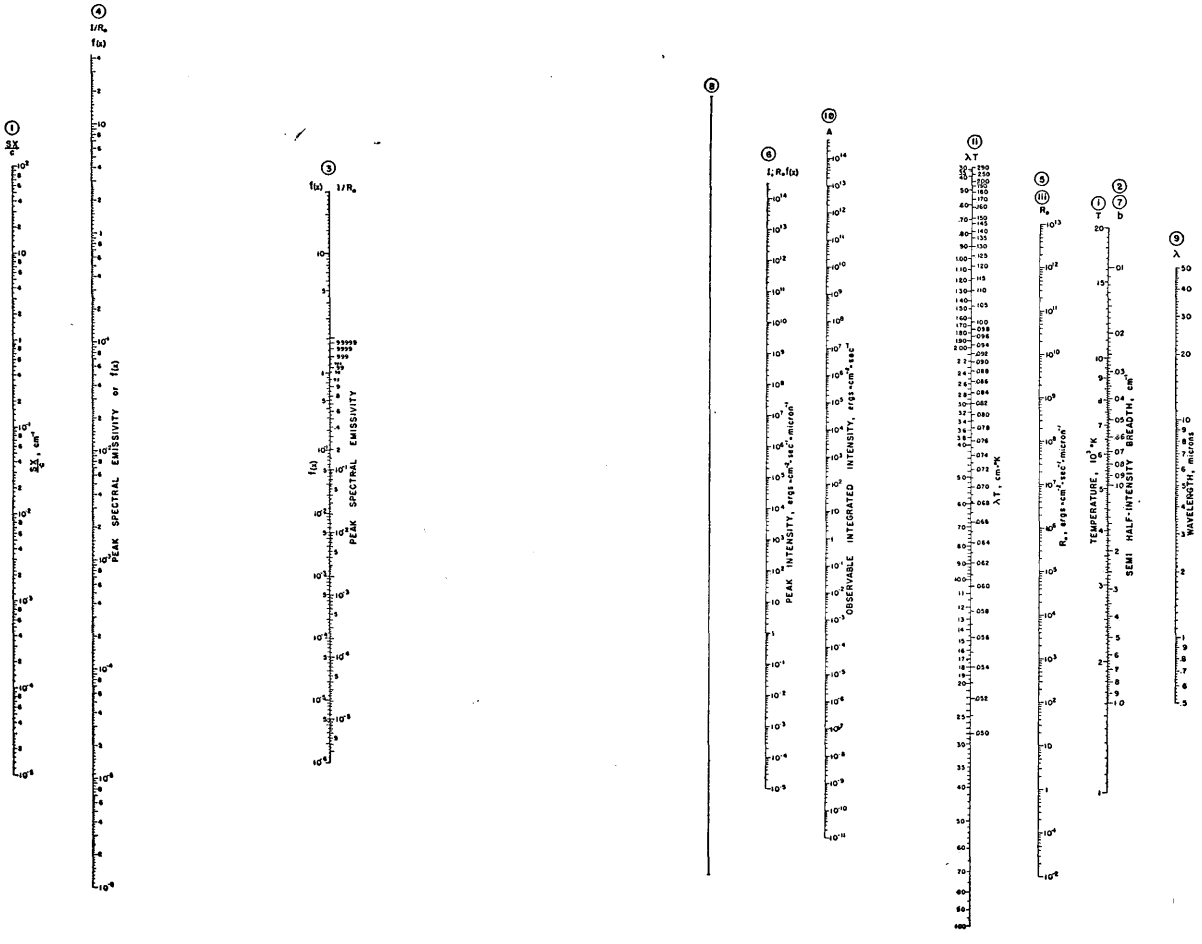

FIG. 1. Nomogram for the determination of blackbody radiancy, and peak and total emitted intensities of spectral lines with resonance contour.

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† The semi-half-width is defined as one-half of the wave-number range for which the spectral absorption coefficient exceeds one-half of its maximum value.

a spectral line with resonance (Lorentz) contour is given by the relation

$$I \equiv I_{\max} = R_0\{1-\exp[-(SX/\pi bc)]\}, \quad (1)$$

where c is the velocity of light. The total intensity of radiation A emitted from a spectral line with resonance contour is obtained conveniently from the expression

$$A = 2\pi x 10^{-4} b\lambda^2 R_0 f(x), \quad (2)$$

where[1]

$$f(x) = x[\exp(-x)][J_0(ix) - iJ_1(ix)], \quad (3)$$

$$x = SX/2\pi bc, \quad i = (-1)^{\frac{1}{2}}, \quad (4)$$

and J_0 and J_1 are Bessel functions of order zero and one, respectively. Here the units have been chosen to agree with the units given in the nomogram.

II. USE OF NOMOGRAM

The nomogram is useful for the determination of R_0, $I = I_{\max}$, and A. The scales are numbered in order of their use either with Roman or with Arabic numerals. Scale 8 represents an intermediate step and is not graduated. On a small nomogram it should be possible to obtain estimates which are accurate to ten percent or better. Copies of large nomograms can be obtained on request.

[1] See, for example, W. M. Elsasser, "Heat Transfer by Infrared Radiation in the Atmosphere," Harvard Meteorological Studies No. 6 (1942).

A. Determination of Blackbody Radiancy

The blackbody radiancy R_0 may be obtained as a function of T and λ by drawing a straight line between scale ii(λT in cm$\times$°K) and scale i(T in °K) to obtain R_0 (in ergs$\times$cm$^{-2}\times$sec$^{-1}\times$ micron^{-1}) on scale iii.

B. Determination of Peak Intensities ($I = I_{\max}$) Emitted by Spectral Lines with Lorentz Contour

Successive use of scales 1 to 6 permits the determination of $I = I_{\max}$ in ergs$\times$cm$^{-2}\times$sec$^{-1}\times$micron^{-1}. The quantity I/R_0 obtained on scale 3 must be transferred to the logarithmic scale 4.

C. Determination of Total Intensities Emitted by Spectral Lines with Lorentz Contour (A)

Successive use of scales 1 to 10 leads to the determination of A in ergs$\times$cm$^{-2}\times$sec^{-1}. The quantity $f(x)$ obtained on scale 3 must be transferred to scale 4.

III. OTHER USES

The nomogram can be used to obtain, for example, the quantity SX/c if I or A has been determined experimentally and T, λ, and b are known. Similarly, if intensity *ratios* are known empirically, ratios of SX/c can be obtained without difficulty. These, in turn, may be used to calculate concentration ratios by utilizing appropriate theoretical expressions for relative numerical values of S/c.