

### A Two-Path Method for Eliminating the Effects of Self-Absorption on Temperature for Isothermal Flames\*

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IT is the purpose of the present note to outline a two-path method for the determination of flame temperatures. The method is valid for *isothermal* systems and *spectral lines with Doppler contour*. All errors arising from self-absorption are eliminated. Practical applications are made by determining the ratio of the total intensity observed when the flame is viewed with a cool blackbody as background to the total intensity obtained with a cool mirror as background. For the sake of simplicity it will be assumed that the reflectivity of the mirror is unity. Spectroscopic studies are made in the usual way, i.e., with a low resolution spectrograph since only the *ratios* of total intensities need to be determined. The method is related to a procedure described in a previous publication for spectral lines with resonance contour<sup>1</sup> but differs in so far as it utilizes the fact that observations on visible and ultraviolet spectra are usually made for individual spectral lines. Using the notation of a previous paper,<sup>2</sup> it is found that for spectral lines with Doppler contour the total observable

intensity of the line identified by the index  $K$  and with center at the frequency  $\nu_{lu}$  is<sup>3</sup>

$$\{A[\nu_{lu}(K)]\}_1 \simeq R^0(\nu_{lu})(mc^2/2\pi kT\nu_{lu}^2)^{-1}[P_{\max}(K)X] \times \sum_{n=0}^{\infty} [(n+1)!(n+1)!]^{-1}[-P_{\max}(K)X]^n, \quad (1)$$

if the light reaching the receiver traverses the flame only once. If intensities obtained by allowing the light to traverse the flame twice are identified by the subscript 2, then it is evident from Eq. (1) that

$$\{A[\nu_{lu}(K)]\}_1/\{A[\nu_{lu}(K)]\}_2 = f(P_{\max}X). \quad (2)$$

The quantity  $f$  is plotted as a function of  $P_{\max}X$  in Fig. 1. But, for spectral lines with Doppler contour and  $h\nu_{lu} \gg kT$ ,<sup>2</sup>

$$P_{\max}(K)X = \text{constant} \times X \times [g_u(q_{lu})^2]_K \times \exp[-(E_u - h\nu_{lu})/kT].$$

The recommended procedure, subject to the limitations stated earlier, is seen to involve only the measurement of intensity ratios, the determination of  $P_{\max}(K)X$  from Fig. 1, and the calculation of  $T$  from the relation

$$\frac{\partial \ln\{P_{\max}(K)X/[g_u(q_{lu})^2]_K\}}{\partial (E_u - h\nu_{lu})} = -1/kT. \quad (3)$$

For isothermal emitters with self-absorption the suggested procedure has the advantage of extreme simplicity. For spectral lines with combined Doppler- and collision-broadening, the quantity  $f$  is no longer a universal function of  $P_{\max}X$  but depends also on the natural damping ratio.

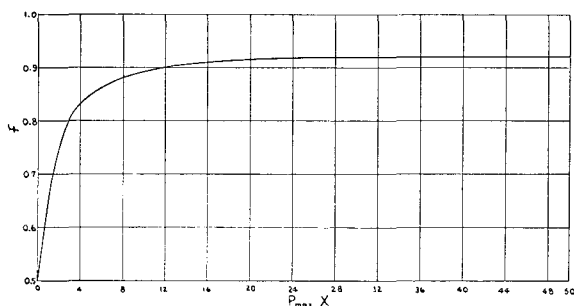


FIG. 1. The quantity  $f(P_{\max}X)$  as a function of  $P_{\max}X$  for spectral lines with Doppler contour.

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<sup>1</sup> S. S. Penner, J. Chem. Phys. 19, 272, 1434 (1951).

<sup>2</sup> S. S. Penner, J. Chem. Phys. 20, 507 (1952).

<sup>3</sup> R. Ladenburg, Z. Physik 65, 200 (1930).

