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NOTE

DIRECT COMPUTATION OF THE INTENSITY OF AMPLIFIED LINES

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Abstract—The intensity of an amplified emission line has been developed as a rational polynomial function. For the general case of the Voigt profile and within a defined bidimensional domain, only 18 independent coefficients are required to reproduce the numerical results satisfactorily.

ANALYSIS

In general the equivalent width W is calculated from the linestrength S and the ratio of half the linewidth at half height b_c of the Lorentz profile to the Doppler semi-half width b_d. The formula used for the calculation is

$$W = 2\int_0^{+\infty} \epsilon\{1 - \exp[-\epsilon P(\omega - \omega_0)X]\}\,d(\omega - \omega_0), \tag{1}$$

Table 1. Non-zero values of the coefficients g_{jk} and h_{jk} of the rational polynomial given in Eq. (4).

j	k	g_{jk}
1	0	0.4611212423
2	0	$-0.1064454513 \times 10^{-1}$
3	0	$-0.2287144015 \times 10^{-3}$
1	1	0.8706741182
2	1	$-0.2882041901 \times 10^{-1}$
3	1	$-0.9999462551 \times 10^{-4}$
1	2	0.6116429677
2	2	$-0.2272764896 \times 10^{-1}$
3	2	$0.7754286259 \times 10^{-5}$
j	**k**	**h_{jk}**
0	0	0.1000000000×10
1	0	0.1239973099
2	0	$-0.5848123069 \times 10^{-2}$
0	1	0.1839462089×10
1	1	$0.2117687786 \times 10^{-1}$
2	1	$-0.3225888236 \times 10^{-2}$
0	2	0.1303610841×10
1	2	$-0.4801975910 \times 10^{-1}$
0	3	$-0.4465392445 \times 10^{-3}$
2	3	$0.6567998653 \times 10^{-6}$

where $\epsilon = +1$ for an absorbing medium or -1 for an amplifying medium, $P(\omega - \omega_0)$ is the absorption (or amplification) coefficient at frequency $\omega - \omega_0$, and X is the optical density of the gas. The Voigt line shape is

$$P(\omega - \omega_0) = \frac{aK}{\pi} \int_{-\infty}^{+\infty} \frac{\exp(-t^2)}{a^2 + (\xi - t)^2}\, dt, \tag{2}$$

where $K = (S/b_d)\,(\ln 2/\pi)^{1/2}$, $a = b_c(\ln 2)^{1/2}/b_d$, and $\xi = (\omega - \omega_0)\,(\ln 2)^{1/2}/b_d$. Our notation follows that of Jansson and Korb,[1] except that our K corresponds to their P'. The known quantities are W and a and the quantity to be determined is KX or S.

The authors of Ref. 1 have calculated and listed W/b_d as a function of a and KX for absorption. We give data for amplification, for which no numerical results seem to have been published. We also express S and

$$\sigma = \frac{S}{b_d}\,(\ln 2/\pi)^{1/2} X \tag{3}$$

as functions of a and $r = W/b_d$. We have found the following empirical relation:

$$\sigma = \left(\sum_{j=1}^{3} \sum_{k=0}^{2} g_{jk} r^j a^k \right) \bigg/ \left(\sum_{j=0}^{2} \sum_{k=0}^{3} h_{jk} r^j a^k \right). \tag{4}$$

Equation (4) contains 18 independent parameters and is valid for $0.2 \leqslant r \leqslant 25.0$ and $0.1 \leqslant a \leqslant 10.0$. The parameters g_{jk} and h_{jk} are listed in Table 1.

REFERENCE

1. P. A. Jansson and C. L. Korb, *JQSRT* **8**, 1399 (1958).