

VIBRATION ROTATION BANDS OF SiO IN SUNSPOTS

(Research Note)

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Abstract. The equivalent widths of P(51) and R(43) lines of the 1–0 and P(45) and R(56) lines of the 2–1 vibration rotation bands of SiO near $8\ \mu\text{m}$ region, have been computed for Zwaan's (1974) sunspot model at the centre of the disc. The predicted equivalent widths suggest a possible presence of these SiO bands in the sunspot spectrum.

1. Introduction

The vibration rotation bands, particularly the first overtone band, of SiO have been detected in the spectra of some cool stars (Cudaback *et al.*, 1971; Wollman *et al.*, 1973; Beer *et al.*, 1974). Besides, the molecule SiO has a larger abundance (Gaur *et al.*, 1973) in sunspots than the molecules HF and HCl, whose vibration rotation bands have already been detected in the sunspot spectrum (Hall and Noyes, 1969, 1972). Consequently, the SiO vibration rotation bands of SiO may show up in the infrared sunspot spectrum.

The present investigation reports the prediction, at the centre of the disc, of the equivalent widths for four selected lines of the 1–0 and 2–1 vibration rotation bands of SiO for Zwaan's (1974) sunspot model, hereinafter abbreviated as ZSM-74. The effect of the choice of dissociation energy of SiO on these predictions has also been discussed.

2. Equivalent Width Calculations

The method for calculating equivalent widths is the same as that used by Lambert (1968) for a weak line. Under sunspot conditions the population of the rotational levels of SiO molecules is expected to peak around $J = 43$. The P(51) and R(43) lines of the 1–0 band and P(45) and R(56) lines of the 2–1 band of SiO were selected for equivalent width calculations at the centre of the disc, for ZSM-74. The respective wavenumbers of these lines are $1143.53\ \text{cm}^{-1}$, $1283.05\ \text{cm}^{-1}$, $1143.36\ \text{cm}^{-1}$ and $1282.24\ \text{cm}^{-1}$ (Singh, 1975). The dissociation constants and partition functions (Glushko *et al.*, 1962) for a dissociation energy $D_0 = 8.327\ \text{eV}$ have been used. The continuous opacities at various depths were computed for ZSM-74 according to the formulations given by Tsuji (1966). For the 1–0 and 2–1 bands of SiO, the oscillator strengths corresponding to $A_{v'v''}(\text{s}^{-1}) = 5.11$ and 9.96

TABLE I
Computed equivalent widths of selected lines of the vibration rotation bands of
SiO for ZSM-74

Band	Line	Equivalent width in mÅ		
		$D_0 = 8.327$ eV	8.1 eV	7.93 eV
1-0	P(51)	65.1	29.4	16.4
1-0	R(43)	86.4	39.0	21.7
2-1	P(45)	95.5	43.2	24.0
2-1	R(56)	63.6	28.7	16.0

respectively were adopted from the estimates made by Hedelund and Lambert (1972) and the necessary molecular constants are from Singh (1975). The Herman-Wallis factor is taken as unity (Beer *et al.*, 1974).

The resulting equivalent widths for the four selected lines are tabulated in Table I. The depth of formation for all the four selected lines turns out to be the same i.e. $\tau_{(5000 \text{ \AA})} = 0.063$ where the model temperature is $\bar{T} = 3360$ K. This depth represents the depth at which half of the calculated equivalent width values are attained (Laborde, 1961).

3. Effect of Choice of D_0

Following Schadee (1964), the influence of the change in the dissociation energy D_0 on the predicted equivalent width W of a line, can be approximately written as:

$$\Delta \log W = \Delta D_0 (5040 / \bar{T}), \quad (1)$$

where \bar{T} is the temperature at the depth of formation of the molecular line. The approximate equivalent widths of the four selected lines of SiO for two more estimates of dissociation energies, viz. $D_0 = 8.1$ eV (Tsuji, 1964) and $D_0 = 7.93$ eV (Hildenbrand and Murad, 1969) based on Equation (1) are tabulated for comparison in Table I. The concentration-optical depth curve for the SiO molecule for ZSM-74 was computed for $D_0 = 8.1$ eV adopting Tsuji's (1964) dissociation constants. A comparison of this curve with the concentration-optical depth curve used by us for ZSM-74 ($D_0 = 8.327$ eV) showed that the use of Equation (1) is approximately justified in the case of the SiO molecule.

3. Conclusions

An inspection of Table I shows that even for the lowest dissociation energy ($D_0 = 7.93$ eV) the equivalent widths of the selected lines of the 1-0 and 2-1 vibration rotation bands, though they are almost 0.25 of those for the case $D_0 = 8.327$ eV turn out to be appreciable for ZSM-74. This suggests a possible presence

of these bands in the infrared region of the sunspot spectrum near $8 \mu\text{m}$. Other bands, such as the 3–2 band may also possibly show up in the sunspot spectrum. However, the small oscillator strengths for the first and higher overtone bands of SiO (cf. Hedelund and Lambert, 1972) seem to exclude their presence in the infrared spectrum of sunspots.

It is desirable that a search for the fundamental bands of SiO near $8 \mu\text{m}$ should be made. If these bands are detected in the sunspot spectrum it may become possible to refine such parameters as the oscillator strengths for these bands, the dissociation energy and the isotopic abundances of the elements Si and O.

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