CH AND CH^+ LINES IN FACULA MODELS

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Abstract

Equivalent width calculations for CH and CH^+ are carried out in three facula models. For CH, the λ4313.662 A line of the (0-0) band of the transition $^2\Delta - {}^2\Pi$ of the Q_{1c} branch, and for CH^+, the λ 4288.407 A line of the (0-0) band of the transition A $^1\Pi$ - $X^1\Sigma^+$ of the Q branch are selected. For CH, the KF and LF facula models seem to behave similarly, whereas the 7B2J model behaves differently, and gives higher equivalent width at the centre of the disc. The resuts for the 7B2J and KF models suggest that the selected line of CH^+ may be seen at the centre of the disc, whereas the LF model leads to an equivalent width which is close to the limit of detectability.

I. INTRODUCTION

The importance of molecular lines in sensing the physical conditions underlying the various facular models has been amply emphasized earlier (Pande *et al.* 1969; Tripathi and Pande 1973). Here we report the results of an investigation for CH and CH^+ lines in three facula models, viz., Livshits (1964), Kuzmynikh (1965) and Chapman (1970), hereinafter respectively abbreviated as LF, KF and 7B2J.

The first reason for picking up CH^+ for investigation of the facular models is the fact that its identification in the photospheric spectrum does not seem to be too secure. The very fact that Grevesse and Sauval (1971), who tentatively identified this species in the photospheric spectrum, are of the opinion: "The presence of CH^+ in the solar photospheric spectrum is not at all as evident as that of SiH^+. The main reason for this is that the final number of lines concerned is rather small and that many of them have extrapolated wavelengths of unknown accuracy", justifies the above assertion. Consequently, inspite of an interference from the photospheric radiation, the identification of CH^+ in faculae may prove helpful, especially if there is a gain in the equivalent width of its lines in the facular spectrum.

The second reason for taking up this problem is that CH^+ is an ionised molecular species. While for neutral molecular species one may expect a diminution in equivalent widths in the facular spectrum as compared to the photospheric spectrum, due to faculae being hotter than the photosphere in the region of molecular formation, the same cannot be said *a priori* for ionised species. It seems to us that in the case of ionised molecular species, a gain in equivalent width of molecular lines in the facular spectrum is also possible. To check this, we compared the concentration-optical depth curve for CH^+ for the HSRA photospheric model as given by Riter *et al.* (1976) with the concentration-optical depth curve obtained by us for the facular model KF. Such a comparison showed that the concentration N (CH^+) in the KF model is larger than the N(CH^+) in the HSRA model at various optical depths, inspite of the fact that the facula is brighter than the photosphere. Though there is an enhancement in the continuous opacity in the KF model as compared to the HSRA model, it is not sufficient to offset the increase in N(CH^+) in the KF model. The molecule CH^+ was therefore picked up to see whether this ionized species can be detected in the facular spectrum. The neutral species CH was picked up for comparison.

II. SELECTION OF LINES

For CH, the line selected is λ 4313.662 A belonging to the Q_{1c} branch of the (0-0) band of the transition $^2\Delta - {}^2\Pi$. For CH^+, the (0-0) band is expected to be the most intense and the Q-branch twice as intense as the R-and P-branches. Therefore, for CH^+, the λ4288.407 A line of the (0-0) band of $A^1\Pi - X^1\Sigma^+$, belonging to the Q-branch, was selected by us. The oscillator strengths ($f_{el}.f_{vib}$) used are 4.5 $\times 10^{-4}$ for CH and 1.2 $\times$ 10^{-3} for CH^+ (Grevesse and Sauval 1971). The procedure adopted for calculating the equivalent widths of the selected lines is as given by Lambert (1968).

III. RESULTS AND CONCLUSIONS

For both the lines, the results of the centre-to-limb calculations of the equivalent widths for three facular models are given in Table 1, where θ denotes the heliocentric distance of the considered point on the disc.

TABLE 1

Equivalent widths of CH and CH^+ lines at various sec θ values.

Molecule	sec θ / Model	1	1.5	2	4
		mA	mA	mA	mA
CH	7B2J	19.9	14.2	12.6	9.8
	KF	17.4	21.1	28.3	37.8
	LF	16.1	25.0	31.3	35.6
CH^+	7B2J	4.4	—	3.2	2.9
	KF	2.8	—	1.5	1.5
	LF	1.8	—	1.3	1.3

Comparative inspection of the T-τ curves for the 7B2J and KF models shows that the 7B2J model is hotter than the KF model upto $\tau = 0.14$ with a monotonic decrease in temperature upto $\tau = 0.24$ followed by a monotonic increase in the deeper layers where the 7B2J model is always cooler than the KF model. Consequently, the concentration-optical depth curves trun out to be different in the two models and lead to different centre to limb variations of equivalent width of the CH line for the two models.

The depth of formation for the λ 4313.662 A line of CH was calculated at different sec θ values in the 7B2J and KF facula models and the concentration of CH, N(CH), at these depths were obtained from the corresponding N(CH) optical depth curves. The variation of N(CH) with sec θ follows the same trend as shown by the equivalent widths. Consequently, the differences between the runs of gas pressure and temperature with optical depth in the 7B2J and KF models are getting reflected in the equivalent widths.

The results for the 7B2J and KF models suggest that the CH^+ lines may be seen at the centre of the disc, whereas the LF model leads to an equivalent width which is close to the limit of detectability. In all the facular models, the equivalent width of the selected CH^+ line is largest at the centre of the disc. Moreover, in observations, the results away from the centre of the disc may get affected by the possibility of greater contamination by the scattered photospheric light. Consequently, observations near to the centre of the disc may prove more fruitful in distinguishing facular contribution to the CH^+ lines.

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