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Brackett-gamma line and facula models

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Abstract. An attempt has been made to show that the profile of the Brackett-gamma line can distinguish between different facula models. It is suggested that low noise high resolution scans of Brackett lines can help improve the existing facula models.

Key words : Brackett line—facula models

1. Introduction

The profiles of strong atomic lines span a large region of the atmosphere in the solar photosphere, sunspots or faculae. Though the Doppler core in such cases originates in chromospheric layers, where the models of these features are less certain, the wings originate in deeper regions, for which models have already been made using centre-to-limb variation of continuum radiation or of line radiation. The Brackett series lines of hydrogen seem to have an advantage over the other strong lines like the strong lines of Balmer or Paschen series of hydrogen *viz.*, they originate from a level with principal quantum number $n = 4$, and thus would be more sensitive to temperature as compared to the lines originating from the levels with principal quantum number $n = 2$ or 3. Using Boltzmann distribution one can show

$$\Delta N_n / N_n = (\chi_n / k)\,(\Delta T / T^2). \qquad \ldots(1)$$

Thus, for the same change in temperature ΔT the percentage change in the number, N_n, of atoms in an excited level with higher excitation potential χ_n is more than the percentage change in the number $N_{n'}$, if $\chi_n > \chi_{n'}$. Further, these lines as also other hydrogen lines will sense the variation of electron pressure with depth, since the hydrogen line wings originate through Stark effect.

2. Computational procedure

The continuum and line intensities for the Brackett line $\lambda 2.1655\ \mu$m have been calculated using the formulations given by Mitropolskaja (1967). Intensities in four facula models *viz.*, Schmahl (1967), Shine & Linsky (1974), Stenflo (1975), 7B14 (Chapman 1978) and two photospheric models *viz.*, Gingerich *et al.* (1971), Vernazza *et al.* (1976) were calculated at the centre of the disk, and the residual intensity, r, for every model was obtained from the relation $r = I_l / I_c$. Here, I_l is the line intensity and I_c the intensity of the continuum in the neighbourhood of the line.

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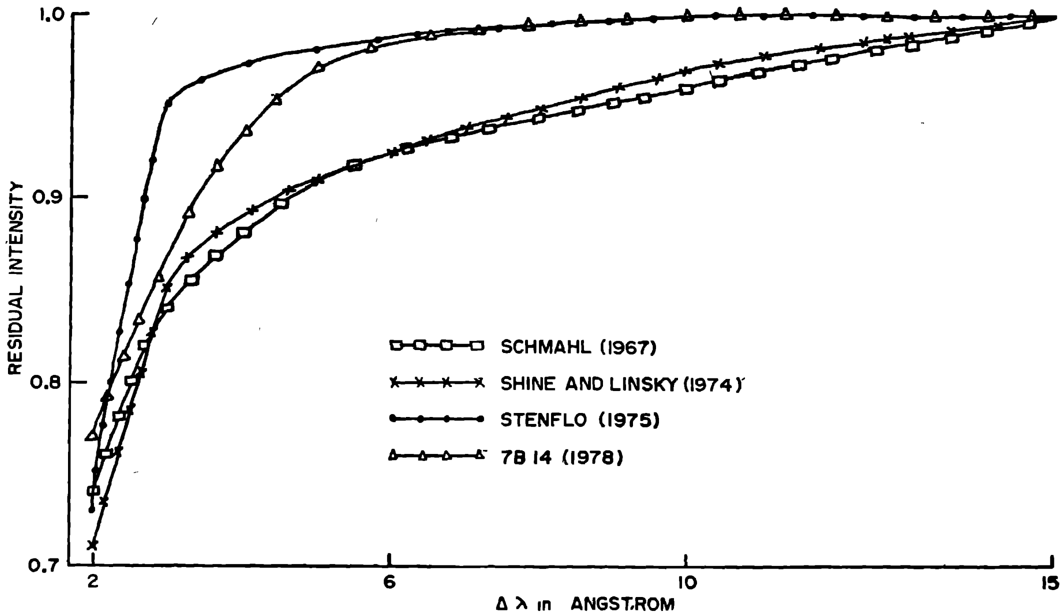

Figure 1. Profiles of the Brackett-gamma line in four facula models.

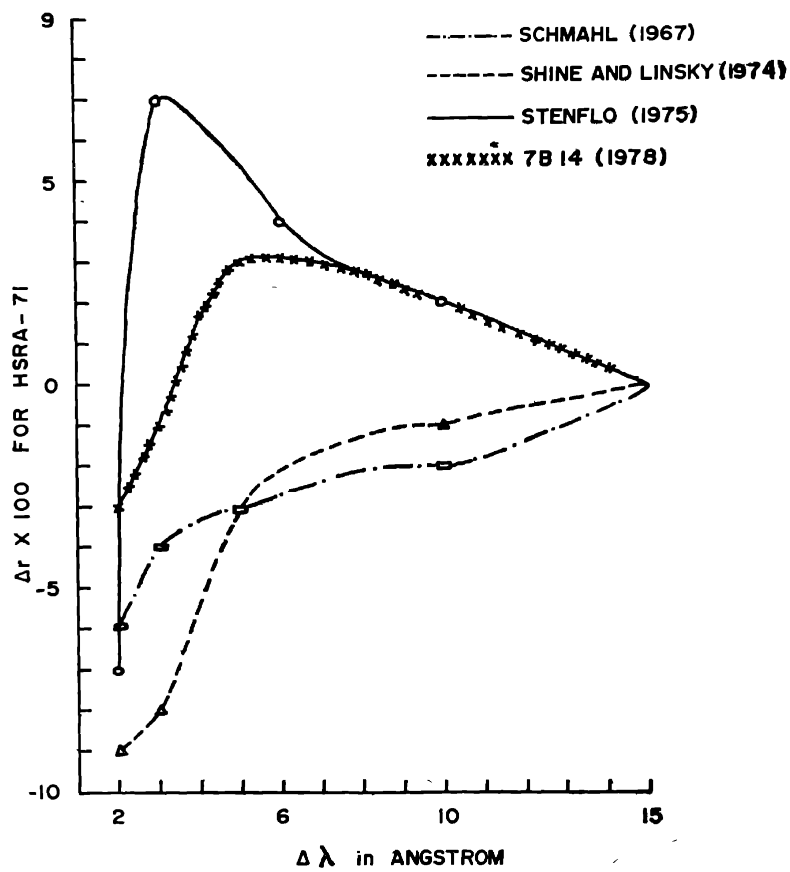

Figure 2. Residual intensity difference, Δr, for the Brackett-gamma line in four facula models, when compared with HSRA-71 model.

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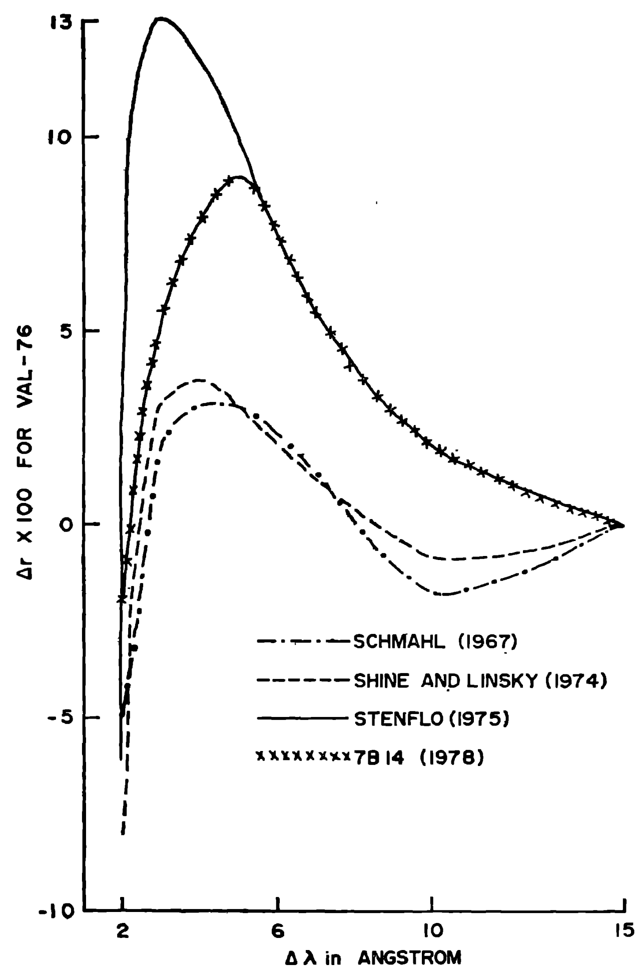

Figure 3. Residual intensity difference, Δr, for the Brackett-gamma line in four facula models when compared with VAL (1976) model.

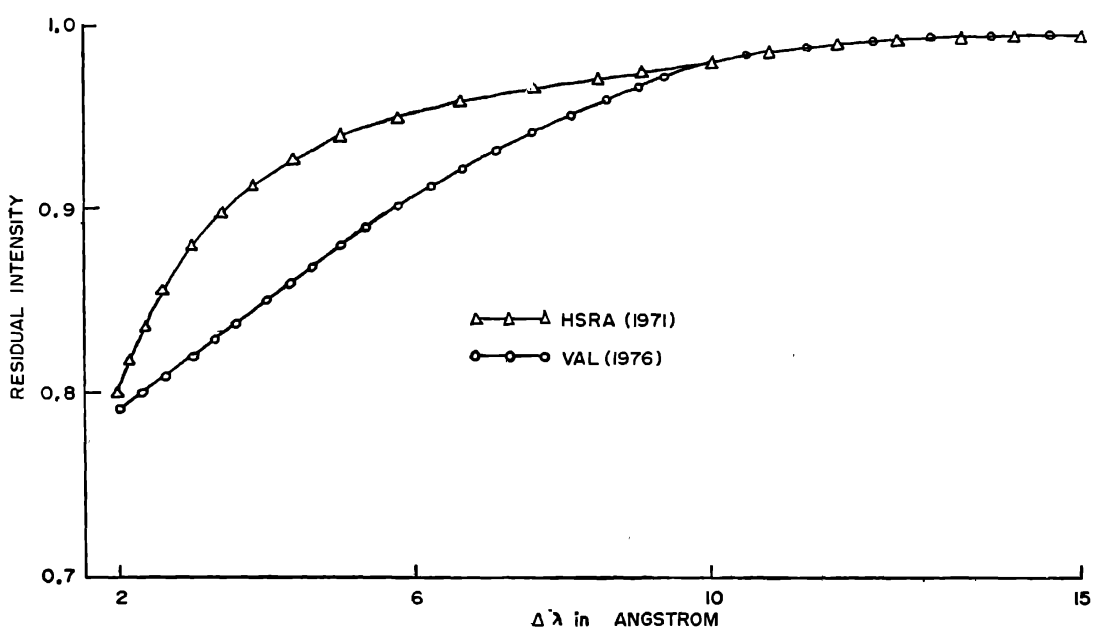

Figure 4. Profiles of the Brackett-gamma line in two photospheric models.

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Having determined the residual intensity, r, for different facula models, the difference between residual intensities of a given facula model against a photospheric model, Δr, was determined as, $r_f - r_p$, where f stands for the facula model and p for the photospheric model. The results of the calculations are presented in Figures 1, 2 and 3.

3. Results and conclusions

The results show that the models of Schmahl (1967) and Shine & Linsky (1974) fall in one category, while models of Stenflo (1975) and 7B14 fall in the other in the sense that they look more or less similar in the plot of Δr against $\Delta\lambda$ (distance in Ångstroms away from thc centre of the line). This is also supported by the contribution by the parts of the profile beyond $\Delta\lambda = 2$ Å to the equivalent width of the selected line. For the former group of models the effective widths for $\Delta\lambda > 2$ Å are 1.0 Å and 0.97 Å respectively, while for the latter these values are 0.26 Å and 0.38 Å respectively. Thus, the contribution is rather low for the models of Stenflo (1975) and 7B14 as compared with the models of Schmahl (1967) and Shine & Linsky (1974). Clearly the profile of Brackett line can distinguish between these models.

The models of Stenflo (1975) and 7B14 are spatially limited models and have explicitly taken into account the magnetic field. The 7B14 model is an extension and refinement of an earlier 7B13 (Chapman 1977) facular model. The 7B13 model was based on line profile measurements. The variation of strong magnetic field with height was considered in 7B13 to achieve appropriate horizontal pressure balance. The 7B14 model uses an extension of the photospheric model of Gingerich *et al.* (1971) in light of the model of Spruit (1974) at the $\tau_{5000} = 2$ level and assumes that the brightness and magnetic field of a facula are cospatial. In the 7B13 model effort has been made to invoke data with a spatial resolution of less than 3 arcsec $\times$ 3 arcsec. In cases where low spatial resolution data have been used Chapman (1977) has adopted the view that contribution by photosphere can be eliminated by determining a free parameter S. However, the Stenflo (1975) model is meant for subarcsec facular features in which magnetic field strength changes slowly with depth and to that extent it is expected to be different than 7B14. This is the case as is clearly seen from Figures 1 and 2. The models of Schmahl (1967) and Shine & Linsky (1974) are homogeneous and therefore can be expected to behave similarly.

Low noise high resolution scans for Brackett lines both for the spatially limited and homogeneous facular models are required for improving the existing models. Figure 4 shows that the profiles of this line differ in two photospheric models and as such it can be used for refining photospheric models also.

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