FACULAR MODELS, THE K-LINE, AND MAGNETIC FIELDS

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Photospheric faculae are now believed to be closely associated with the small-scale solar magnetic field. In order to obtain reliable observations of solar magnetic fields, one needs to have a good description of faculae, which is presently lacking. The problem in obtaining good observational data is severe because faculae are usually not spatially resolved, particularly so in the case of spectroscopic observations. Proper use of spectroscopic observations also requires some knowledge of solar velocity fields and atomic physics in the case of a non LTE analysis. Many of these problems can be avoided by making use of the wings of the Ca II K-line. The wing of this line is unaffected by magnetic and velocity effects. The formation of the line has become increasingly well understood and most of the wing (with the exception of the inner 1 - 2 Å) is formed in LTE. The line is so strong that its formation spans the whole depth of the photosphere.

For some time we have been making calculations of the K-line wing for a variety of facular models. These calculations have assumed LTE for the source function and the ionization state. We have determined the damping constant by matching the profile calculated for the HSRA model (Gingerich et al., 1971) with the observations of White and Suemoto (1968). This procedure is quite similar to that followed by Shine and Linsky (1974) in their study of facular models. Figure 1 shows line profiles obtained by these techniques with the observations of White and Suemoto indicated. The calculated continuum intensity for the HSRA is 2.16×10^{-5} erg s^{-1} cm^{-2} Hz^{-1} $ster^{-1}$. The absorption coefficient is assumed to be quadratic of the form (Aller, 1963)

$$\frac{a(\nu)}{a_o} = \frac{\delta' \, \Delta\nu}{\pi^{1/2} \, (\nu - \nu_o)^2} \tag{1}$$

where ν_o is the line center frequency, $\Delta\nu$ is thermal and turbulent broadening, and $\delta' = (8.6 \times 10^7 + S)/2\pi$. The quantity S is given by

$$S = \pi \left(\frac{3\pi^2}{4}\right)^{2/5} NV^{3/5} \, C_6^{2/5} \tag{2}$$

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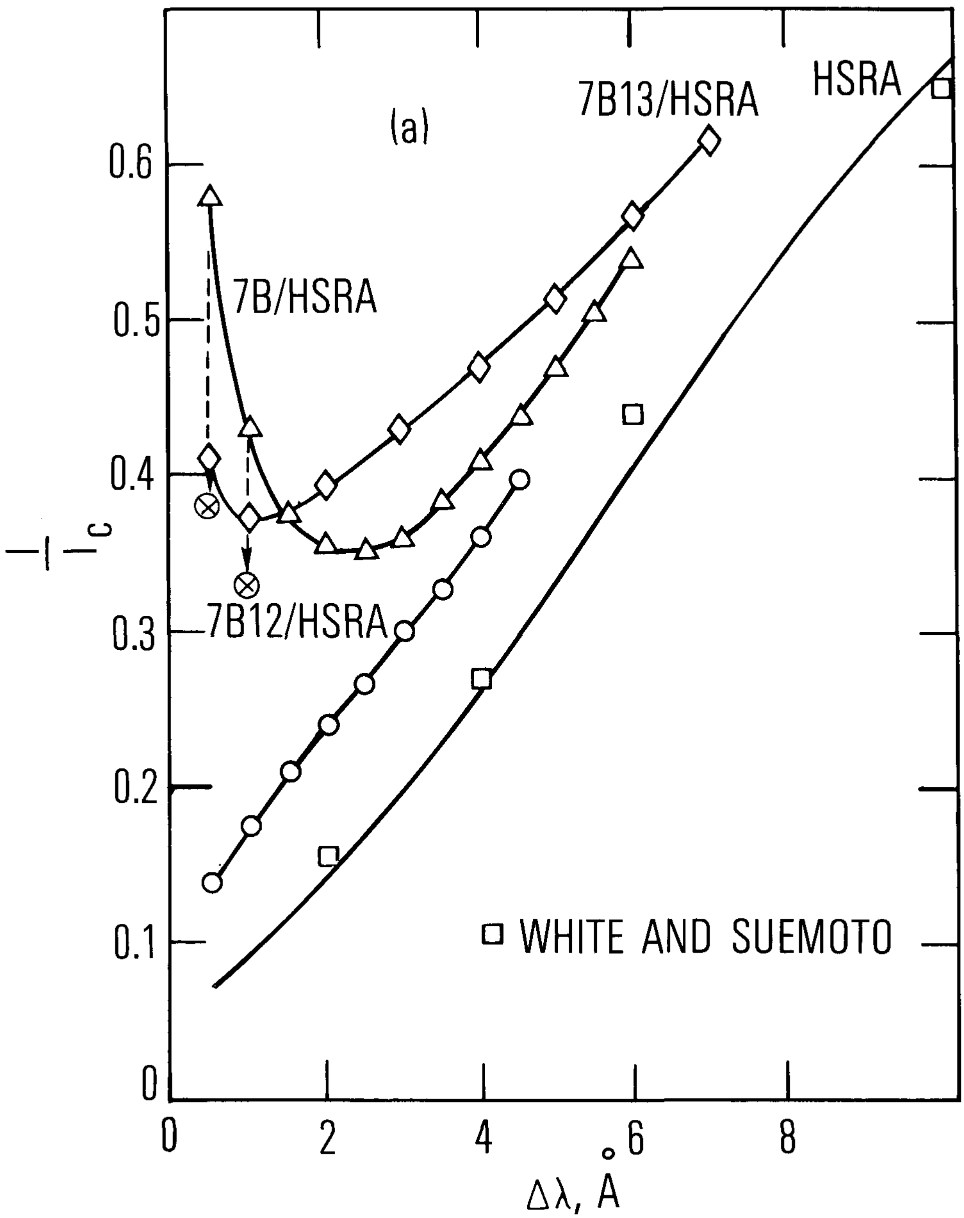

Figure 1. Profiles of the Ca II K-line for various facular models. The circled x's show the effects of partial redistribution for facular model 7B/HSRA.

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where N and V are the Cgs number density and velocity of the perturbing atoms. For an assumed Ca/H abundance ratio of 2.4×10^{-6}, we obtained $C_6 = 2.5 \times 10^{-32}$.

The ideal observational data would be spatially resolved spectra or ultra-narrow band filtergrams at clean windows in the K-line wing. Such observations have not been obtained to the authors knowledge. The best available data are the broad-band filtergram contrast measurements of Mehltretter (1974). These observations were obtained with an interference filter having a FWHM of 16 Å centered on the K-line. In order to compare calculated and observed contrasts we have convolved the profiles of Figure 1 (assumed symmetric about $\Delta\lambda = 0$) with a Lorentzian filter transmission of 16 Å FWHM. Each normalized profile has been rescaled by the appropriate continuum intensity. The resultant filtergram contrast, $\Delta F/F$, is given in Table 1 where

$$F = \int_{-\infty}^{\infty} T(\lambda)\ I\ (\lambda) d\lambda \tag{3}$$

with

$$T(\lambda) = \left[1 + (\Delta\lambda/\Delta\lambda_{HWHM})^2\right]^{-1} . \tag{4}$$

Table 1

K-line filtergram contrasts

facular model	7B13/HSRA	7B12/HSRA	Stenflo(1975)	observed
contrast	0.324	0.261	0.173	0.65±0.31
contrast with $I_{K_{232}} = I_c$	0.382	0.325	0.238	

The effects of partial redistribution on K-line profiles of facular models, discussed by Heasley et al. (1976), do not significantly alter these results.

Faculae are hotter than their surroundings in the upper photosphere because the associated magnetic field is involved with mechanical energy dissipation. The actual run of temperature and density with depth in the facula is related to the behavior of the magnetic field with depth as clearly shown by Dicke (1970). Thus we have a potentially powerful tool for testing facular models by (a) obtaining the depth variation of $\delta\rho$ and δT, assuming hydrostatic equilibrium from observations in the K-line, (b) calculating a self-consistent magnetic field from the run of $\delta\rho$ and δT, and (c) comparing the computed magnetic field with magnetic fields observed simultaneously with the K-line. We are presently analyzing such data obtained at Kitt Peak National Observatory with the help of Gillespie, Livingston and Lynch. A more thorough analysis will appear in the near future (Chapman and Lynch, 1976).

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