OBSERVATIONAL TEST FOR HYDRODYNAMICAL MODELS OF SOLAR FACULAE.

M. Semel and E. Ribes
D.A.S.O.P. Observatoire de Meudon
D. Rees
Department of Applied Mathematics, University of Sydney

In an earlier paper (Unno, Ribes, 1979), the thermodynamics was added to the M.H.D. equations in order to provide a heating mechanism for the solar network. Various thermodynamical situations were considered, leading to 3 models with the following characteristics :

Model n° 1 :

Describes the steady Bernoulli flow for an "*infinitesimally thin*" tube : the flow decelerates with increasing depth, a temperature excess of 1000°K is localized in the upper photosphere and the magnetic field strength at $\tau = 1$ is of the order of 300 gauss.

Model n° 2 :

Differs from model n° 1 only by the dilution factor. The tube is *no longer optically thin*. The dilution factor W was chosen rather arbitrarily since the 3 dimensional transfer was not solved ($W = 1$ at $\tau = 1$, and increases by 50 % at the top of the photosphere) the magnetic field strength is stronger at $\tau = 1$ ($\approx$ 800 gauss).

Model n° 3 :

Describes an ADIABATIC steady flow and is more relevant to the deeper layers. The flow accelerates very rapidly with increasing depth (from 0.5 Km s^{-1} at the top of the photosphere up to 7 Km s^{-1} at $\tau = 1$). The temperature excess is localized at $\tau = 0.5$. The magnetic field has a strength of 1300 gauss at $\tau = 1$ and diverges very rapidly with height (magnetic scale height = 110 Km).

In this paper, we report results of LTE line formation calculations performed for these hydromagnetic models. The calculations were restricted to the axis of the magnetic tube located at the disc center where the magnetic field is longitudinal. All the lines were approximated by Zeeman triplet.

The main results are as follows :

1) Weakening in the lines, as a function of the Agf value (Abundance times Landé factor times oscillator strength) and as a function of the potential excitation.

- We have made a curve of growth for 4 lines of neutral Iron (Fig. 1a, b, c). We found that the weak lines weaken more than the strong lines. Both temperature excess and velocity gradients reduce the saturation in the lines and increases the slope of the curve of growth. This is in good agreement with the magnetic field observations made by Semel (1980) and by Shimizu et al. (1981). An excess of temperature has the tendancy to weaken the lines of neutral iron. But for strong lines, the combined effect of velocity gradients and temperature excess may result in an increase of the equivalent width. We should note that in general, an enhanced brightness in the core of the lines (weakening) is possible even if the equivalent width increases (probably because ΔT, B and $\frac{dV}{dZ}$ contribute all to the weakening in the line center).

- The effect of the potential excitation is clearly seen in Fig. 1a, b, c when comparing 2 lines with the same equivalent width. The weakening is larger for lines with a lower potential excitation.

2) Net circular polarization (N.C.P.)

Our computations indicate a net circular polarization (N.C.P.) in the lines. This phenomenon is the result of the presence of both velocity and magnetic field gradients (ILLING et al. 1975 ; MAKITA, 1980). Fig. 2a, b, c shows that the N.C.P. increases with the Landé factor and varies with the three models. In particular, note that the sign of the N.C.P. for model n° 3 is opposite to that of the models n° 1 and 2 : this is due to the opposite sign of the flow velocity gradient. Future observations of the net circular polarization may be a good test for hydromagnetic models.

3) Continuum enhancement.

When the 3 models were elaborated, a constraint of no temperature excess at $Z = 0$ ($\tau_{HSRA} = 1$) was applied for two reasons. First, observers claimed that the

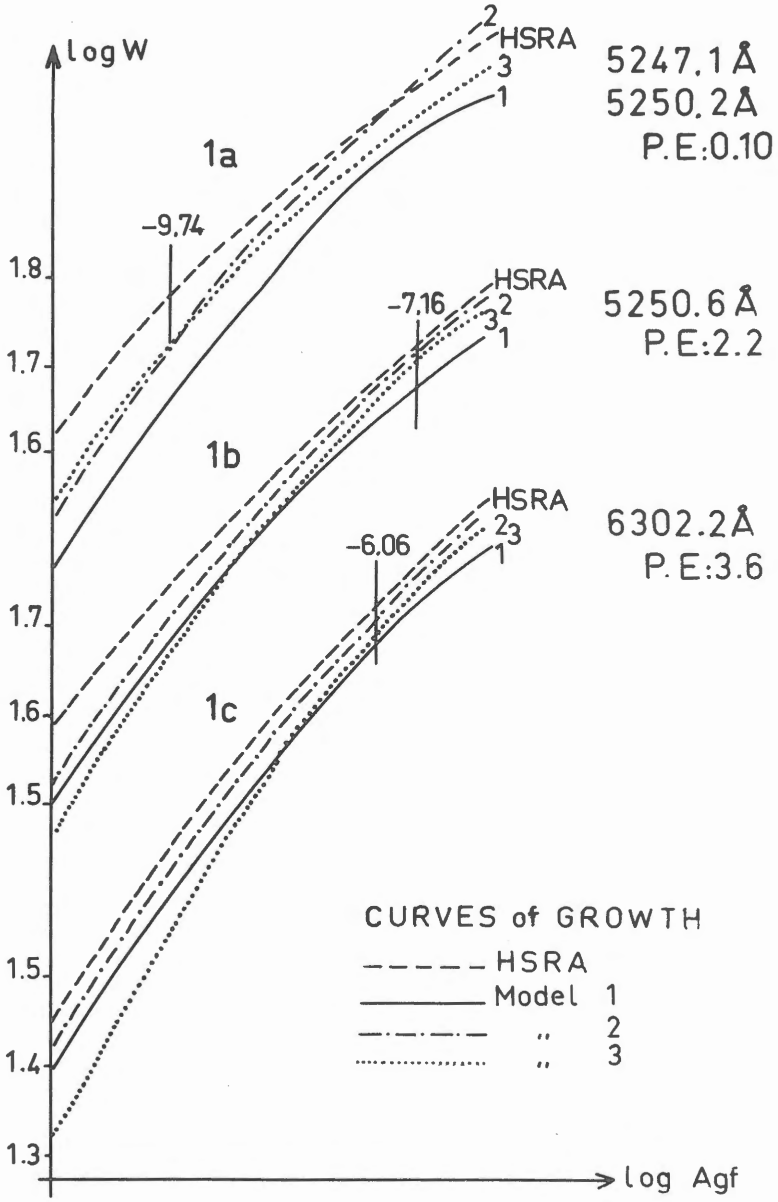

Fig. 1a, b, c represents the curves of growth for iron lines in the 3 models and in the H.S.R.A. reference atmosphere. The adopted log Agf value for the respective lines are :

- 9.74 (5247.1 Å and 5250.2 Å), - 7.16 (5250.6 Å) and - 6.06 (6302 Å).

faculae were not visible in the continuum at the disc center. Second, at this level, the opacity is high and the radiative losses become significant. Therefore, a small temperature excess could be sufficient to balance the excess of entropy transport. However, our computational results indicate an excess of the continuum brightness, as seen in Table 1. This is not in contradiction with the constraints mentioned above : the continuum in the magnetic tube is emitted at lower geometrical depth than $\tau_{HSRA} = 1$, and, therefore, at higher temperature.

As this stage, we should recall that all our calculations were made along the axis of the magnetic tube. We can estimate the apparent continuum enhancement if we know, at least, the cross-section of the magnetic tube. At $\tau = 1$, the cross-section can be extremely small (Koutchmy 1977). Thus, even if a brightness is not observed in the continuum, it may not be negligible and the problem of the enhancement of the facular continuum is still open (Rees, thesis 1973).

CONCLUSION.

The line formation calculations show how the lines are affected by the various physical conditions (temperature excess, velocity distribution, density etc...) in the faculae. They can be used eventually as a test for theoretical models. The predicted weakening for the 4 lines is qualitatively in agreement with observations. Future observations of the net circular polarization will be useful to indicate the presence of velocity gradients. Although the observations don't show any significant brightness excess in the continuum faculae, model 3 cannot be rejected in spite of the results in Table 1. The contradiction may disappear with very high resolution observations.

The three models differ by their thermodynamics. None of the 3 models is completely satisfactory because none of the 3 thermodynamical situations is valid throughout the photosphere and chromosphere. For the low chromosphere we suggest the model n° 1 as representative, for the deep photosphere, the adiabatic flow model (model n° 3) and in between the model n° 2. The next step will be to solve the Bernoulli flow with a combined thermodynamical situation.

TABLE 1

CONTINUUM	ENHANCEMENT		
	Model 1	2	3
5250 Å	4 %	16 %	55 %
6302 Å	1 %	13 %	46 %

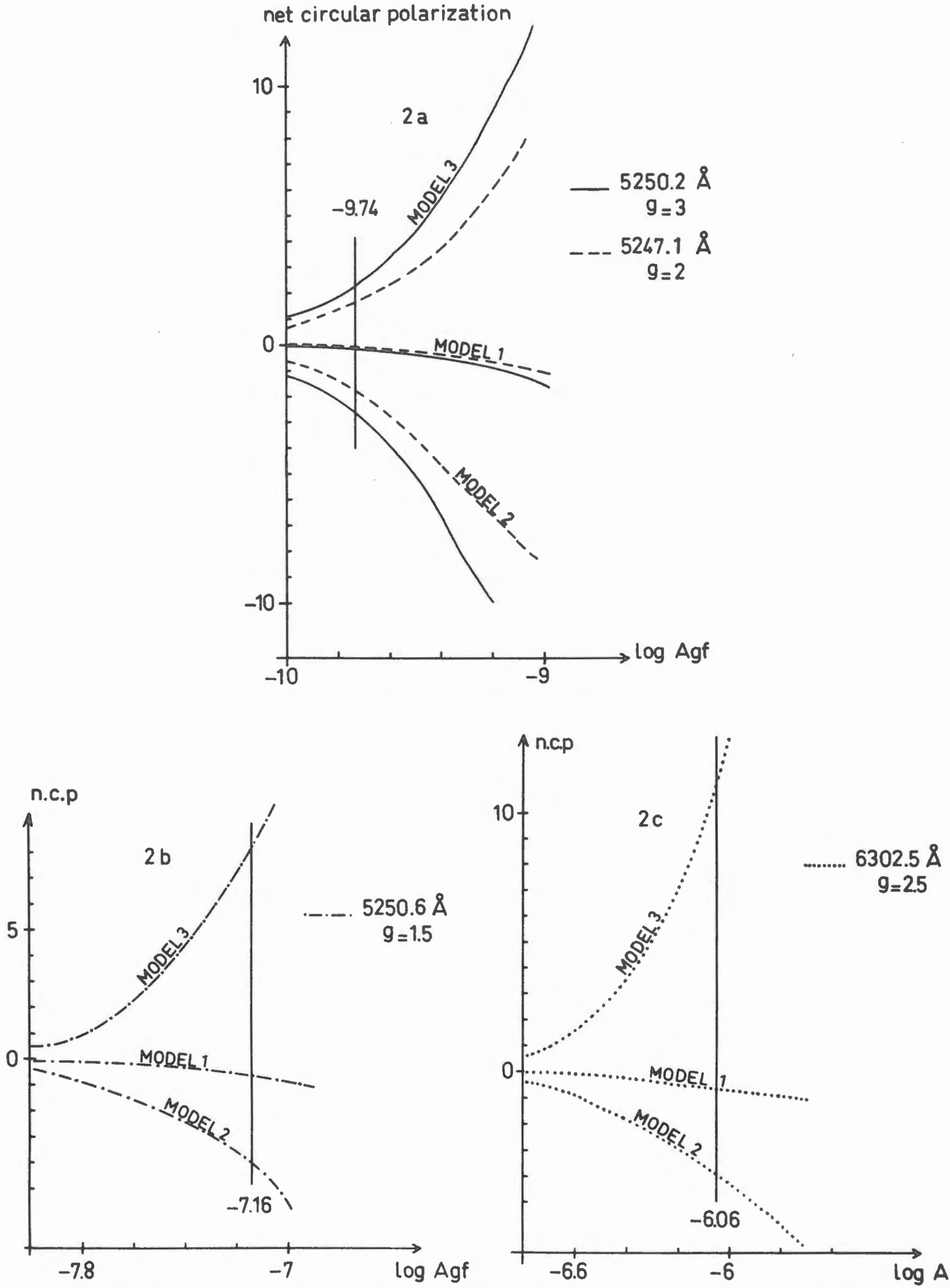

Fig. 2a, b, c shows the net circular polarization for the Iron lines in the 3 hydromagnetic facular models.

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