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A MODEL FOR THE FIBRIL STRUCTURE OF NORMAL-POLARITY SOLAR PROMINENCES

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Abstract. A normal-polarity prominence is modelled as a series of cool fibrils set in the hotter corona. Equations of magnetostatic equilibrium are solved and each fibril corresponds to a dip in the magnetic field. The ratio of fibril width to interfibril spacing is dependent on the prominence-coronal temperature ratio and the ratio of plasma to magnetic pressure. The prominence mass is found to depend on the square of the magnetic field strength. When variations along the prominence are allowed in addition to those across the prominence, an apparently random pattern of fibrils results.

1. Introduction

Most prominence models (for example, Kippenhahn and Schlüter, 1957; Kuperus and Raadu, 1974; Priest, Hood, and Anzer, 1989; Hood and Anzer, 1990) have represented prominences as single sheets or blocks of cool, dense plasma.

Observations reporting internal structure within prominences have been available for several decades (e.g., Menzel and Evans, 1953). Engvold (1976) reports features for limb prominences on a scale of several hundred kilometres which last for times of less than an hour. Velocity patterns on similar scales were subsequently reported (Engvold, 1981). Oscillations have been observed in these fibrils (Zhang Yi and Engvold, 1991). Internal structure is also observed for prominences seen against the bright disk of the Sun (Simon *et al.*, 1986). Prominences appear as series of threads which are sheared relative to the magnetic inversion line (Schmieder and Mein, 1989).

The number of fibrils per prominence is not clear. Zirker and Koutchmy (1989, 1990) suggest numbers less than twenty but other authors (e.g., Zharkova, 1989) consider that the number may be higher. Orrall and Schmahl (1980) and Schmahl and Orrall (1986) estimate 1 to 10 threads or fibrils along a line of sight but stress that this is a lower limit. Work indicating that prominences form by thermal instability gives length scales for fine structure which depend on the ratio of heat conduction along the magnetic field to that across it (Van der Linden and Goossens, 1991a, b). Such work indicates that several thousand fibrils should be encountered along a prominence.

Although observational evidence has long been available to suggest that the structure of prominences is considerably more complicated than had been modelled, the general philosophy has been to understand the support of a large quantity of cool plasma by the magnetic field before dealing with the internal structure of a prominence.

Priest, Hood, and Anzer (1991) went a step further by suggesting that prominences

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consisting of fibrils can be formed as a result of radiative and other instabilities and they set up a simple fibril model. Hood, Priest, and Anzer (1991) extended this model for the magnetostatic equilibrium of a prominence consisting of a number of fibrils. Their fibril temperature was half of the coronal temperature and the fibrils and interfibril spacings were equal. Their approach was firstly to model variations across the prominence and then to consider variations along the prominence.

Ballester and Priest (1989) had previously presented a model where a prominence consists of a series of fibrils parallel to the magnetic field which is inclined to the prominence axis. Variations in this case occur as one moves along the prominence axis.

One recent normal-polarity prominence model (Hood and Anzer; 1990) considered a prominence to be a single cool slab at a uniform temperature surrounded by a corona at another uniform temperature. While the assumptions of uniform temperature in the prominence and corona are not totally realistic, this model produces realistic field lines.

The purpose of the present paper is to adapt the prominence model of Hood and Anzer to consider a prominence consisting of several fibrils rather than a single cool slab. Firstly variations across the prominence will be considered and then variations along the prominence will be included. The number of fibrils considered here will be less than twenty but it will be seen that this number can be increased without significantly changing the results.

2. Structure across the Prominence

The aim of this section is to find a prominence consisting of several fibrils with the temperature varying as one moves across the prominence, i.e., perpendicular to the prominence axis. The prominence, therefore, consists of many cool slabs aligned parallel to the prominence axis.

The coordinate system used is as follows. The x-axis is aligned perpendicular to the long axis of the prominence, i.e., x measures distances across the prominence. The plane $x = 0$ is the centre of the prominence. The y-coordinate measures distances parallel to the prominence axis and the z-axis points vertically upwards.

Hood and Anzer (1990) assume forms for the magnetic field and plasma pressure, namely

$$\mathbf{B} = (X(x), Y(x), Z(x))\, e^{-kz} \tag{1}$$

and

$$p = P(x)\, e^{-2kx}, \tag{2}$$

and assume that the temperature $T(x)$ is a function only of x, the direction across the prominence. From the magnetostatic equation, the equation for non-divergence of the magnetic field, and the perfect gas law, they show that

$$Y(x) = \alpha X(x), \tag{3}$$

$$\frac{dX(x)}{dx} = k\,\frac{dZ(x)}{dx}, \tag{4}$$

$$\frac{\mathrm{d}Z(x)}{\mathrm{d}x} = \frac{k}{X}\left[\left(1 - \frac{1}{2kH}\right)Z^2 + \frac{1}{2kH}\,(2\mu P_T - X^2 - Y^2) - 2\mu P_T\right], \tag{5}$$

where P_T (a constant) is given by

$$2\mu P(x) + X^2 + Y^2 + Z^2 = 2\mu P_T\,, \tag{6}$$

α is a parameter and

$$H = \frac{RT(x)}{\mu g} \tag{7}$$

is the pressure scale-height.

The approach of Hood and Anzer is to assume that, close to the prominence axis, the temperature is equal to a uniform prominence value (T_c) with a corresponding scale height H_{cool} and that further from the axis the temperature is equal to a uniform coronal value (T_h) with its corresponding scale height H_{hot}. In the region away from the prominence $2kH = 2kH_{\text{hot}} = 1$ but in the prominence $2kH$ is lower.

An alternative approach is to assume that as one moves away from the prominence axis, the temperature is alternately at prominence and coronal values, i.e., the prominence can be considered as a series of vertical sheets running parallel to the prominence axis. Such an approach has been described in Hood, Priest, and Anzer (1991).

This paper extends the work of Hood, Priest, and Anzer in several ways. Instead of considering hot regions and cool regions of equal width, the ratio of the widths of the hot regions to the widths of the cool regions is determined by the equations. Hood, Priest, and Anzer included only an odd number of fibrils (i.e., there was always a cool fibril at the prominence centre). In this work, an even number is allowed as well so that the prominence centre can be at coronal temperatures. Hood, Priest, and Anzer considered a temperature ratio of hot to cool plasmas of only two and did not go ahead to solve the equations. Here, a more realistic temperature ratio is used and the resulting equations are solved numerically.

Hood, Priest, and Anzer assume that the widths of the hot and cool sheets are equal, but a more general approach is to assume that the cool sheets are of one width and that the hot sheets between them are of a different width. So

$$T = T_c\,, \qquad -1 < \frac{x}{x_c} - 2if < 1 \tag{8a}$$

when $|i| \le (n_{\text{prom}} - 1)/2$ and n_{prom} is odd,

$$T = T_c\,, \qquad -1 < \frac{x}{x_c} - (2i + 1)f < 1 \tag{8b}$$

when $|2i - 1| \le (n_{\text{prom}} - 1)$ and n_{prom} is even,

$$T = T_h \qquad \text{otherwise}\,, \tag{8c}$$

i.e., x_c is the half-width of the cool sheets and fx_c is the half-width of a structure comprising one cool sheet and one hot sheet. The number of cool sheets is n_{prom}. If n_{prom} is odd a cool sheet lies on the axis. If, however, n_{prom} is even, the axis marks the midpoint between two cool sheets. In each case, however, the field is horizontal on the axis.

Carrying out a non-dimensionalisation with $x = x^*/k$, $X = X_0 X^*$, $Y = X_0 Y^*$, $Z = Z_0 Z^*$, $P_T = X_0^2/\mu P_T^*$, $T = T_0 T^*$ ($T_0 = 10^5$ K) one obtains

$$\frac{\mathrm{d}X^*}{\mathrm{d}x^*} = Z^* , \tag{9}$$

$$\frac{\mathrm{d}Z^*}{\mathrm{d}x^*} = \frac{1}{X^*}\left[\frac{C^*}{T^*}\,(2P_T^* - X^{*2}(1 + \alpha^2) - Z^{*2}) + Z^{*2} - 2P_T^*\right], \tag{10}$$

where C^* is given by

$$C^* = \frac{\mu g}{2RT_0 k} .$$

Instead of applying boundary conditions at the centre of the cool filaments as in Hood and Anzer (1990), the boundary conditions will here be applied at the centres of the warmer regions, i.e., the points equidistant between fibrils. The boundary conditions themselves, however, will be those used by Hood and Anzer, i.e.,

$$X^*(0) = X_0 ,$$

$$Z^*(0) = 0 .$$

The quantity P_T^* satisfies

$$P_T^* = \frac{\mu P(x) + X_0^2/2}{X_0^2} = \tfrac{1}{2}(1 + \beta) , \tag{11}$$

where β is the ratio of plasma to magnetic pressure in the corona or the interfibril region. Assuming a value for β of 0.02, P_T^* will be taken as 0.51. Assuming a scale height for pressure variations in the vertical direction of $1/2k$ (see Equation (1)), C^* can be shown to equal unity in the hot regions and to equal $2T_{\text{hot}}/T_{\text{cool}}$ in the cool regions. The factor of 2 arises from the assumption that the plasma is fully ionised in the hot regions but not in the cool regions.

The question arises as to which quantities can be specified and which must be calculated from the equations. For example, the equations determine the relationship between the total prominence width and the proportion of the prominence which is taken up by the cool plasma. The approach of Hood, Priest, and Anzer was to assume that exactly half the prominence volume was filled by cool plasma; this is rather a restrictive assumption and instead the proportion of the prominence filled by cool plasma will here be determined from the prominence width and certain other parameters.

The following parameters will be set:

$T_{\text{hot}} = 10^6$ K
$T_{\text{cool}} = 10^4$ K

Coronal scale height $H = \dfrac{RT_{\text{hot}}}{\mu g} = 60.7$ Mm
$k = 1/2H = (121.4\ \text{Mm})^{-1} = 8.23 \times 10^{-9}\ \text{m}^{-1}$
Prominence half-width $= 1/40k = H/20 = 3.03$ Mm
$\alpha = B_y/B_x = 2.5$
$P_T^* = 0.51$
$n_{\text{prom}} = 4$

The prominence half-width referred to above is not the distance from the prominence axis to the furthestmost point of cool plasma but instead is the distance to the first zero of the vertical magnetic field beyond this. The reason for this will be explained in Section 3. The value of α chosen gives a magnetic field which is stronger parallel to the prominence axis than perpendicular to it and which makes an angle of about 22° to the axis; compare with observed figures of 15° (Tandberg-Hanssen and Anzer, 1970) and 25° (Leroy, Bommier, and Sahal-Brechot, 1983; Nikolsky *et al.*, 1984).

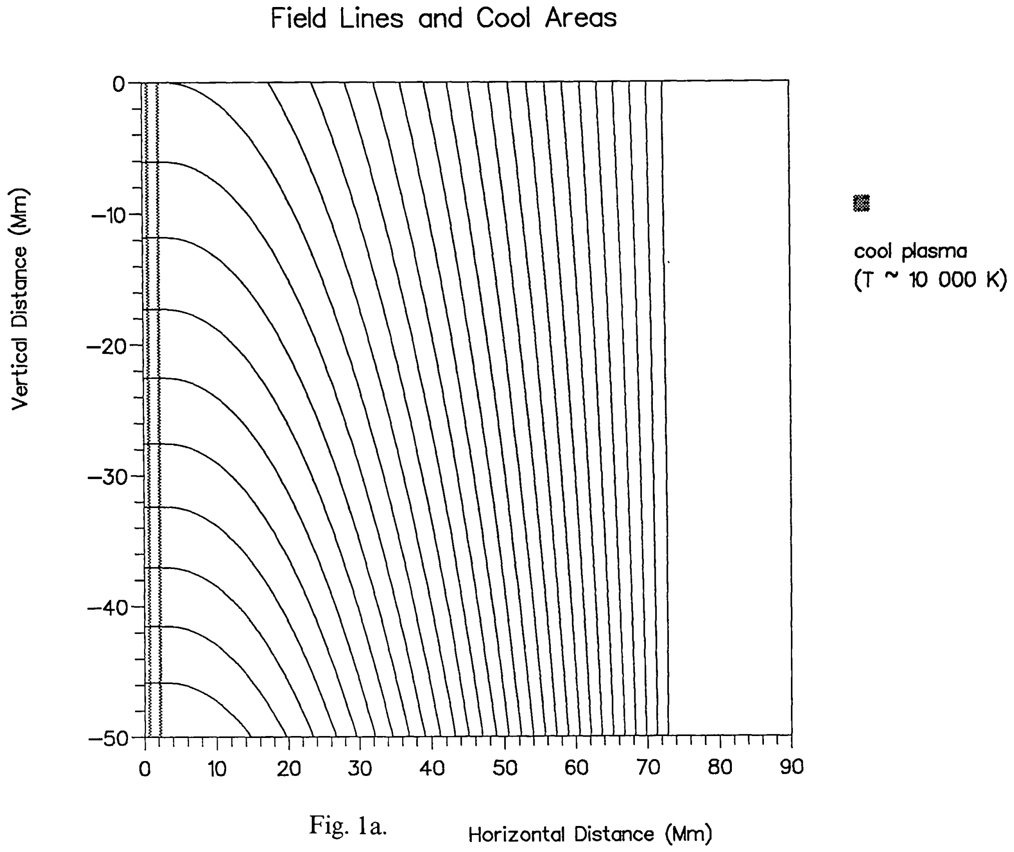

Fig. 1a.

Fig. 1a–c. A cross-section through a fibril prominence consisting of four fibrils: (a) shows half the surrounding arcade and two of the fibrils, (b) concentrates on the vicinity of the fibrils and shows that the cool areas correspond to dips in the magnetic field, (c) as (b) but for five fibrils instead of four.

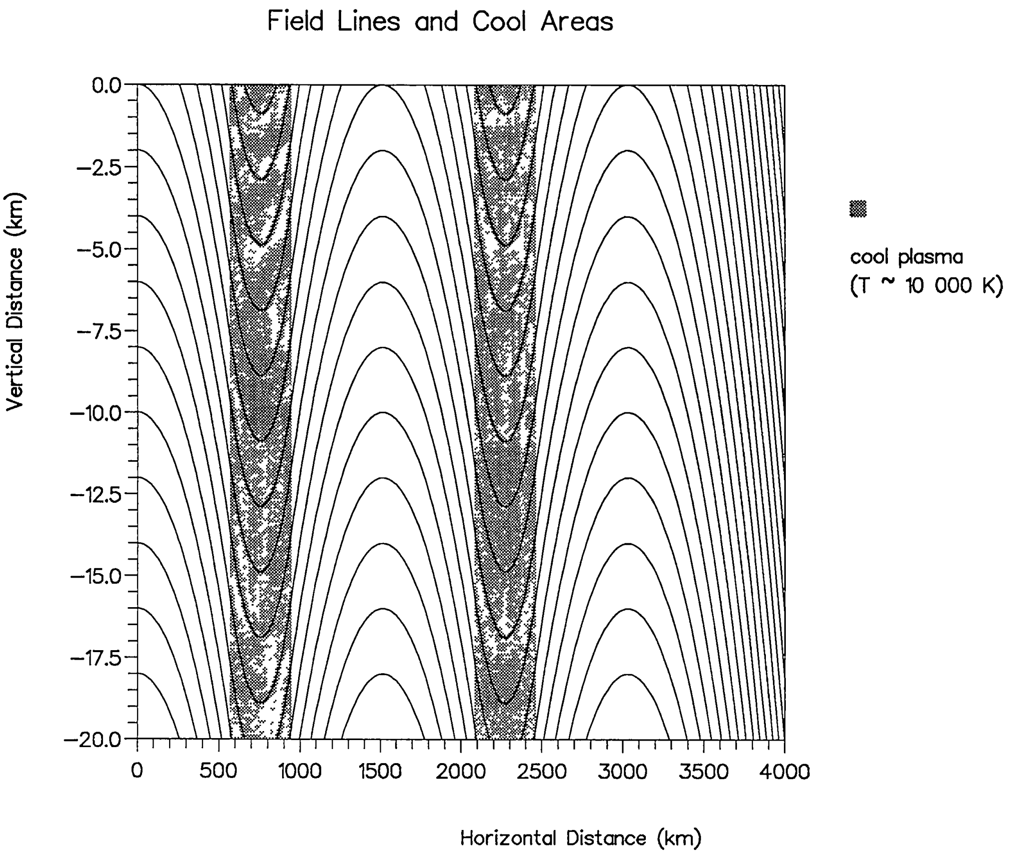
Field Lines and Cool Areas
Vertical Distance (km)
0.0
−2.5
−5.0
−7.5
−10.0
−12.5
−15.0
−17.5
−20.0
0
500
1000
1500
2000
2500
3000
3500
4000
Horizontal Distance (km)
▨
cool plasma
(T ~ 10 000 K)

Fig. 1b.

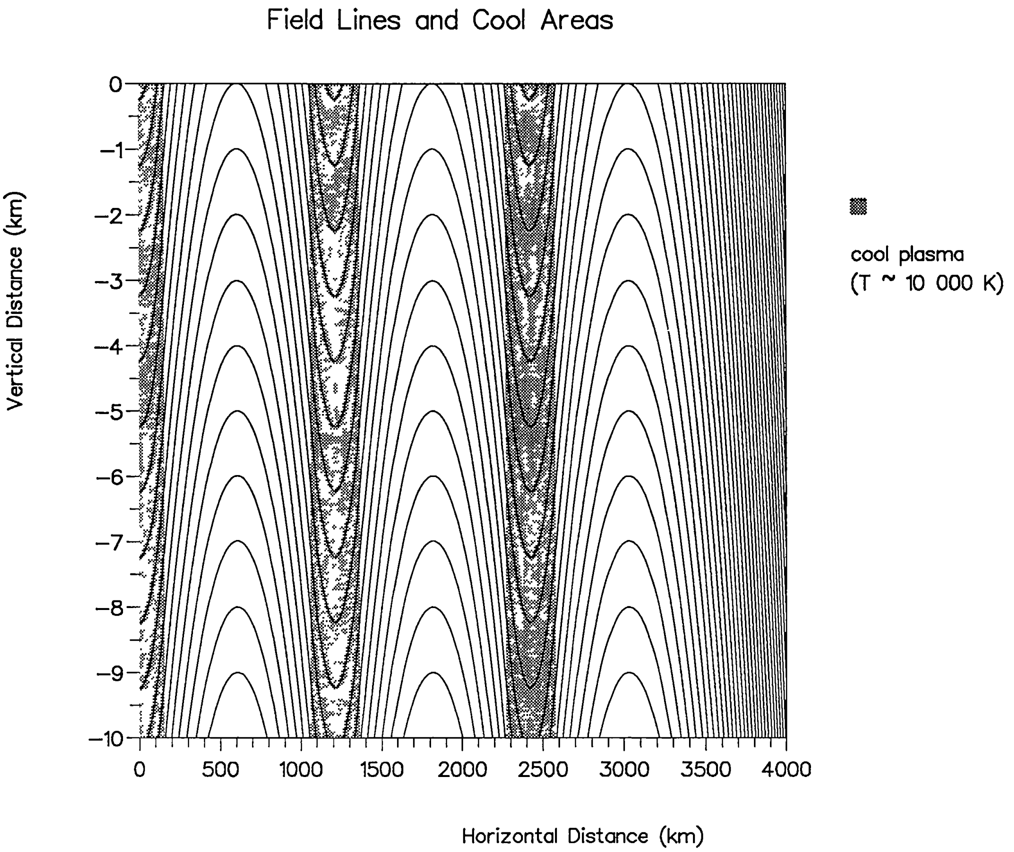
Field Lines and Cool Areas
Vertical Distance (km)
0
−1
−2
−3
−4
−5
−6
−7
−8
−9
−10
0
500
1000
1500
2000
2500
3000
3500
4000
Horizontal Distance (km)
▨
cool plasma
(T ~ 10 000 K)

Fig. 1c.

Figure 1(a) shows the magnetic field lines and areas of cool plasma for a prominence and the surrounding arcade satisfying the above parameters. At the extreme left is the prominence axis – the side of the arcade not shown can be inferred by symmetry. The outer edge of the arcade is taken where the horizontal component of the magnetic field becomes zero (i.e., at a horizontal distance from the prominence axis of about 70 Mm in this particular case). Obviously at greater distances from the prominence some other magnetic structure would be present but none is drawn.

Figure 1(a) suggests that close to the prominence axis the magnetic fields are basically horizontal. Figure 1(b) shows this central area greatly magnified (particularly in the vertical direction). It can be seen that in each cool region, each field line exhibits a dip while in the hot regions the field lines are concave downwards. Figure 1(c) shows the same situation but with five fibrils instead of four. Here, of course, there is a fibril on the prominence axis. Note that in both Figure 1(b) and 1(c) each field line reaches its highest position at a distance of 3.03 Mm from the prominence axis.

2.1. FRACTION OF PROMINENCE FILLED BY COOL PLASMA

In the cases shown so far, about a quarter of the prominence is filled by the cool plasma. Obviously the proportion of the prominence which comprises cool plasma is an important quantity and it is instructive to see determine its dependence on various parameters. Two parameters are important namely the parameter P_T^* and the ratio of the hot to cool temperatures. The following paragraphs describe a situation where all parameters are set to their values in Table I except one which is varied.

Figure 2(a) shows the proportion of cool plasma plotted against P_T. From Equation (11) the lowest possible value of P_T^* is 0.5 and values close to this correspond to prominences which are mainly cool. As P_T is raised the proportion of cool plasma drops. This behaviour can be explained in terms of a strong field supporting the cool, dense plasma while a weaker field has mainly warmer, less dense plasma to support.

Figure 2(b) shows the corresponding variation with the reciprocal of the plasma beta (which is related to P_T^* by Equation (11)). The fraction of plasma at the cool temperature is roughly inversely proportional to the plasma beta.

The fraction of cool plasma is also highly dependent on the ratio of the coronal temperature to the fibril temperature (see Figure 2(c)). For a high temperature ratio, the majority of the prominence is at the hot temperature but as this temperature ratio reduces, more of the prominence is at the lower temperature. For temperature ratios of less than about 30 no equilibrium can be found but such temperature ratios are not realistic.

The fraction of the prominence at low temperatures is less dependent on other parameters. When the number of fibrils is allowed to vary, Figure 2(d) displays how this fraction changes. For few fibrils, the fraction which is at a cool temperature is slightly less than for many fibrils but the variation is not great. Similar magnitudes of variation are found when other parameters are varied, such as α, the ratio of the horizontal magnetic fields or the total width of the prominence.

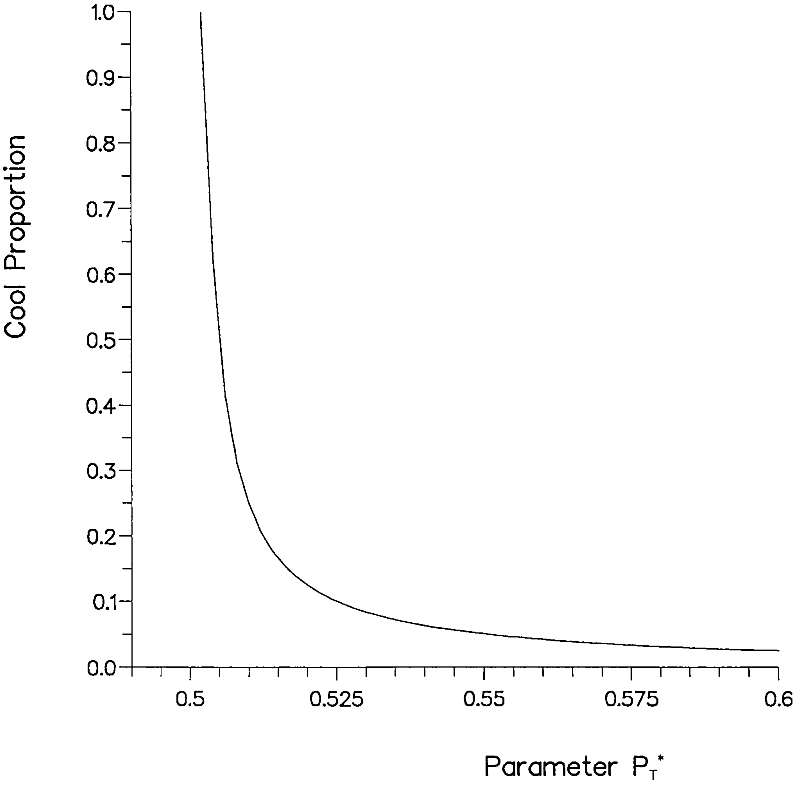

Fig. 2a.

Fig. 2a–d. The dependence of the proportion of cool plasma in the prominence on (a) the parameter P_T^*, the non-dimensional total pressure, (b) the plasma beta β, (c) the ratio of coronal-to-prominence temperature, and (d) the number of fibrils in the prominence.

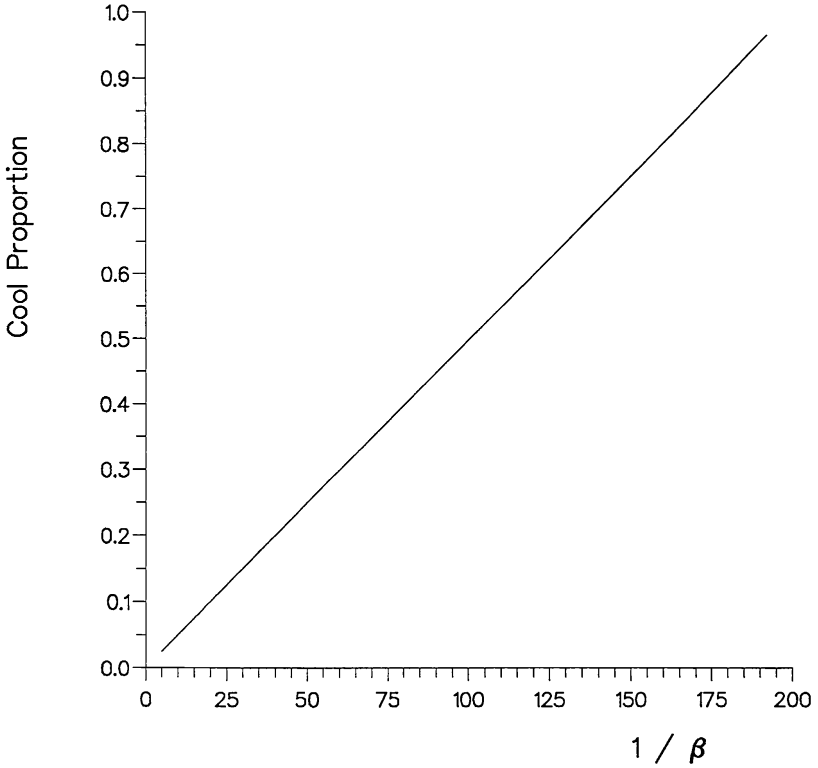

Fig. 2b.

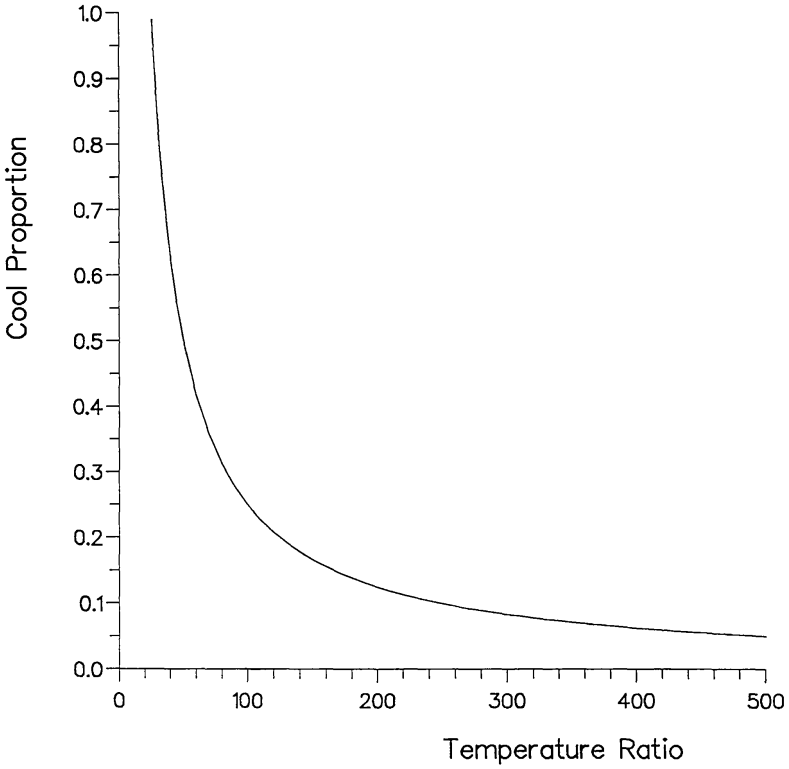
Cool Proportion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
100
200
300
400
500
Temperature Ratio

Fig. 2c.

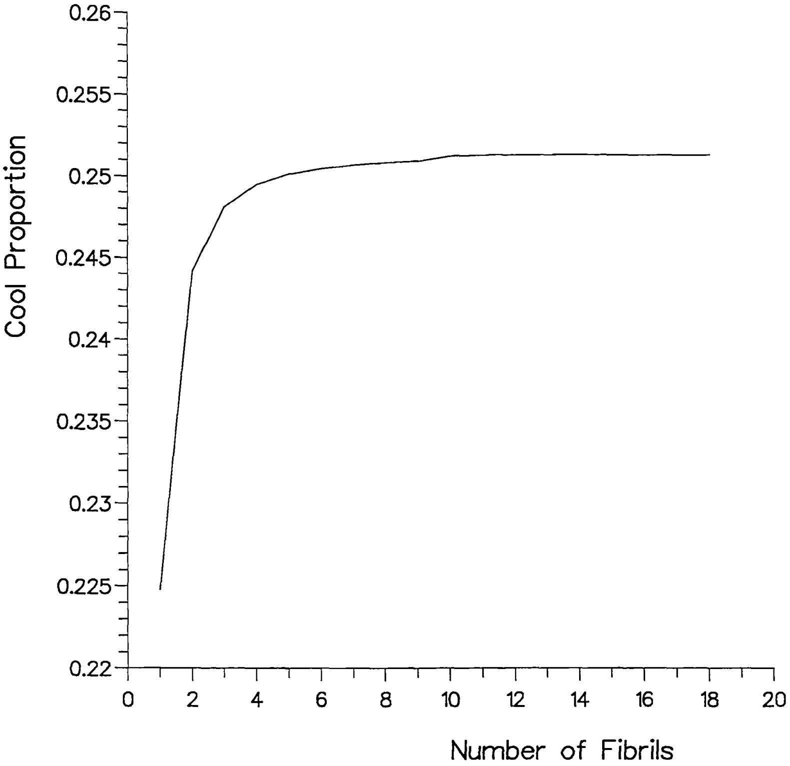
Cool Proportion
0.26
0.255
0.25
0.245
0.24
0.235
0.23
0.225
0.22
0
2
4
6
8
10
12
14
16
18
20
Number of Fibrils

Fig. 2d.

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2.2. ARCADE WIDTH

There are two parameters which strongly influence the width of the arcade surrounding the prominence, namely the ratio of the field along the prominence to that across and the coronal temperature. The arcade width is roughly proportional to the coronal temperature (Figure 3(a)) and depends on the parameter $\alpha = B_y/B_x$, the ratio of the horizontal magnetic fields, in the manner shown in Figure 3(b). The higher the field ratio, the narrower the arcade although it must be pointed out that the size of the arcade measured along the field-lines themselves remains roughly constant. Of course, arcade half-widths of 200 Mm and very small values of B_y are not realistic and so this part of the graph is shown dashed.

The arcade width does not vary greatly when other parameters such as the number of fibrils or the fibril temperature are changed. When the prominence width varies the arcade width changes only very slightly (i.e., the distance from the prominence edge to the arcade edge remains constant). Conditions outside the prominence are not influenced significantly by conditions inside; the arcade structure is determined by the coronal temperature and the horizontal magnetic field ratio which is the same in the arcade as in the prominence.

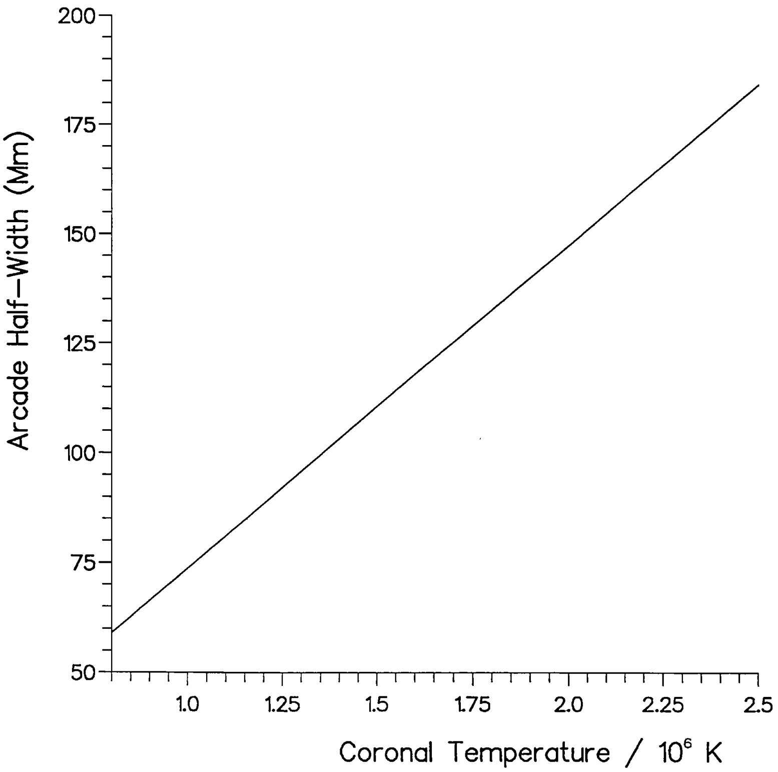

Fig. 3a.

Fig. 3a–b. The arcade half-width as a function of (a) coronal temperature and (b) the ratio of magnetic field along the prominence to that across the prominence.

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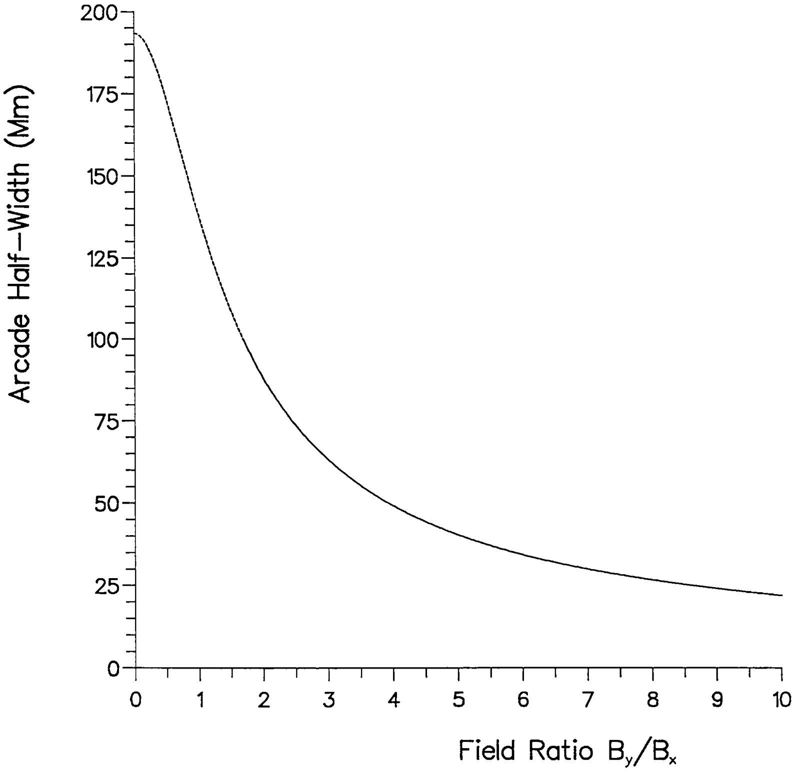

Fig. 3b.

2.3. PROMINENCE MASS

It is a straightforward matter to calculate the mass of the prominence. However, as the prominence is homogeneous in the direction along its axis and the only vertical variations are those of pressure and magnetic field, it is only the variations in the direction across the prominence which are affected by the fibril nature. Thus the mass per unit length and height is defined as

$$M = \int_0^{x_{\rm edge}} \rho \, \mathrm{d}x \,, \tag{12}$$

which equals

$$\int_0^{x^*_{\rm edge}} \frac{X_0^2}{RkT\mu} \left[P_T^* - \tfrac{1}{2}[X^{*2}(1 + \alpha^2) + Z^{*2}] \right] \mathrm{d}x^* \tag{13}$$

and is thus proportional to

$$M^* = X_0^2 \int_0^{x^*_{\rm edge}} \frac{\mu}{T^*} \left[P_T^* - \tfrac{1}{2}[X^{*2}(1 + \alpha^2) + Z^{*2}] \right] \mathrm{d}x^* \tag{14}$$

(where μ is the molecular mass per particle) which in turn can be shown (by considering

Equations (9) and (10) and integrating by parts) to equal

$$2X_0^2 \int_0^{x^*_{\text{edge}}} (P_T^* - Z^{*2})\,\mathrm{d}x^* . \tag{15}$$

Figure 4 shows how M^* (calculated from Equation (14)) varies as certain input parameters are varied. Figure 4(a) deals with the effect of the parameter P_T^* and it can be seen that the mass of the prominence is almost exactly proportional to this parameter. Similarly (not shown graphically), the prominence mass is proportional to its width. The other parameters affect the mass to a lesser degree; the effect of the number of fibrils is shown in Figure 4(b) to be of only minor importance. Varying the temperatures in the prominence has no significant effect on the mass. This seems a surprising result until it is remembered that varying the temperatures changes the amount of cool plasma and this happens in such a way as to keep the mass constant. Equation (14) shows that the prominence mass is proportional to the horizontal magnetic field strength; i.e., a stronger magnetic field is capable of supporting a greater amount of plasma.

The approach of this section has been to model the prominence as a series of cool sheets all lying parallel to the prominence axis. However, the observed fibril structure is of threads rather than sheets and so in the next section some structure is added in the direction along the prominence in order to make the model more realistic.

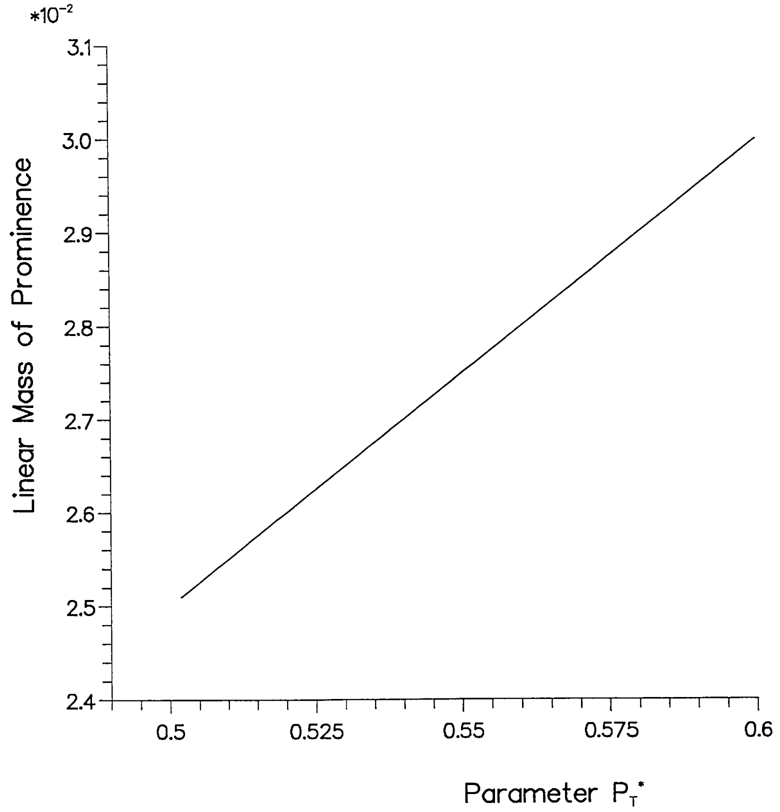

Fig. 4a.

Fig. 4a–b. The non-dimensional linear mass of the prominence plotted as a function of (a) the non-dimensional total (plasma plus magnetic) pressure and (b) the number of fibrils in the prominence.

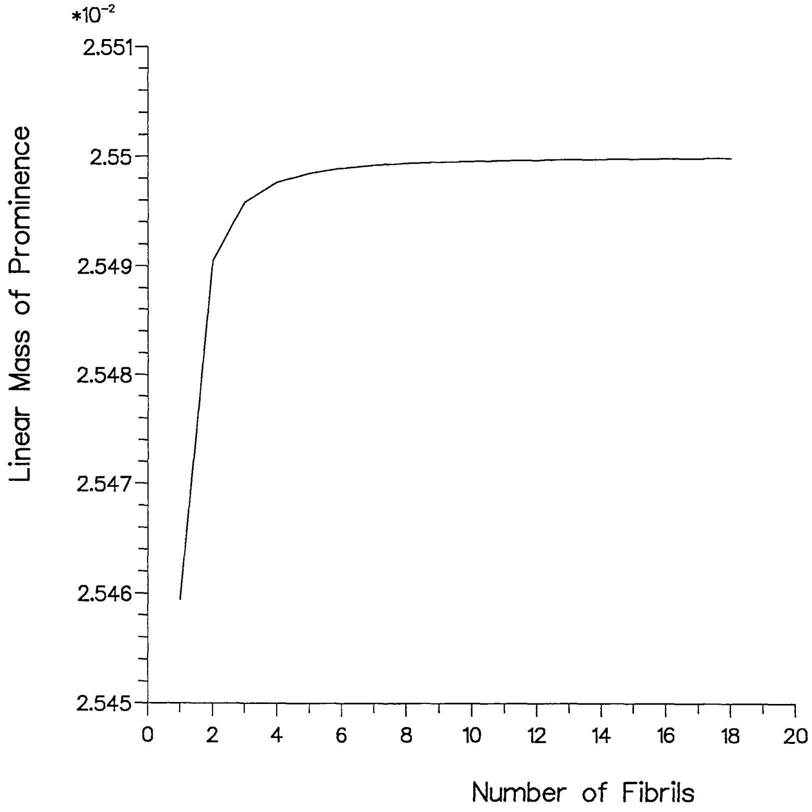

Fig. 4b.

3. Structure along the Prominence

The approach of Hood, Priest, and Anzer to structure along the prominence is to assume that for some values of y (the coordinate aligned along the prominence axis) cool fibrils and hot plasma alternate in a manner similar to that described in Section 2 while for other values of y, there is no cool plasma present.

This approach has its drawbacks; their fibrils are arranged on a rectangular array (skewed by the addition of a longitudinal field). From particular angles, the fibrils would therefore appear to line up, as would the gaps between them.

The matter of the interface between the prominence and the external corona also presents difficulties. It is necessary that the field be continuous as one moves from the prominence to the corona and it is also desirable that field in the surrounding corona is not dependent on which part of the prominence the field line links to. A surrounding region of hotter plasma (i.e., hotter than the corona) is invoked in an attempt to make the fields continuous.

The approach used in this paper differs in several ways from that of Hood, Priest, and Anzer. As one moves along the prominence in the y-direction, the number of fibrils is allowed to vary. Sometimes there may be a single fibril on the prominence axis, sometimes two (one either side) while for other values of y there can be five, ten or more. The number of fibrils need not be determined by the part of the prominence being considered and neither need the length of prominence for which this applies.

Of course, it is still necessary to ensure that the magnetic field remains continuous at the interface between the prominence and the external corona. This is done by defining the prominence boundary to be the first point outside the cool plasma where the vertical magnetic field is zero. At this point, the horizontal magnetic field is fixed, hence the rather curious choice of location to apply boundary conditions in Section 2.

Figure 5(a) displays the distribution of cool areas as the number of fibrils is allowed to change. The outer boundary of the prominence in each case is at a distance of 3034 km from the prominence axis but the position of the outermost portion of cool plasma depends on the number of fibrils. The pattern that is exhibited here would be continued as the number of fibrils is increased further.

It was mentioned above that the magnetic field has to be continuous at the prominence-corona interface and that in the corona, the magnetic field has to be independent of the origination of the field line in the prominence. Figures 5(b) and 5(c) show that this property is satisfied. Figure 5(b) shows what happens as the number of fibrils is varied and one field line is drawn for each case. Inside the prominence, the magnetic field is highly dependent on the number of fibrils, but in the corona the field

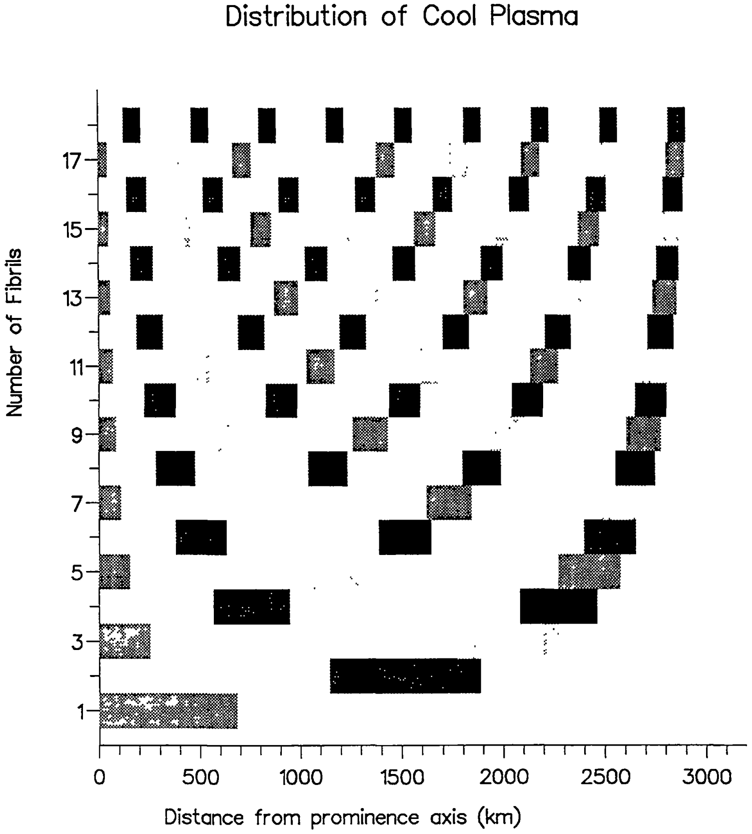

Fig. 5a.

Fig. 5a–c. (a) The regions occupied by cool plasma drawn for differing numbers of fibrils, (b) field lines for prominences for differing numbers of fibrils. The magnetic fields differ in the prominence region, but in the external corona they join smoothly onto a single field profile; (c) as (b) but concentrating on the cases where there are five fibrils or more.

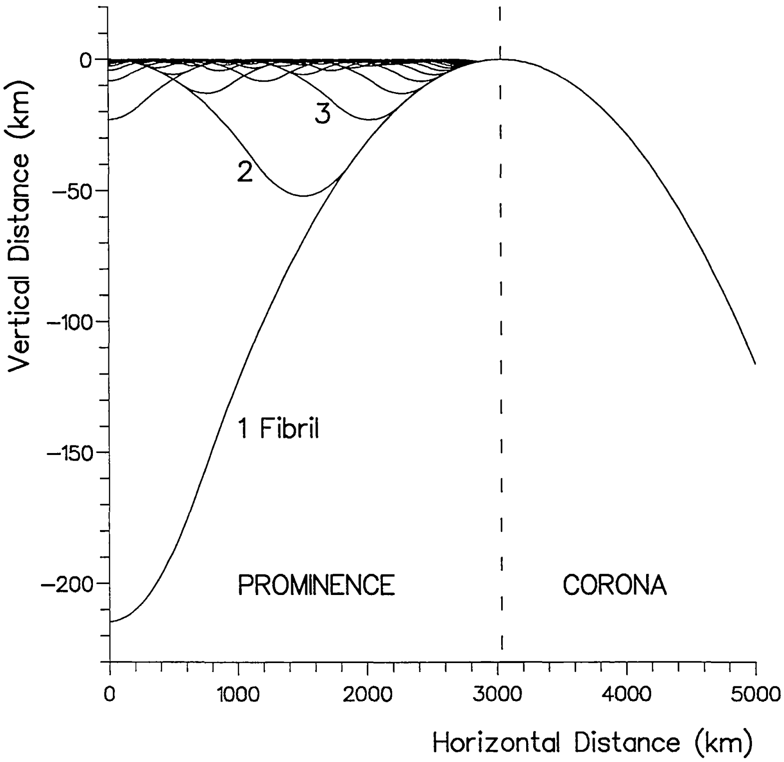
Vertical Distance (km)
0
−50
−100
−150
−200
3
2
1 Fibril
PROMINENCE
CORONA
0
1000
2000
3000
4000
5000
Horizontal Distance (km)

Fig. 5b.

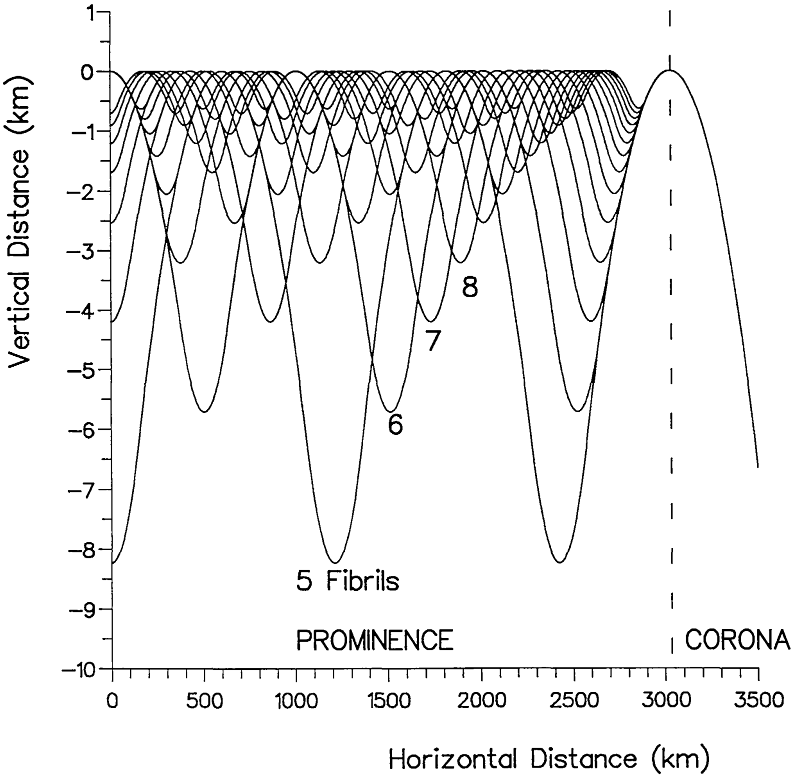
Vertical Distance (km)
1
0
−1
−2
−3
−4
−5
−6
−7
−8
−9
−10
8
7
6
5 Fibrils
PROMINENCE
CORONA
0
500
1000
1500
2000
2500
3000
3500
Horizontal Distance (km)

Fig. 5c.

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lines all lie along the same direction. It can also be seen from this figure that a prominence with a smaller number of fibrils has a deeper dip. Of course, this is necessary in order to support a larger amount of plasma. Figure 5(c) shows in more detail the situation for 5 fibrils or more. It is only in the cool areas that the shape of the field lines is governed by the number of fibrils.

It is possible now to produce a top view of a fibril prominence in which the number of fibrils varies as one moves along the prominence and the magnetic field remains continuous. Figure 6(a) shows such a view for the parameters from Table I. The number of fibrils is allowed to vary in a random manner between 1 and 18 as a function of the distance along the prominence. Also the fibril widths are random up to about 180 km. The effect is that there is an apparently random distribution of fibrils. The effect of the shear in the prominence together with the cases where the number of fibrils is small produces a few 'sheet-like' surfaces but it must be remembered that some numbers of fibrils may occur more often than others and that low numbers of fibrils need not be common.

Instead of a longitudinal to transverse field ratio of 2.5, Figure 6(b) shows the case for a field ratio of unity, i.e., the magnetic field is inclined to the axis by 45 deg. In this

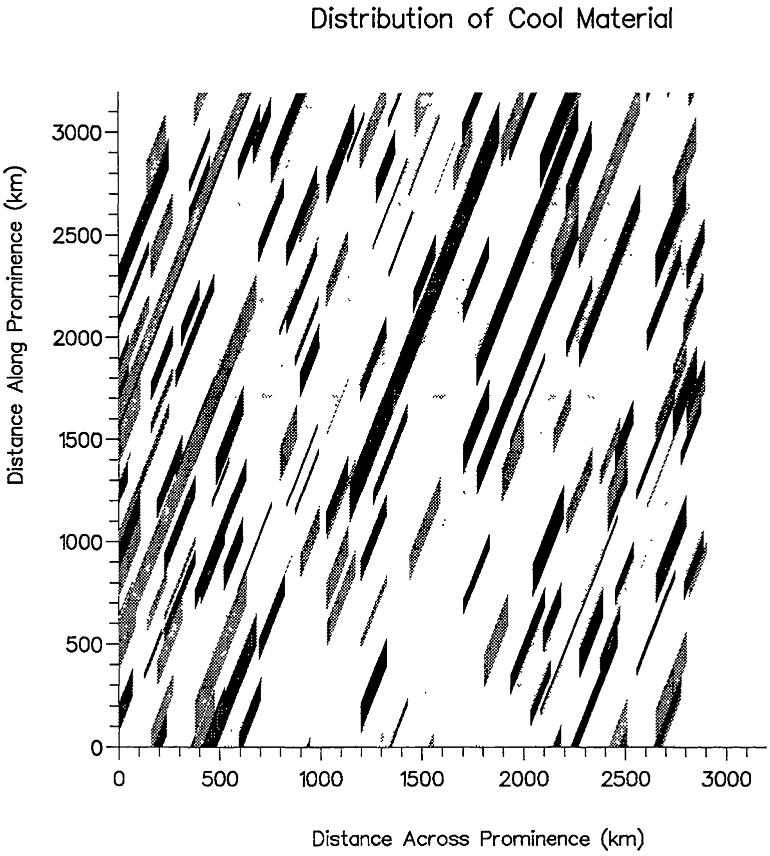

Fig. 6a.

Fig. 6a–b. A top view of a prominence where the number of fibrils varies in a random manner along the prominence. This figure deals with the case where the ratio of field along the prominence to that across it is (a) 2.5 and (b) 1.0.

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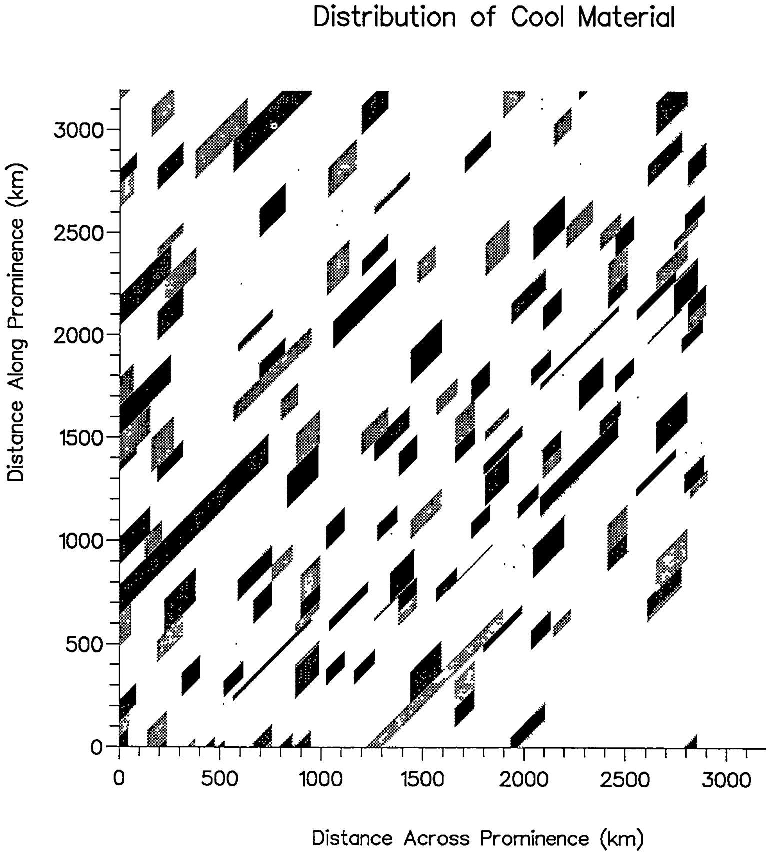

Fig. 6b.

case the long sheet-like structures are less common and the random fibril pattern remains.

4. Conclusions

A normal polarity prominence has been modelled as a set of cool fibrils separated by plasma at coronal temperatures. Firstly, it was assumed that the prominence is uniform in the longitudinal direction with the structure being experienced as one moves across the prominence. The temperature profile has been imposed (although the fibril width has been allowed to vary) and equations of magnetostatic equilibrium have been solved. It is found that the cool fibrils coincide with dips in the prominence magnetic field.

The ratio of widths of the cool fibrils to the hot interfibril regions depends strongly on the ratio of temperatures and the plasma beta, the ratio of plasma to magnetic pressure. High values of beta or the temperature ratio give fibrils which are thin relative to the spacing between them. The average density of the prominence is found to vary with the square of the horizontal magnetic field.

Subsequently the assumption of the prominence being uniform in the longitudinal direction has been removed. The fibrils then form an apparently random pattern.

There are several ways in which this model can be developed further. The prominence and coronal temperatures have been imposed but further work can include solving an energy equation in parallel with the magnetostatic equations. Such an approach has been studied for a prominence modelled as a single structure by Degenhardt *et al.* (1992). Each magnetic field line can be modelled in isolation as the heat conduction across a field line is less than that along the field line by many orders of magnitude (Spitzer, 1962). Models of the thermal structure of coronal loops with cool summits (e.g., Steele and Priest, 1990) indicate that very large temperature gradients occur at the interface between hot and cool plasma so it is expected that using a realistic rather than imposed thermal structure will not greatly affect the results.

Another approach to the temperature structure would be to assume that the whole of the prominence structure is at cool temperatures but that it is only in the dips in the magnetic field that plasma gathers to form fibrils. It has been assumed in this paper that along a magnetic field line the width of each fibril remains constant. Relaxation of this assumption is not expected to change the details greatly but will add to the general random apearance of the prominence.

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