POSSIBLE AMOUNT OF MAGNETIC FLUX RECONNECTED THROUGH QUIESCENT PROMINENCES OUTSIDE THE ACTIVE REGIONS

M.H. Gokhale and K.R. Sivaraman
Indian Institute of Astrophysics, Bangalore, India

Introduction

Quiescent prominences are known to occur invariably above the neutral lines in the large scale photospheric fields. This suggests that such prominences may be coronal current sheets across which the magnetic fields reconnect (cf. e.g. Raadu and Kuperus, 1973). In the absence of any satisfactory model for quiescent prominences (cf. Report of Working Group 1 in this Colloquium), the reconnection hypothesis remains as yet unsettled. However, if it is true, we have here an evidence to show that the quiescent prominences outside the active regions might account for the reconnection of almost all the photospheric magnetic flux emerging in the active regions as required by the theories of the 11-yr cycle of activity (e.g. Babcock, 1961).

Formula for the estimation of the reconnected magnetic flux

Assuming the validity of the reconnection hypothesis the amount of magnetic flux reconnected through a quiescent prominence may be estimated as:

$$\phi = \langle B \rangle \; v_{app} \int L dt = \langle B \rangle \; v_{app} d^{-1} \int A dt, \qquad (1)$$

where L(t) is the instantaneous length of the chromospheric filament at the base of the prominence, d is the thickness of the filament (assumed constant), A is its area, $\langle B \rangle$ is the mean photospheric field of either polarity in the neighbourhood of the filament, v_{app} is the speed with which this field approaches the filament (either by diffusion, or by largescale systematic motion or by a combination of both) and the integral extends over the life of the prominence. Using the magnetic diffusivity due to the normal granulation (viz. $\sim 5 \times 10^{12} cm^2 s^{-1}$) and assuming the length scale of variation of the "neighbouring" photospheric field as $\sim 10^9 - 10^{9.5}$ cm we estimate:

$$v_{app} \approx 2\text{-}5 \times 10^3 \text{cm s}^{-1}. \qquad (2)$$

The lower estimate matches with the supply of magnetic flux by *systematic* poleward field migration on much larger scales observed by Howard (1974).

The total amount of magnetic flux reconnected during any period can be written as

$$\Phi \approx \langle B \rangle \, v_{app} \, d^{-1} \, \Sigma \int A dt, \qquad (3)$$

where the summation extends over all prominences occurring in that period, provided $\langle B \rangle$, v_{app} and d are approximately the same for different prominences, which is true within reasonable limits.

Data and results

From the daily spectroheliograms in H-alpha which are available at Kodaikanal, we measured the areas of all the "filaments" formed outside the active regions during the years 1941, 1942, 1943, 1945 and 1946. After correcting these areas for foreshortening we computed the yearly values of $\Sigma \int A dt$, and corrected these sums for the days of "missing data" and for prominences on the other side of the Sun. The corrected values of $\Sigma \int A dt$ are given in Table I along with the mean sunspot numbers for these years. In the last column of the Table we have given the estimates of the magnetic flux Φ reconnected during these years, as obtained by assuming B $\approx$ 10 G, $v_{app} \approx 2 \times 10^3$ cm s^{-1} (cf. Eq. 2) and d $\approx$ 3000 km.

Conclusions and Discussion

a) We notice that the annual values of $\Sigma \int A dt$ show a trend similar to the mean sunspot number, even though the magnetic flux will require some finite time (e.g., $\sim$ 1 year or less, cf. Howard, 1974) to migrate from the place where it emerges above the photosphere to the location of the prominence where it is reconnected.

b) Over an 11 year cycle the amount of magnetic flux reconnected through the quiescent prominences outside the active regions may add up to ~ 11/5 times the sum of the fluxes in the last column of Table I, i.e. up to $\approx 1.5 \times 10^{24}$ Mx. Thus it seems that such reconnections might account for the removal of almost the entire magnetic flux emerging in active regions during the cycle as required by the theories of the solar cycle.

c) We have also determined the latitude distribution of $\Sigma\int Adt$ for each year in latitude belts of 5° each. These distributions seem to confirm the poleward migration of the high latitude prominence zone and the equatorward migration of the middle latitude prominence zone described earlier by Waldmeier (1973).

Table I: Annual corrected values of $\Sigma\int Adt$ in units of "millionth hemisphere x day" and of Φ in Mx.

Year	Relative Sunspot Number	$\Sigma\int Adt$ (corrected)	Φ
1941	47.5	1344756	23.2×10^{22}
1942	30.6	543832	9.4 x "
1943	16.3	419392	7.2 x "
1945	33.2	547794	9.4 x "
1946	92.6	1156526	20.0 x "

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References

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