

## 4-day periodic variation in the Sun's meridional flow

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**Abstract.** In latitude interval  $20^{\circ}$ – $30^{\circ}$ , the dependencies (i) ‘initial’ meridional motion,  $v_{ini}(\tau)$ , of sunspot groups with life spans  $\tau = 2$ –12 days, on  $\tau$  of the spot groups, and (ii) mean meridional motion,  $v(\tau)$ , of sunspot groups with  $\tau=10$ –12 days on age ( $t$ ) of the spot groups, are often significant. The patterns of  $v_{ini}(\tau)$  and  $v(t)$  are largely systematic and mutually similar, and suggest existence of a periodic variation in the solar meridional flow with period 4-day and amplitude  $10$ – $20 \text{ m s}^{-1}$ . However, the relations of  $\tau$  and  $t$  with depths of anchoring of magnetic structures of the spot groups suggest that the patterns of  $v_{ini}(\tau)$  and  $v(t)$  may represent spatial structure of solar meridional flow in the Sun's convection zone, rather than temporal variation of the flow.

### 1. Introduction

Recently, we analysed Greenwich data on sunspot groups during 1874-1939 and investigated: (i) how the ‘initial’ rotation frequency of a spot group related to the spot group life span, and (ii) how the mean rotation frequency of long (10-12 days) lived spot group related with the spot group age. From these we estimated depths of initial anchoring and rising rates of spot group magnetic structures (Javaraiah and Gokhale 1997, hereafter JG97). We have now analysed a large data set of sunspot groups compiled from *Greenwich Photoheliographic Results* during 1874-1976 and from NOAA/ USAF data during 1977-1981, and investigated the dependence of meridional motions of sunspot groups on their life spans and age. Here we present the preliminary results.

### 2. Data analysis

The method of data reduction is the same as in JG97, where we determined rotation rate (longitudinal drift) of spot groups, whereas in the present analysis we determined meridional velocity (latitude drift). For each specified value of the age ‘ $t$ ’ of a spot group, the mean meridional velocity ( $v(t)$ , and the standard deviation ( $\sigma$ ), were computed for spot groups of given life span in given latitude interval. The value of  $v(t)$  at  $t = 3/2$  is defined as the mean ‘‘initial’’ meridional velocity  $v_{ini}(\tau)$ . In order to have better statistics, the data in the same latitude intervals in the northern and southern hemispheres were folded. We adopted the following

convention: a positive value of the meridional velocity indicates poleward flow in either hemisphere.

### 3. Results and discussion

In each of the latitude intervals  $0^{\circ}$ – $10^{\circ}$ ,  $10^{\circ}$ – $20^{\circ}$  and  $20^{\circ}$ – $30^{\circ}$ , the values of  $v_{ini}(\tau)$  of spot groups with  $\tau=2$ – $12$  days and of  $v(t)$  of spot groups with  $\tau = 10$ – $12$  days were found to be often different from zero significantly. Figures 1(a) and 1(b) show the variations of  $v_{ini}(\tau)$  and  $v(t)$  in the interval  $20^{\circ}$ – $30^{\circ}$ . In this interval the variations are largely systematic, mutually similar and suggest existence of a periodic variation in the solar meridional flow with period 4-day and amplitude  $10$ – $20$   $m s^{-1}$ .

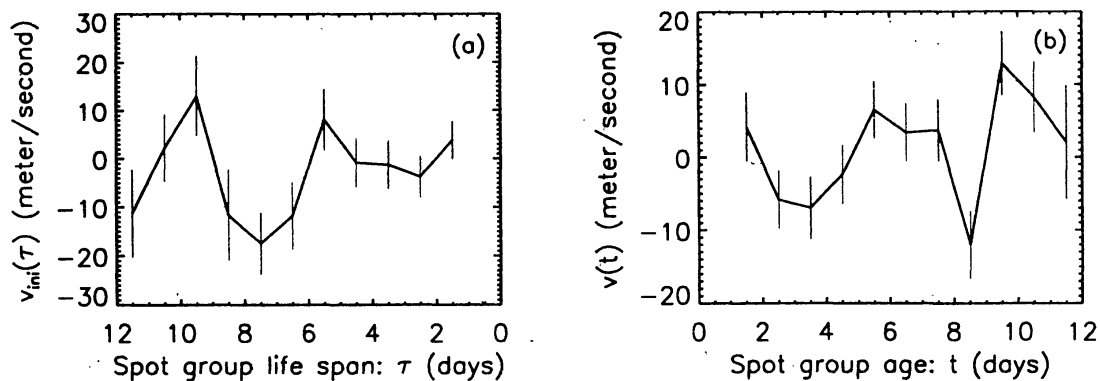


Figure 1. Plots of (a)  $v_{ini}(\tau)$  versus  $\tau$  for spot groups of life span 2 to 12 days and (b)  $v(t)$  versus  $t$  for spot groups of life span  $\tau = 10$ – $12$  days, in latitude interval  $20^{\circ}$ – $30^{\circ}$

[In view of the relations of  $\tau$  and  $t$  with the anchoring depths of sunspot magnetic structures derived earlier, (JG97), we have chosen the scale of abscissa of Figure 1(a) in the reverse order. This helps to compare the variation of  $v_{ini}(\tau)$  with that of  $v(t)$  and vice-versa. Note : the first value of  $v(t)$  is the average of first three values of  $v_{ini}(\tau)$ .]

The maximum relative variations in  $v_{ini}(\tau)$  and  $v(t)$  are slightly greater than the relative errors of heliographic positions. The trends of  $v_{ini}(\tau)$  and  $v(t)$  obtained from the separate data sets of northern and southern hemispheres are also found to be mutually similar. Existence of a 4-day periodicity in the total solar irradiance is reported by some authors (e.g., Froelich and Pap 1989). In view of all these factors, the 4-day periodic variation seen in  $v(t)$  seems to be of the solar origin. However, the relations of  $\tau$  and  $t$  with depths of anchoring of magnetic structures of the spot groups (JG97) suggest that the patterns of  $v_{ini}(\tau)$  and  $v(t)$  may represent spatial structure of solar meridional flow in the Sun's convection zone, rather than temporal variation of the flow.

### References

- Froelich C., Pap J., 1989, A&A, 220, 272.  
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