Bull. Astr. Soc. India (1999) **27**, 73-74

Comparison of periodicities of the Sun's 'mean' and differential rotations determined from sunspot group and from Mt. Wilson velocity data

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Abstract. There seem to be considerable differences in the periodicities (in the range 2-11 years) of the differential rotation coefficients $\bar{A}$ and $\bar{B}$ determined from the spot group data and the velocity data. These differences may be because the rotation rate determined from the velocity data represents the rotation rate of shallower layers (~ 1.0 $R_\odot$), whereas the average rotation rate determined from combined data of all types of sunspot groups represents the rotation rate of the deeper layers (~ 0.9 $R_\odot$).

1. Introduction

Earlier, we analyzed the Greenwich data on sunspot groups during 1879-1976 and detected periodicities in the range 2-45 year, including one at ~ 20 year, in the ratio B/A of the coefficients of differential rotation (Javaraiah and Gokhale, 1995, hereafter Paper I). Recently, we have also shown the existence of periodicities at ~ 45 year, 21.3 year, 13.3 year and 10.5 year in the north-south (N-S) asymmetries of A and B, and also in the asymmetry of 'mean' (or 'rigid body') rotation, $\bar{A}$ (Javaraiah and Gokhale, 1997a, hereafter Paper II). In the present paper, I study the periodicities in the differential rotation through the FFT analyses of the 'mean rotation' $\bar{A}$, the differential rotation parameters $\bar{B}$ and $\bar{C}$ determined from Mt. Wilson velocity data, and $\bar{A}$ and $\bar{B}$ determined from sunspot group data (see Paper II for definition of $\bar{A}$, $\bar{B}$ and $\bar{C}$). For this, I used the published values of A, B and C derived from the Mt. Wilson full disc velocity data for Carrington rotations 1516-1719, during January 1, 1967 to March 21, 1982 (Howard et al., 1983). The sunspot group data and the method of the reduction are the same as in Papers I and II.

2. Results and discussion

Table 1 shows the significant periodicities in $\bar{A}$ and $\bar{B}$ determined from the velocity and sunspot group data. In the FFT spectrum of $\bar{C}$ (determined from the velocity data) only a peak at ~ 11 year is found to be significant.

Table 1. Periodicities in $\bar{A}$ and $\bar{B}$ determined from FFT analyses of Mt. Wilson velocity data (MWVD) and sunspot group data (SSGD). The levels of significance (in units of σ) of the peaks in the FFT spectra are also given.

Data name	$\bar{A}$ Period	σ	$\bar{B}$ Period	σ
MWVD	4.8±1.0 year	5.0	~ 9.6 year	5.1
	1.4±0.2 year	3.0	2.0±0.2 year	2.6
	1.0±0.1 year	4.4	1.1±0.1 year	3.6
	162±8 day	1.8	332±20 day	4.4
			94±4 day	1.8
SSGD	~ 64 year	2.8	18.3±3.0 year	2.1
	8.5±0.5 year	1.9	8.5±0.5 year	1.9
	3.1±0.1 year	2.1	3.9±0.3 year	2.1
	2.6±0.1 year	2.8	3.1±0.2 year	2.1
			2.6±0.1 year	1.9
			2.1±0.1 year	2.3

From Table 1, one can see that there are considerable differences in the 2-11 year periodicities (and their levels of significance) of $\bar{A}$ and $\bar{B}$ determined from the sunspot and the velocity data. [Here it is possible to compare only the periodicities in the range 2-11 years. It is important to note that the temporal resolutions and lengths of the two data sets are different. The time series of the spot group data contains 98 yearly bins, whereas the velocity data are binned in 204 Carrington rotation periods. Moreover, the spot group data are limited to the ±35° latitudes and the rotation rate determined from the sunspot group data depends on the type of sunspot groups used (Javaraiah and Gokhale, 1997b)].

I compared the average rotational frequency at latitude 15° determined from the velocity data during 1967-1984 and the average rotational frequency at the same latitude determined from the entire spot group data during 1874-1976 with the radial gradient of plasma rotational frequency Ω(r) at latitude 15° determined from the helioseismic data (the values of Ω(r) were provided by Dr H. M. Antia, see Javaraiah and Gokhale, 1997b). I have found that the average rotational frequency of the spot groups has the value of plasma rotation frequency at radius r ~ 0.9 $R_\odot$. The average rotation frequency determined from the velocity data represents the rotation frequency of the surface layer. Hence, the differences in the temporal behaviours of $\bar{A}$ and $\bar{B}$ determined from the spot group and the velocity data may be because the rotational frequencies determined from these data sets represent plasma rotation frequencies at different depths.

References

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