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Short-term periodicities in the north-south asymmetry of the Sun's surface rotation

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Abstract. Power spectra of N–S asymmetries of the coefficients $\bar{A}$ and $\bar{C}$ of the Sun's surface differential rotation determined from the Mt. Wilson velocity data during 1982–1994 suggest the existence of a period at 374 $\pm$ 30 day in the N–S asymmetries of $\bar{A}$ and $\bar{C}$ with $>$ 99.9% confidence level. The spectrum of the N–S asymmetry of the coefficient $\bar{B}$ suggests existence of the periods at 374 $\pm$ 30 day, 78 $\pm$ 2 day and 49 $\pm$ 1 day in the N–S asymmetry of $\bar{B}$ with $\geq$ 99% confidence level.

Keywords : Sun: rotation–differential rotation–north-south asymmetry

1. Introduction

Study of the temporal variations in the N–S asymmetry of the differential rotation is important which may provide a clue for understanding the underlaying mechanism of the solar activity and the N–S asymmetry of solar activity. Earlier, Javaraiah and Gokhale (1997), detected the long-term periodicities at 45 ± 11 yr, 21.3 ± 4.5 yr, 13.3 ± 1.5 yr and 10.5 ± 0.5 yr in the N-S asymmetry of the differential rotation using the Greenwich data on sunspot groups during 1879–1976. In the present analysis we determined the short-term periodicities of the order of 1 yr in the N-S asymmetries of the differential rotation using the Mt. Wilson velocity data during 1982–1994.

2. Data analysis

Dr. R. F. Howard kindly provided us the daily values of the differential rotation parameters A, B and C derived from the Mt. Wilson Doppler velocity data during 1967–

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1994, for northern and southern hemispheres separately. The A, B and C are the coefficients in the standard form, $\omega(\lambda) = A + B\sin^2\lambda + C\sin^4\lambda$, where $\omega(\lambda)$ is the sidereal angular velocity at latitude λ, A represents the equatorial or 'mean' rotation rate, B and C measure the latitude gradient of the rotation rate with B representing mainly low latitudes and C representing largely higher latitudes. We focus on observations obtained after 1981 with the reduced instrumental noise. To reduce the influence of gaps in the daily data we binned the daily data into 19-day consecutive intervals (Javaraiah and Komm, 1999). We converted the A, B, C into the corresponding $\bar{A}$, $\bar{B}$, $\bar{C}$, viz., coefficients in the differential rotation representation using Gegenbauer polynomials: $\omega(\lambda) = \bar{A} + \bar{B}(5sin^2\lambda - 1) + \bar{C}(21sin^4\lambda - 14sin^2\lambda + 1)$. These coefficients are free of crosstalk (for references see Javaraiah and Komm, 1999).

The N–S asymmetry (Xa) of a measure of a solar phenomenon X can be defined as $Xa = (Xn - Xs)/(Xn + Xs)$, where Xn and Xs are the measures of X in the northern hemisphere and southern hemisphere, respectively. Using this formula we calculated the N–S asymmetries, $\bar{A}a$, $\bar{B}a$ and $\bar{C}a$, of the coefficients $\bar{A}$, $\bar{B}$ and $\bar{C}$ and computed FFT power spectra of $\bar{A}a$, $\bar{B}a$ and $\bar{C}a$.

3. Results and discussion

In the FFT spectra $\bar{A}a$ and $\bar{C}a$ the peak at the period of 374 $\pm$ 30 day was found to be dominant with $>$ 99.9% confidence level. In the spectrum of the $\bar{B}a$ the peaks at the periods of 374 $\pm$ 30 day, 78 $\pm$ 2 day and 49 $\pm$ 1.0 day were found to be significant with 99–99.8% confidence level. In this spectrum the two peaks at periods of 67.5 $\pm$ 1.0 day and 42.7 $\pm$ 0.3 day, and in the spectrum of $\bar{C}a$ the peak at period of 44.2 $\pm$ 0.4 day were found to be significant with 98% confidence level. In all these three power spectra the peaks at the period of $\sim$ 11 yr were found to be highly insignificant or absent.

Influence of the 7.17° inclination of the Sun's equator to the ecliptic may be responsible for the dominance of 374 day periodicity in the N–S asymmetry of the solar differential rotation. However, it is not yet clear to us whether this period is a physical solar property or an artifact of errors in the Mt. Wilson measurements which might be caused by the seasonal variations due to the earth rotation.

References

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