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'1.3-Year' and '153-day' Periodicities in the Sun's Surface Rotation

J. Javaraiah*
Indian Institute of Astrophysics, Bangalore 560 034

Abstract. Using the daily Mt. Wilson velocity data during 1986–1994, we found 1.3 ± 0.1 yr periodicity is dominant in the Sun's surface 'mean' rotation rate ($\bar{A}$) during 1986–1994 (solar cycle 22). A 153 ± 5 day periodicity found to be substantially significant in $\bar{A}$ during the decay phase of solar cycle 22.

Keywords : Sun: surface rotation–solar activity

1. Introduction

Dr. R. F. Howard kindly provided with us the daily values of coefficients of the solar differential rotation derived from Mt. Wilson velocity data during 1967-1994. Using this data during 1982-1994, Javaraiah & Komm (1999) found the existence of, beside several other periodicities, 1.2 ± 0.2 yr periodicity in $\bar{A}$ (note: the differential rotation law: $\omega(\phi) = \bar{A} + \bar{B}(5\sin^2\phi - 1) + \bar{C}(21\sin^4\phi - 14\sin^2\phi + 1)$ was used, where $\omega(\phi)$ is the angular velocity at latitude ϕ and the coefficient $\bar{A}$ represents surface 'mean' rotation rate). Using GONG and SOHO helioseismic data over the period 1995 May to 1999 June 26, Howe et al. (2000) found the existence of 1.3-yr periodicity in Sun's internal rotation rate around base of the convection zone at the equatorial region. The 1.3-yr periodicity seems present also in sunspot activity (Krivova & Solanki 2002). The existence of 150-160 day periodicity in several solar activity indices is well known. In the present study, we attempted to determine accurate value of the aforesaid ~1.2-yr periodicity and to find the 150-160 periodicity in $\bar{A}$.

*e-mail:jj@iiap.ernet.in

2. Data Analysis

We have used the daily Mt. Wilson velocity data during 1986-1994, which is relatively more accurate than the data before the year 1986 (Ulrich 2001). Earlier, to reduce influence of gaps in the daily data to the derived results, the data were rebinned into 19-day consecutive intervals (Javaraiah & Komm 1999). Now, in order to determine the values of the short periodicities in $\bar{A}$ accurately, we avoided rebinning of the daily data and the gaps were filled with interpolated data. We have computed the power spectrum of $\bar{A}$ and shown it in Figure 1 (lower frequencies portion).

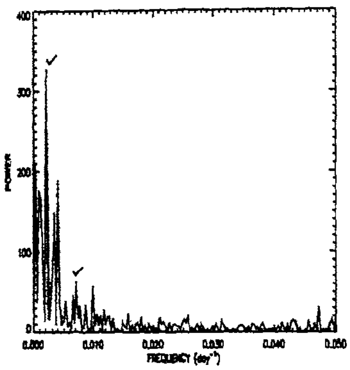

Figure 1. Power spectrum of the daily values of $\bar{A}$ during 1986-1994. The peaks at the corresponding frequencies of 1.3-yr and 153-day periodicities in $\bar{A}$ are indicated by tick marks.

3. Results and Discussion

In Figure 1, the peak at the corresponding frequency of the 1.3 ± 0.1 yr periodicity in $\bar{A}$ is dominant and significant on 23σ level. The peak at the corresponding frequency of the 153 ± 5 day periodicity in $\bar{A}$ is significant on 3.2σ level. In the power spectrum of $\bar{A}$ obtained from the data during the decay phase of cycle 22, it is found that the peak at the corresponding frequency of the ~153-day periodicity is significant on 6.3σ level. The 1.3-yr periodicity in $\bar{A}$ may be related to the 1.3-yr periodicity seen in variation of the Sun's internal rotation rate near the base of the convection zone. The aforesaid both periodicities in $\bar{A}$ may also be related to the similar periodicities seen in sunspot activity.

References

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