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Solar rotation rate from minimum to maximum of activity cycle

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Abstract. Using helioseismic data from SOI/MDI and GONG for the current solar cycle 23, from solar minimum to near maximum phase, we report here on the temporal variation of the rotation rate.

Key words : Sun : oscillations, Sun : activity

1. Introduction

Over last few years remarkable progress has been made in characterising the differential rotation of the sun. Using the first 4 month's Global Oscillation Network Group (GONG) data, Thompson et al. (1996) have qualitatively confirmed the results of earlier analyses that the differential rotation changes to rigid rotation below the outer 30% of the solar radius. In addition, data from GONG network and medium-l program of Michelson Doppler Imager (MDI) onboard Solar and Heliospheric Observatory (SOHO) have allowed more detailed study of the rotational dynamics of the Sun. This is achieved due to the splitting of the Sun's global oscillation frequencies by large scale flows.

2. Analysis and results

In this study, we use data from both GONG and MDI to determine the rotation rate in the convection zone. Each of the 45 GONG data sets covers a period of 108 days from May 7, 1995 to December 23, 1999 (splitting coefficients are fitted up to a_9). The MDI data consist of twenty 72 days time series from May 1, 1996 to August 31, 2000 (coefficients up to a_{18}) and include the breakdown period of mid 1998. In the present work, we restrict the frequency range to $1.5 \leq \nu \leq 3.25$ mHz and $50 \leq \ell \leq 190$.

We have carried out a detailed analysis of variation in odd-order a coefficients. We find that first few odd-order coefficients (up to a_7) from MDI show significant correlation with activity indices while GONG odd-order coefficients reveal weaker correlation (for details, see Jain, Tripathy and Bhatnagar, 2001).

To calculate rotation rate, we use the analytical method of Morrow (1998) where the appropriate combination of odd order splitting coefficients reflects the depth variation of angular velocity at chosen latitude θ (Jain, Tripathy & Bhatnagar, 2000 and references therein).

Figure 1 shows the residual surface rotation rate at two different latitudes obtained after subtracting the average angular velocity. It is evident that at higher latitudes, the residual rotation rate, commonly known as zonal flows, is time dependent and has a magnitude of approximately 1-2 nHz at equator. This variation is marginally larger than the error bars. There results mostly agree with similar studies using inversion techniques (Antia and Basu, 2000; Howe et al., 2000).

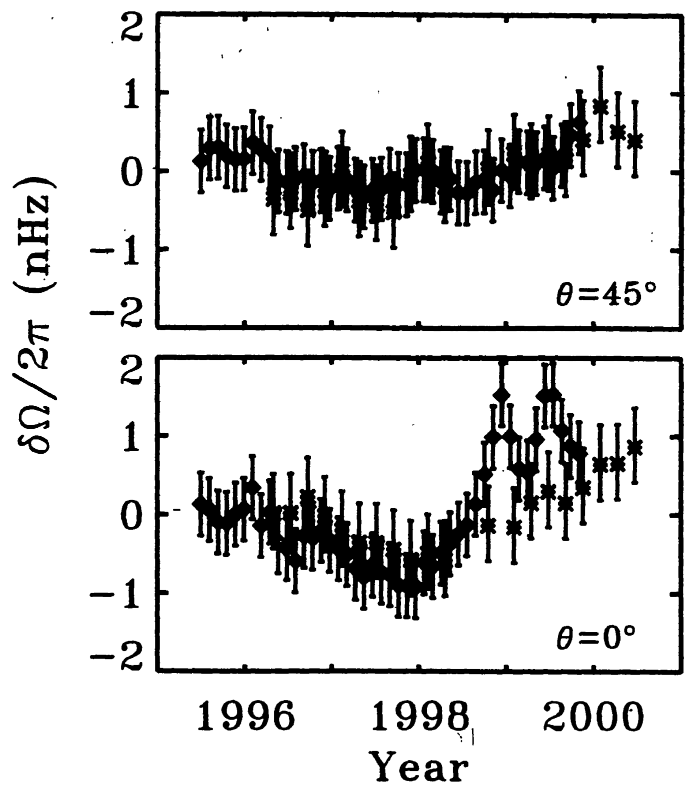

Figure 1. The temporal evolution of residual rotation rate on the surface at two different latitudes using both GONG (diamonds) and MDI data (stars). The error bars are shown by 1σ values.

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