Have We Entered a 21st Century Prolonged Minimum of Solar Activity?
Revisiting a 1987 Prediction: Updated Forecast and New Results

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Fairbridge and Shirley (1987) predicted that a Maunder-type prolonged minimum would be under way by 2013 on the basis of a study of the solar motion with respect to the solar system barycenter in the years 765-2100.

Nearly all of the effects predicted or observed to accompany solar prolonged minima are now in evidence (Table 1).

Recurrence patterns of two dynamical indices of the solar motion were employed to obtain the prediction. Key aspects are summarized below.

Orbital spin coupling is a leading hypothesis for the observed relationships of solar motion and solar variability (Shirley 2006). Direct evidence of solar orbit-spin coupling is found in Juckett (2003; Fig. 4 below) and in Javaraiah (2005).

New evidence of a direct relationship linking the variability of the solar orbital angular momentum with the excitation of time-varying meridional flows on and within the Sun is presented in Figure 4.

Figure 1: Phase synchronization of dL/dt and SSN: Symmetric orbit progression and moderate levels of solar activity

Figure 2: Disordered orbit progression and loss of synchronization of dL/dt and solar activity

Figure 3: Reconstructed low-frequency variability of torsional oscillations in sunspot group motions compared with dL/dt (Juckett, 2003). The solid curve of panel (a) is reconstructed from Fourier coefficients describing the spatial and temporal patterns of sunspot group motions over 125 yr. The dotted curve gives dL/dt (after Jose, 1965) for the same interval. Panel (b) shows Fourier coefficients of the two series, which are both dominated by a signal at the frequency of the synodic period of the planets Jupiter and Saturn.

Table 1. Observed and predicted effects associated with solar prolonged minima.

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Figure 4. dL/dt and Meridional Flow Speeds for Cycles 21-23.

Meridional flows are believed to play an important role in setting both the timing and the amplitude of sunspot cycles (Dikpati & Charbonneau 1991, Wang et al. 2002, Dikpati et al. 2004).

Upper curve: High-resolution absolute value of dL/dt for 1979-2010 (JPL Horizons System solution for solar motion). Time step 5 days. Higher frequencies are due to inter planet contributions.


Lower: Monthly sunspot numbers (NOAA).

Summary

Present conditions are consistent with the predicted inception of a new prolonged minimum of solar activity during cycle 24.

Advances in our understanding since 1987 provide no reason to modify the prediction. Maximum solar activity levels attained during prolonged minima should be comparable to levels observed during normal solar cycle minima.

New findings continue to support the hypothesis of an influence of the solar orbital motion on the excitation of solar variability. Orbit-spin coupling is a strong candidate.

Observed solar meridional flow speeds over 3 solar cycles appear to vary with the rate of change of the solar orbital angular momentum dL/dt (Fig. 4).

We propose that the variability of the observed meridional flows is a direct result of solar orbit-spin coupling.

Dynamo models incorporating dL/dt as a scaling factor for solar meridional flows may yield new insights. Theoretical investigations to advance the development of an appropriate mathematical formalism for solar orbit-spin coupling are recommended.

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New Results: dL/dt and Meridional Flows

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