Estimates of the Height and Date of the 25th Cycle of Solar Activity

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Abstract. Further development of the work of Obridko et al. [1] based on recent data confirms the assumption that the 25th cycle of solar activity is a medium-low cycle. Its height is expected to be 125.2 ± 5.6, and the expected date of the maximum phase is the end of 2023 or the first quarter of 2024.

Introduction

Obridko et al. [1] analyzed the evolution of the large-scale magnetic field on the Sun during the last four cycles from 1976 to early 2022. WSO data (http://wso.stanford.edu/) have been used. Special attention was paid to the effect of prolonged cycles of solar activity. The term appeared in literature in 1988 [2, 3], although during that decade, observational evidence appeared indicating that the magnetic activity of one cycle overlapped for some period of time (often up to several years) with that of the previous cycle [4]. As observed on the surface, the extended solar cycle starts during the sunspot maximum at high latitudes and consists of a relatively short polarward branch (described as "rush to the poles") and a long equatorward branch, which continues through the solar minimum and the following sunspot cycle [5], see also [6] for review.

The polaward and equatorward waves appear almost simultaneously and have opposite predominant polarity of the magnetic field. There are periods when two вЂњrush to the polesвЂќ waves with the field of opposite signs coexist in the Sun, one of which has nearly reached the pole and the other has just appeared at mid latitudes. In such periods we can see three zones of alternating polarity in each hemisphere.

The moment, when all three types of waves are simultaneously present on the disk and, as a whole, six intermittent zones are observed, exactly corresponds to the zonal harmonic with $l = 5$. We propose to call this time interval "the overlapping phase". As seen below, the overlapping phase can be quantitatively described in terms of the 5th zonal magnetic field harmonics, which, in this connection, can be referred to as the height of the overlapping phase. During the overlapping phase, three activity waves coexist on the solar surface, which lead to the appearance and enhancement of the odd zonal harmonic with $l = 5$.

The maximum amplitude of this harmonic dramatically decayed over the past four cycles similar to the cycle amplitude recorded in sunspot numbers. A particularly strong decline
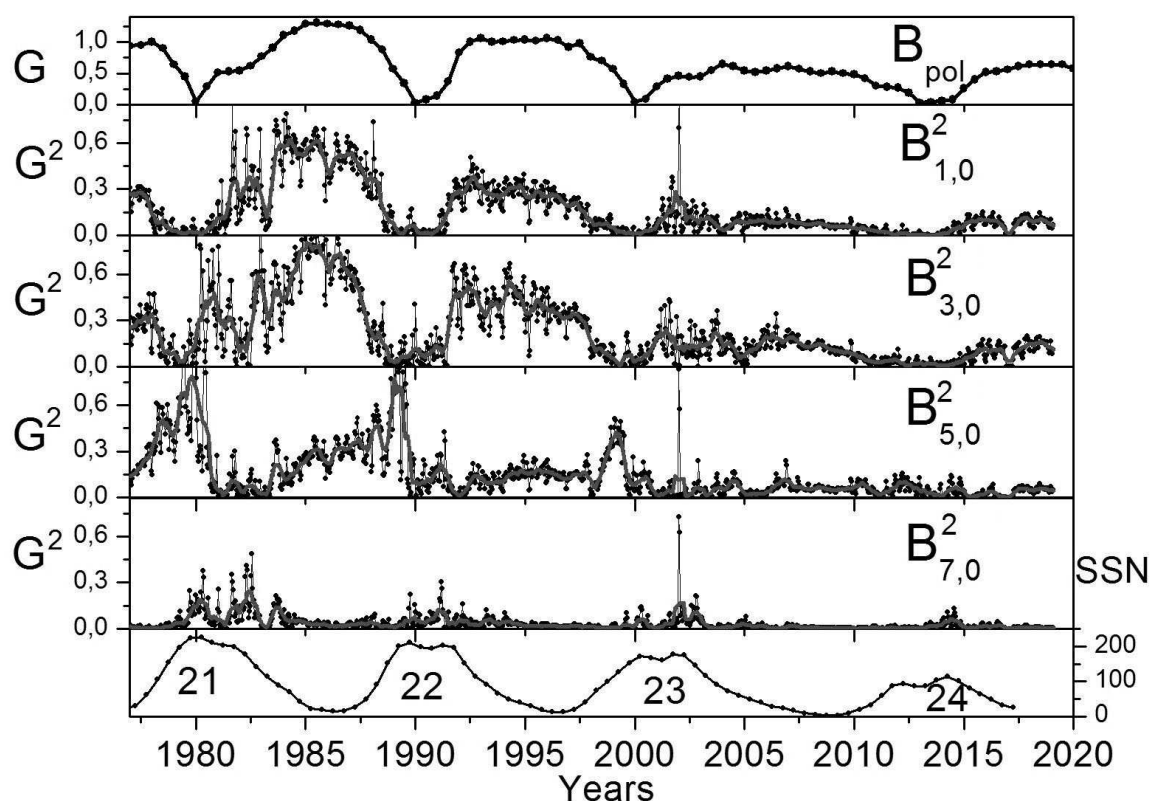
Figure 1: Time dependence of the squared magnetic field connected with the first odd axisymmetric harmonics up to $l = 7$ [1] . The lowest plot represents the time variation of sunspot numbers (SSN) with the cycle numbers indicated; the top plot is the polar field.

in the value of the $g_{5,0}$ harmonic is observed after 2000, and this led to the low Cycle 24. Of course, four cycles are not enough to provide a convincing statistics; however, it seems plausible that Cycle 25 will not be much higher than Cycle 24.

New estimates

At present, new data have appeared that support this conclusion.

1. In the middle of 2022, an increase of the fifth zonal harmonic was recorded. Although this peak is not high and is much lower than in Cycles 21, 22, and 23, it certainly indicates the near onset of a low sunspot maximum. In Cycles 21, 22 and 23, the maximum of this harmonic was ahead of the sunspot maximum by no more than 1-1.5 years.

2. In March 2023, a reversal of the polar magnetic field was recorded, and in June 2023, half the sum of the field values at both poles turned to zero. This usually indicates the proximity of the sunspot maximum. At the same time, in Cycles 21 and 22, the field

reversal virtually coincided with the date of the sunspot maximum; in the low Cycle 24, the polarity reversal was ahead of the sunspot maximum by about a year.

3. The relation between the magnitude of the polar field and the height of the upcoming sunspot maximum number has been often used for forecasting. At present, reliable measurements of the polar field strength in Cycles 22, 23, and 24 are available. The relationship between the polar field strength and the height of the upcoming cycle is described by the formula:

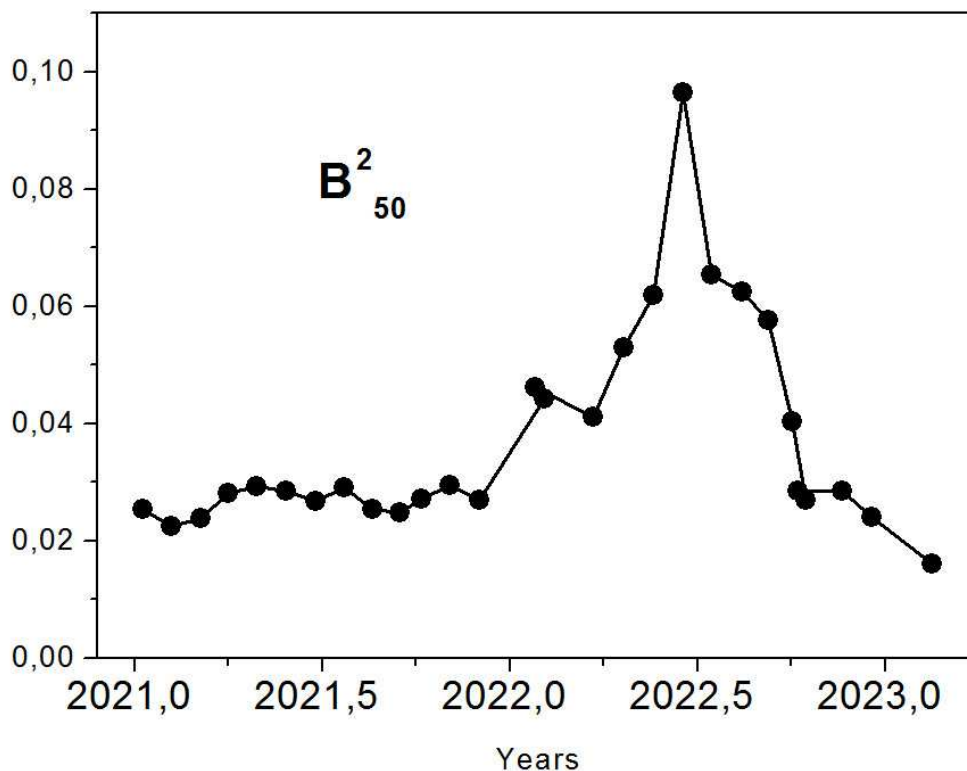$$SSN_{max} = 36.405 + 1.3666\, B_{pol} \tag{1}$$

Figure 2: The squared amplitude of the fifth harmonic as a function of time in 2021-2022.

The last maximum value of B_{pol} equal to 65 μT was recorded in summer 2019 (see the site http://wso.stanford.edu/Polar.html). Hence, the predicted value of SSN in Cycle 25 is 125.2 ± 5.6. This is only a few units higher than in Cycle 24 (116.4).

References

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