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# Dependence of solar cycles duration on the magnitude of the annual module of the sunspots magnetic field

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**Abstract.** The dependence of the solar cycle duration, $T$, on the 3 years averaged module of the large-scale sunspots magnetic fields (30-60 arcsec), $B_{sp}$ index, was investigated on the base of about 10,000 visual observations conducted during last eight (16-23) cycles. It was found that the duration $T$ of the investigated cycles linearly depends on the index $B_{sp}$ of the magnetic fields observed during 3 years on decline phase of the solar cycle (second, third and fourth years after solar maximum $T_{max}$). Namely, the duration of the cycles $T$ was varied between 9,5 and 12,5 years, when the magnetic index $B_{sp}$ was ranged from 2450 to 2600 G. An explanation for this dependence is proposed within the framework of non-linear $\alpha\Omega$- dynamo model. We found the following equation for the dependence of solar dynamo-period on magnetic index: $T \approx B_{sp}^{3/2}$. Therefore, the large observed index $B_{sp}$, the longer calculated period $T$.

**Keywords.** Sun: activity, Sun: sunspots, magnetic fields

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The new index of annual averaged module of the magnetic fields for the large-scale sunspots with penumbra diameter 30-60 arcsec (22-44 Mm), $B_{sp}$, measured by visual method on the Zeeman splitting in the Fe I $\lambda\lambda$ 525.02 and 630.25 nm lines was proposed (Lozitska 2005). The dependence of duration of last eight (16-23) solar cycles, $T$, on the observed annual index, $B_{sp}$, was investigated by Lozitska this year. Firstly, it was ascertained the dependence of sunspot magnetic field value on the time, years of cycle relatively maximum epoch, $T_{max}$, of the average solar period (Fig. 1, where $B$ corresponds to index $B_{sp}$). Then it was found that the duration of the investigated cycles, $T$, was varied between 9,5 -12,5 years, when the maximal 3 years averaged magnitude of magnetic induction, $B_{(Tmax+3)}$ (index $B_{sp}$), was ranged from 2450 to 2600 G (Fig. 2).

An explanation for the derived dependence is proposed within the framework of non-linear $\alpha\Omega$- dynamo model. According to our conception (Krivodubskij 2012) the magnetic index $B_{sp}$ reflects information on values of the deep toroidal field $B_T$ in the solar convection zone (SCZ). So this index could be used for the dynamo-period estimation. In this case the period of solar dynamo-cycle in non-linear regime is determined by equation $T = 2\pi/\{(1/2)\,|\alpha(\beta)\,\partial\Omega/\partial r|\}^{1/2}$ where $\alpha$ is the parameter of mean helicity of turbulent convective pulsations, $\partial\Omega/\partial r$ is the radial gradient of angle velocity, $\Omega$, in the SCZ, $\alpha(\beta) = \alpha_0\ \Psi_\alpha(\beta)$ is the helicity parameter of the turbulent pulsations, $\alpha_0$ is the "non-magnetic" helicity parameter, $\beta = B_{sp}/B_{eq}$ is the normalized magnetic field, $B_{eq} \approx v(4\pi\rho)^{1/2}$ is the equipartition magnetic induction, $v$ is the small-scale turbulent velocity, $\Psi_\alpha(\beta)$ is the quenching-function. We took into account that the alpha-quenching for strong magnetic field ($\beta \gg 1$) is expressed by the equation $\alpha(\beta) = \alpha_0\ \Psi_\alpha(\beta) = \alpha_0 15\pi/64\beta^3$ (Rüdiger & Kitchatinov 1993; Krivodubskij 2005). Since the period of

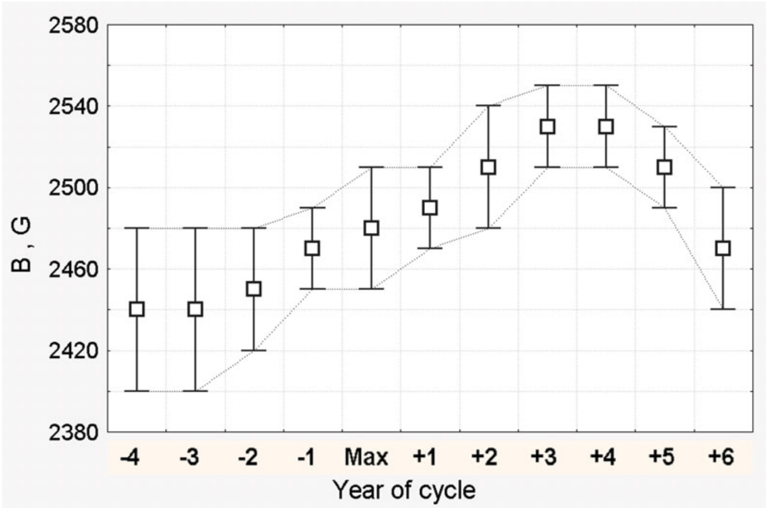


**Figure 1.** Sunspots magnetic field 3 year averaged, $B_{(Tmax+3)}$, relatively solar maximum, $T_{max}$, against years of average cycle period (16 -23 cycles).

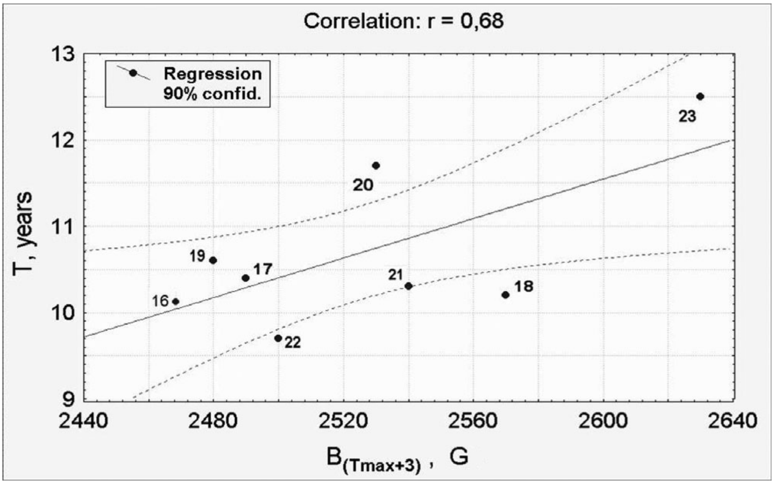


**Figure 2.** Solar cycles duration, $T$, dependence on 3 years average sunspots magnetic field, $B_{(Tmax+3)}$ (index $B_{sp}$), during 2, 3 and 4-th years after epoch of maximum sunspots relatively numbers (16 -23 cycles).

dynamo-cycle $T$ is reversely proportional to square root from the parameter $\alpha(\beta)$ then we found following equation for the period dependence on the magnetic parameters, $T \approx \beta^{3/2}(\approx B_{sp}^{3/2})$. Thereby, we received following correlation between magnetic index and cycle period: the large observed index $B_{sp}$, the less calculated quenching-function $\Psi_\alpha(B_{sp})$, and therefore the longer calculated period $T$.

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