

Long-term variation in the Sun's activity caused by magnetic Rossby waves in the tachocline

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Abstract:

Long-term records of sunspot number and concentrations of cosmogenic radionuclides (^{10}Be and ^{14}C) on the Earth reveal the variation of the Sun's magnetic activity over hundreds and thousands of years. We identify several clear periods in sunspot, ^{10}Be , and ^{14}C data as 1000, 500, 350, 200, and 100 years. We found that the periods of the first five spherical harmonics of the slow magnetic Rossby mode in the presence of a steady toroidal magnetic field of 1200-1300 G in the lower tachocline are in perfect agreement with the timescales of observed variations. The steady toroidal magnetic field can be generated in the lower tachocline either due to the steady dynamo magnetic field for low magnetic diffusivity or due to the action of the latitudinal differential rotation on the weak poloidal primordial magnetic field, which penetrates from the radiative interior. The slow magnetic Rossby waves lead to variations of the steady toroidal magnetic field in the lower tachocline, which modulate the dynamo magnetic field and consequently the solar cycle strength. This result constitutes a key point for long-term prediction of the cycle strength. According to our model, the next deep minimum in solar activity is expected during the first half of this century.