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Persistence of weak magnetic cycles during solar grand minima episodes

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Sunspot observations over the past few centuries reveal that the Sun occasionally slips into quiescent phases, known as solar grand minima. In our dynamo model, we employ stochastic fluctuation in the source term of the polar fields to simulate such grand minima episodes. Our simulations detect a gradual decay of the polar field at the onset of a solar grand minimum followed by a halt in the polar field reversals. But, the large-scale meridional circulation continuously dredges up magnetic fields to the solar surface and advects them further to the polar caps. This eventually builds up polar magnetic fields, strong enough to sustain the regular surface activity again, aiding in the recovery from the grand minimum. Spectral analysis of the hemispheric polar flux time series during simulated grand minima reveals the significant signature of multiple frequencies apart from the 11-year sunspot cycle. In this work, we focus on a ~ 5-year component and establish its causal connection with the meridional circulation characteristic timescale. Our numerical results are in good agreement with the long-term reconstructed solar activity data.

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