Empirical solar/stellar cycle simulations

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Abstract

In the Sun, as a result of the solar dynamo, the level of magnetic activity varies according to the 11-year solar cycle. The changes in the overall magnetic field are accompanied by a periodic variation of the number of emerging sunspots, the total area covered by them and the gradual equatorward migration of sunspots. Likewise, the properties of solar oscillations, in particular frequencies and amplitudes, are observed to vary over the solar cycle. However, it is still not clear to what degree these variations result from the direct effect of the sunspots on the propagation properties of the acoustic waves. With the recent discovery of manifestations of activity cycles in the the asteroseismic data of other stars, and the consequent perspective of studying stellar dynamos under different conditions, the understanding of how different agents contribute to the activity-related variations in the properties of stellar oscillations becomes even more important.

The primary objective of the work presented here is to build an empirical model capable of simulating the main characteristics of the distribution of sun/stellar spots over an activity cycle. The variation in the number of sunspots, their areas and latitudes are taken as inputs to our model. We started by a simple toy model and gradually increased its complexity in order to improve the simulations. Here we present the model and show that the current simulations reproduce reasonably well the properties of the sunspot cycle (number of sunspot groups, areas and latitudinal distribution). It is our intention, at a later stage, to reduce the model complexity to simulate cycles of other solar-like stars, from which much less information is available.

The simulations obtained from our model can be used to estimate the frequency shifts induced by the presence of spots in the stellar surfaces. Here we present a preliminary comparison of the simulated frequency shifts with the frequency shifts observed over the solar cycle.

Finally, we note that this kind of simulations may have other applications, such as in the study of radial velocity signals for exoplanet search. In particular, the simulations may help designing strategies to reduce the signatures induced by stellar activity in the radial velocity.

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