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Non-stationarity and cross-correlation effects in the MHD solar activity

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Abstract

The analysis of turbulent processes in sunspots and pores which are self-organizing long-lived magnetic structures is a complicated and not yet solved problem. The present work focuses on studying such magneto-hydrodynamic (MHD) formations on the basis of flicker-noise spectroscopy using a new method of multi-parametric analysis. The non-stationarity and cross-correlation effects taking place in solar activity dynamics are considered. The calculated maximum values of non-stationarity factor may become precursors of significant restructuring in solar magnetic activity. The introduced cross-correlation functions enable us to judge synchronization effects between the signals of various solar activity indicators registered simultaneously.

Keywords: Solar activity; Sun: magnetic fields; Sunspots; Methods: multi-parametric analysis; Non-stationarity and cross-correlation effects

1. Introduction

Despite the advances in modern ground and space observations of the Sun using the high spectral and spatial resolution devices for spectro-polarimetric data analysis and the progress made in studying the structure and the dynamics of sunspots, the problem of establishing a link between global dynamo processes in the Sun and formation of sunspots is very complicated to solve, since spontaneous generation of self-organizing magnetic structures (e.g. sunspots and pores) presents a complex interaction between convection and magnetic fields at various scales. Thus, during a simulation of sunspots formation it is necessary to take into account a large number of multi-parametric dynamic processes (e.g. influence from self-forming strong horizontal magnetic fields and self-organizing turbulent ascending and descending streams) (Kitiashvili, 2012). At the same time, helioseismology studies of small magnetic sunspots self-organization into larger structures show the importance of taking into account turbulent convection. The recent achievements in numerical simulation of MHD of sunspots have allowed building realistic radioactive numerical models (Kitiashvili et al., 2016; Kitiashvili, 2016).

The solar magnetic activity cycles and large-scale structures of the solar magnetic field may be described by non-linear dynamo models in the convection zone (Weiss and Tobias, 2000; Kleeorin et al., 2003). The non-linearity effects in solar magnetic activity appear for a reason. This is connected with the fact that the interaction between the magnetic field and the moving plasma is a non-linear process due to the solar axial rotation. We should also note that oscillations of Wolf daily numbers are of noise nature. The considered periods are of quasi-periodic nature with irregular changes of phase and amplitude. It has been found previously the chaotic nature of solar activity processes manifests at relatively long periods of time (Isliker

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