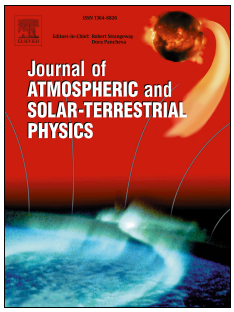
Accepted Manuscript



On a role of quadruple component of magnetic field in defining solar activity in grand cycles

E. Popova, V. Zharkova, S. Shepherd, S. Zharkov

PII: S1364-6826(17)30003-2

DOI: 10.1016/j.jastp.2017.05.006

Reference: ATP 4592

To appear in: *Journal of Atmospheric and Solar-Terrestrial Physics*

Received Date: 3 January 2017

Revised Date: 7 April 2017

Accepted Date: 6 May 2017

Please cite this article as: Popova, E., Zharkova, V., Shepherd, S., Zharkov, S., On a role of quadruple component of magnetic field in defining solar activity in grand cycles, *Journal of Atmospheric and Solar-Terrestrial Physics* (2017), doi: 10.1016/j.jastp.2017.05.006.

On a role of quadruple component of magnetic field in defining solar activity in grand cycles

Popova E.[a], Zharkova V.[b], Shepherd S.[c], Zharkov S.[d]

[a]*Lomonosov Moscow State University, Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences, Russia*
[b]*Department of Mathematics, Physics and Electrical Engineering, Northumbria University, UK*
[c]*School of Engineering, Bradford University, UK*
[d]*Department of Physics and Mathematics, Hull University, UK*

Abstract

In this paper we revise our prediction of solar activity using a solar background magnetic field as a proxy by the inclusion of eigen vectors of solar magnetic waves produced by quadruple magnetic sources, in addition to the principal eigen modes generated by two-layer dipole sources (Zharkova et al., 2015). By considering the interference of two dipole and one quadruple waves we produce the revised summary curve for the last 400 years accounting for the additional minima of solar activity occurred at the beginning of 19th (Dalton minimum) and 20th centuries. Using the dynamo model with meridional circulation and selecting the directions of circulation for quadruple waves, we estimate the parameters of quadrupole waves best fitting the observations in the past grand cycle. The comparison shows that the quadruple wave has to be generated in the inner layer of the solar convective zone, in order to provide the additional minima observed in 19 and 20 centuries, thus, naturally accounting for Gleissberg centennial cycle. The dynamo wave simulated for the dipole and quadruple sources reveals much closer correspondence of the resulting summary curve derived from the principal components of magnetic field varitions to the solar activity oscillations derived from the average sunspot numbers in the current grand cycle.

Keywords: sunspots, magnetic field, solar activity cycle, Principal Component Analysis, solar dynamo, Gleissberg cycle, grand cycle