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EXOPLANETS AND POPULATION APPROACH IN PLANETARY DYNAMOS

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Observation of exoplanet systems opens new perspectives in various branches of astrophysics. Here we suggest how to use in future the data concerning the magnetic field of exoplanets to clarify the place of geodynamo among other kinds of spherical dynamos.

Keywords: Exoplanets – Geodynamo – Planetary dynomo.

1. INTRODUCTION

Successful observations of exoplanetary systems open a new and very important page in contemporary astronomy. Available sample of more or less firmly identified exoplanets with estimated mass, orbital radius, orbital period and other relevant integral quantities is already quite large. It looks reasonable now to think how this information can be used to clarify various more general astronomical and paleontological problems. An example of such investigation is presented in a recent paper [1] which demonstrates how data concerning exoplanets and magnetic activity of their host stars allow us to reject the hypothesis that the 11-year solar activity cycle is driven by the effect of Jupiter (corresponding orbital period is also 11 year). The aim of this short note is to suggest one more direction of similar development, i.e. clarification of the place of geodynamo among other dynamos.

2. GEODYNAMO AMONG ANOTHER ASTROPHYSICAL AND PLANETARY DYNAMOS

The Earth's magnetic field is believed to be driven by more or less the same physical process as, say, solar magnetic field, i.e. by a dynamo driven by differential rotation in convective shell and mirror asymmetry of convection. The

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temporal behavior of the Earth's magnetic field is however quite different from that of the solar magnetic field (e.g. [2]). Solar magnetic field oscillates with a period about 22 years, which leads to 11-year oscillations in sunspot numbers. In contrast, the Earth's magnetic field remains almost stationary in times comparable with the human civilisation age and demonstrates in a geological timescale a sequence of abrupt magnetic field inversions which occur in randomly distributed instants. Both types of behaviors can be reproduced in the framework of suitable dynamo models which are however quite different from one another. In particular,a more or less realistic solar dynamo model can be formulated in terms of a mean-field approach with a dynamo saturation presented in terms of magnetic helicity balance while differential rotation is only moderately modified. In contrast, a realistic simulation of geodynamo requires microscopic direct numerical simulations and includes substantial modification of differential rotation in the outer core of the Earth.

Contemporary geodynamo models are quite complicated. Relevant direct numerical simulations became realistic in 90-th of the previous century only. Qualitative analysis of the models is a problematic undertaking. At the previous stage of research, in early 1990th expertis is geodynamo developed a number of less sophisticated numerical models which allow a qualitative analysis which isolated a number of various regimes with various scalings of relevant parameters, say, magnetic and rotational moments (see for review e.g. [3]). Such scalings was discussed in planetary dynamo studies at the early stages of research (e.g. [4]) however do not attract attention in cointemporary models. It is impossible to get such scalings from observations inside solar systems because the Earth seems to be an isolated example here in respect to its magnetic properties and comparison with, say, Jupiter's satellites seems to be of limited importance.

3. POPULATION APPROACH

It looks plausible that observations of magnetic properties for exoplanets could help in understanding of the place which occupies the Earth among various more or less similar planets and understand the place of geodynamo among other regimes of spherical dynamos. One can refer to this approach as a population approach in planetary dynamos. This approach can be compared with similar approaches in stellar activity studies. A more or less rich stellar sample with known magnetic activity was obtained here in 1990th in the framework of so-called H-K project [4] what allow to obtain a scaling between stellar rotational moment J and corresponding magnetic moment M which scale as follows [5]:

$$M \sim \sqrt{J}. \tag{1}$$

Further studies yields in isolation of other stellar populations where scaling (1) is saturated (e.g. [6]). Both scalings admit a qualitative explanation in terms of spherical dynamos.

Our point is that obtaining similar scalings for exoplanet magnetic fields may be an important step to understand the place of geodynamo among other spherical dynamos and isolate particular regimes of planetary dynamos.

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