Dear Referee,

We appreciate your interest to our article and your remarks. We replay on them step by step.

1. REFEREE.

The title of the paper is misleading. "Non-local" implies rather some spatial non-locality (space correlation, non-local interactions, etc.), than time effects. In fact, authors intend to introduce a dynamo model with memory. Different titles can be suggested (Reversals in an $\alpha\Omega$-dynamo model with memory, Reversals in an $\alpha\Omega$-dynamo with retarded quenching, etc.).

AUTHORS.

Non-local properties may be considered both in time and space. In our paper we describe just the time non-locality (of memory or hereditarity). However, we agree, that we should specify it in the title more accurately. It is important since we unsuccessfully put together the spatial (large-scale) and time (non-locality) characteristics. So, we decided to change the title of the manuscript to "Reversals in a large-scale $\alpha\Omega$-dynamo with memory". We'll also note it in the annotation and in the text of the paper, that "non-locality" implies just time non-localness.

2. REFEREE.

The introduction is redundant large. People, who can be attracted by the title (or the abstract) are familiar for sure with the induction equation (in the general form and in mean-field approximation). The idea of Parker's dynamo model is also well known in the dynamo community.

AUTHORS.

The main equations to dynamo theory and the $\alpha\Omega$-dynamo mechanism are well known by the specialists in this area. However, NPG is not a dedicated journal of dynamo community. The readers are the specialists in different areas of Geophysics. Thus, we find it appropriate to describe the main notions of dynamo in the introduction.

3. REFEREE.

On the contrary, the main part of the paper could be extended. In my opinion, the model (6) is more attractive, because it is really a model with memory. Authors found that this model cannot give reversals without the change of the sign of $R_\alpha$, and stopped by this. It's a pity that they have not tried to overcome this problem. A simple suggestion is to consider $B^T B^T$ instead of $B^2$. There are many other possibilities of course.

AUTHORS.

We determined that the model (6) has two asymptotically stable stationary points. We think that this does not give the possibility to reversal the system between these points.

If we use the products $B^T B^T$ in (5) and (6) instead of $B^2$, we'll obtain not so much the quenching as the control of magnetic helicity.

Generally speaking, it follows from the expression for Lorenz force, that the quenching mechanism must be quadratic in magnetic field. In the considered model it means that $R_\alpha$ must be a quadratic function (functional) from $B^T$ and $B^P$. The product $B^T B^P$, which you suggested, is also quadratic. However, if we want to realize quenching, the relations $R_\alpha R_{\Omega 1} > 1$ for $B < 1$ and $R_\alpha R_{\Omega 1} < 1$ for $B > 1$ must be satisfied. Any quadratic function from $B^T$ and $B^P$, satisfying these relations has the form (5). If it is necessary, we can prove it mathematically.

4. REFEREE.

The random model (7-9) is interesting, but uses an independent random process, which has nothing to do with the memory of the dynamo process. Why not include in some way the "dynamo memory" in this random process? Also a variety of possibility to realize it exists.

Summarizing, it is a pity that authors have not considered a real dynamo model with memory (implicitly promised in the introduction). In my mind it requires few additional efforts only.

AUTHORS.

The random process considered in the model (7-9) is independent from the functions $B^T$ and $B^P$. We suppose that two large-scale modes, toroidal and poloidal ones, are distinguished in the average field, and present them by the amplitudes $B^T$ and $B^P$. But besides them there are smaller modes in the average field, the equations of which we neglect. We assume that a random process describes the effect of these neglected modes (lines 16-19, p. 1721). That is why the process is independent only from two large-scale modes. Non-Markov character of the process $\xi$ result in non-Markov solutions of the stochastic system (4, 7-9). These solutions have the memory, the memory in stochastic sense, just like any non-Markov process does. Thus, we think that there is memory in the model (4, 7-9).

As you write, it is possible to try to include dynamo memory into a random process. It is possible, for example, to join the expressions (6) and (7-9). We mentioned such a possibility (lines 20-22, p. 1721) and plan to make such generalization in the future.

However, to our opinion, the described model is the result of a separate stage of work and may be the subject of an article.

5. REFEREE.

The English should be checked (What is "differential nature of the middle course", "real space dynamo systems", "the authors of Frick et al. (2006) found that", etc.).

AUTHORS. The authors are not English native speakers, that is why they appreciate any remarks on the language. All the phrases you’ve mentioned will be changed.

'Comments to paper', Anatoly S. Leonovich, 19 Feb 2015
Dear Dr. Leonovich, We appreciate your interest to our article and your remarks. We replay on them step by step.

1. REFEREE.

It is clear that if the dynamic equilibrium system get unbalance due to intense random shocks, it either after a brief excursion come back to its original state, or goes into a new equilibrium state.

AUTHORS.

Almost any dynamic system can be transferred between the equilibrium states due to intense random shocks, of course. We tried to understand the following: Is it possible to obtain a sequence of reversals with certain statistical properties in such a dynamical system?

2. REFEREE.

Another question is how well such a simple model describes the real inversion of the geomagnetic field. This model can be applied to any dynamic equilibrium systems.

AUTHORS. We wanted to get the sequence of reversals with the statistical properties of the real paleomagnetic polarity scale exactly in the SIMPLEST model of $\alpha \Omega$-dynamo.

This model must to retain only the main features of dynamo equations: 1) quadratic nonlinearity, 2) the generation of the toroidal field on $\Omega$-stage and the generation of the poloidal field on $\alpha$-stage (for $\alpha \Omega$-dynamo), 3) mechanism of quenching, quadratic on the magnetic field. The results of our calculations indicate that reversals with needed properties can be obtained even in this simplest case.

3. REFEREE.

It seems to me, that the similar works were carried out already by other authors for more complex geodynamo models. It would be interesting if the authors compared their results with those obtained in previous works by follow authors: M.Yu. Reshetnyak, Frank Strfani, A. Giesecke, G. Rudiger

Please also note the supplement to this comment: http://www.nonlin-processes-geophys-discuss.net/1/C931/2015/npgd-1-C931-2015-supplement.pdf

AUTHORS.

In this article researched the model $\alpha^2$-dynamo. Authors of article took into account the spatial structure of the fields and of the $\alpha$-effect. In the article obtained an irregular sequence of inversions, However, the polarity interval has an exponential distribution. Sequence of reversals is a Poisson process. In this processes can not get the self-similarity, and almost unbelievable superchrons duration of $10^8$ years. Such superchrons exist in real paleomagnetic polarity scale. Variation interval polarity by 5 orders of magnitude can only give a power-law distribution.

'Referee Comments', Anonymous Referee #2, 09 Apr 2015

Dear Referee, We appreciate your interest to our article and your remarks. We replay on them step by step.

REFEREE.

1.) General comments:

The length of the different sections does not coincide with their importance for the paper. The introduction and the description of the models are much longer than the actual results and their discussion. In my opinion there are three main parts missing:

A) Discussion on the applicability of the models for the geodynamo. Why do the authors neglect the alpha in the generation of the toroidal field completely? Is the differential rotation really so important for the geodynamo? What are the consequences for the model? And for the achieved results?

AUTHORS.

We adhere to the view expressed in [1] that the prevalence of axial dipole is a sign of the dominant role of differential rotation. Therefore, in our opinion consider $\alpha^2 \Omega$-dinamo makes sense for sufficiently detailed models, and simple model generation, described in the article confine $\alpha \Omega$-dynamo.

If we consider a simple model of $\alpha^2$ - dynamos, similar to that discussed in the work, it would be:

\[
\frac{dB^T}{dt} = R_\alpha B^P - B^T,
\]

\[
\frac{dB^P}{dt} = \pm R_\alpha B^T - B^P.
\]

Analysis system. At constant $R_\alpha$ we obtain in the case of the "minus" damped oscillatory solution, in the case of the "plus" get non oscillatory solution - a condition generation unit has the form $R_\alpha > 1$. By varying the $R_\alpha$ generate stable reception mode field inversions in such a model is not possible. In a much more general situation problematic occurrence oscillating solutions to $\alpha^2$ - dynamo is shown for example in [2]. Therefore we do not consider $\alpha^2$ mechanism.

These considerations at this point we are adding to the text of the article:

Section 2, page 1719, line 8.

REFEREE.

B) Comparison of the achieved results with other results in the dynamo community for similar models and also for the reversal of the geodynamo. For example: Wicht & Meduri, 2015 or Hubbart & Brandenburg 2009 and reference therein.

AUTHORS.

We have compared their results with those of other authors for similar models and add them to the article:

Section 1, page 1717, line 11;

Section 2, page 1720, line 24.

REFEREE.
C) What do these new achieved results mean for the dynamo community in general and for the geodynamo community in particular?

AUTHORS.

Discussion of the results added to the text of the article:
Section 5, page 1727, line 16.

REFEREE.

2.) More specific comments:

A) The authors use 'mean field' and 'large-scale' interchangeable. But actually there are not the same. A large-scale field can be also obtained by Fourier filtering. This method does not follow the Reynolds rules, which are required to calculate for example alpha. Therefore, I would suggestion to use "mean field", after the mean field induction equation has been introduced.

AUTHORS.

Since we are talking about the model of $\alpha \Omega$ - dynamo, they have suggested that it is a mean-field dynamo. But most average field contains, in general, different scale structures. Our approach is consistent with the single-mode approximation for the toroidal and poloidal components. It is clear that in this case we can talk about the larger scale. Ie we are talking about a large-scale approach for the middle of the field. Appropriate specification set:
Section 1, page 1718, line 20;
Section 2, page 1719, line 9;
Section 2, page 1721, line 1;
Section 2, page 1721, line 3.

REFEREE.

B) Section 2 i) What do the authors mean with: "... the spatial structure of the mean-field is axis is simple..."? Do they mean axis symmetric?

AUTHORS.

Quotations are not sure. We wrote the following: "... the spatial structure of the mean-field is simple...", This does not imply a mandatory axial symmetry, we mean that the dependence on the spatial components of the field variables can be neglected. More precisely, our views on this matter are set out in the answer to the following reviewers' comments.

REFEREE.

ii) How can the authors use a scale function for the poloidal field? It is more common to use instead the toroidal vector potential, because its curl is the poloidal field.

AUTHORS.

Used to represent the magnetic field two scalar function of time as follows. Consider the single-mode approximation for the toroidal and poloidal components: $B = B^T(t) \vec{b}^T(\vec{r}) + B^P(t) \vec{b}^P(\vec{r})$.

When we say that "... the spatial structure of the mean-field is simple...", we mean the possibility of such a representation. If we substitute this expansion into the equation of the middle of the field, and use the Galerkin method, we obtain a system of equations for the amplitudes of $B^T(t)$ and $B^P(t)$. This system is arranged as well as a system (3). This axial symmetry modes $\vec{b}^T(\vec{r})$ and $\vec{b}^P(\vec{r})$ is not required. We added the text of the article to be determined:
Section 2, page 1719, line 9.

REFEREE.

iii) Related to 1A, the authors should mention that they neglect the alpha in the first line of Equation (3) and give an explanation.

AUTHORS.

We agree. Corresponding changes have been made:
Section 2, page 1720, line 2.

REFEREE.

C) Section 3: Please move the parts below line 14 that contains results to the Section 4: 'Simulation results'. It is always good to have a clear distinction between model/simulation descriptions and results.

AUTHORS.

Taken into account, the transfer is made:
Section 3, page 1723, line 14.

REFEREE.

D) Section 4: lines 7-14: The authors speak about an power asymptotic dependence and try to express their results in terms of $\zeta^{-\delta}$. However, the plots shown to illustrate this posses a linear scale. I would strongly suggest to use a log-log scale instead of a linear scale to illustrate the power law behavior. Also then another question rise: The data does not contain more than one order of magnitude. How reliable is to use a power law for this limited data? Furthermore, I would like to know, what are the methods applied to obtain the values $\delta$? And more important: What are the errors related to this method and data?

AUTHORS.

Unfortunately, we failed to use labels on the coordinate axes. In fact, Figures 3 and 4 are constructed in a logarithmic scale, and the marks on the axes correspond to the order of magnitude. Therefore these figures show the relationship between two or three orders of magnitude. For $\delta$ calculation used the slope of the regression line for the data on a logarithmic scale. The coefficient of correlation modulo thus was not less than 0.92. This level of correlation suggests quite reliable choice of both the power relationship and the value of $\delta$. We have added in Table 1 except the values of $\delta$ dependence on $\gamma$ and $\epsilon$ value of the correlation coefficient for the corresponding straight sections of graphs to $10^3$.

Figure 3, page 1733;
Figure 4, page 1734;
Table 1, page 1730;
Section 4, page 1726, line 9.

REFEREE.

3.) Technical and small comments:

A) The authors often use the expression: "large-scale model $\alpha \Omega$ - dynamo" or something similar. But the model is not "large-scale", the magnetic field or maybe the dynamo is large-scale. Please revise.

AUTHORS.

Corresponding changes have been made:
In the equation, the magnetic field can be dimension by him for an arbitrary characteristic value. Thereafter, the output is stable generation of the value of the field \( B = \sqrt{|B_T|^2 + |B_P|^2} \) on the value of one. It is this suppression mechanism is provided, represented by the formulas (5) and (7).

**REFERENCES:**