Average magnetic field in a random stream with an update

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Abstract: In this paper we derive the equation of the average magnetic field in a random flow with an update and an asymptotic analysis of the obtained equation is carried out.

Consider the equation of magnetic induction $\overrightarrow{H} = \overrightarrow{H}(t,x)$ in a random flow $\overrightarrow{V}(t,x)$ of an incompressible medium with a constant magnetic viscosity ν_m $(t \geq 0, x \in R^3)$:

$$(1) \qquad \frac{\partial \overrightarrow{H}}{\partial t} = \nu_m \triangle \overrightarrow{H} - (\overrightarrow{V}, \nabla)\overrightarrow{H} + (\overrightarrow{H}, \nabla)\overrightarrow{V}, \overrightarrow{H}(0,x) = \overrightarrow{H_0}(x).$$

Next, consider the problem (1) in the model of a random flow with an update: $\overrightarrow{V}(t,x) = \overrightarrow{V}_k(x), t \in [k\tau, (k+1)\tau), k = 0,1,2,..., \tau > 0$ is the update time, $\overrightarrow{V}_k(x)$ are independent identically distributed random velocity fields with nonzero means.

We denote by $\overrightarrow{\mathbf{H}}(t,x) = \langle \overrightarrow{H}(t,x) \rangle$ the average magnetic field in the distribution of the velocity field.

In [1], an equation for $\overrightarrow{\mathbf{H}}(t,x)$ was obtained by means of the transition to the Fourier transform $\overrightarrow{\mathbf{H}}(t,x)$ with respect to the spatial coordinate. In this paper, we derive the equation for the mean magnetic field directly, using the probabilistic representation of the solution (1) in the form of a conditional mathematical expectation along the trajectories determined by the operator $A = \nu_m \triangle - (\overrightarrow{V}, \nabla)$ of the random process. In the asymptotic analysis of the resulting equation, we use the expansions of the coefficients of the equation $\overrightarrow{\mathbf{H}}(t,x)$ with respect to the degree of the small update time τ.

Keywords: Random stream with update, a magnetic field, average magnetic field, conditional mathematical expectation.

2010 Mathematics Subject Classification: 60J25, 60J22, 60J55

References

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