Functional Materials **7**, No.3 (2000)

Effect of topologically non-trivial magnetic fields on the magnetic moment evolution

Zh.V.Slyozova, A.V.Tur*, V.V.Yanovsky

Institute for Single Crystals, National Academy of Sciences of Ukraine,
60 Lenin Ave., 61001 Kharkiv, Ukraine
*Center D'etude Spatiale Des Rayonnements, C.N.R.S.,
9 Ave. Colonel-Roche, 31028 Toulouse Cedex 4, France

Received June 9, 2000

Magnetic moment behaviour in random, topologically non-trivial magnetic fields has been studied. Two effect types associated with the field non-triviality have been shown to arise even in homogeneous and isotropic external fields. These are the drift flux in the velocity space and the cross-diffusion.

Изучено поведение магнитных моментов в случайных, топологочески нетривиальных магнитных полях. Показано,что даже в случае однородных и изотропных внешних полей появляется два типа эффектов, связанных с их топологической нетривиальностью. Это — дрейфовый поток в пространстве скоростей и перекрестная диффузия.

Investigation into effect of random fields on the dynamics of various systems is among the most advanced physics branches [1–3]. Lately, studies associated with the effect of topologically non-trivial fields are under a particular attention. The role of such random fields was first born in mind in the MHD when the magnet field generation problem was considered [4, 5]. The helical turbulence (where the pseudo-scalar $\langle \mathbf{V}\mathrm{rot}\mathbf{V}\rangle$ is non-zero) turned out to generate and support magnetic fields (α effect [4]). The same α effect was revealed much more lately in a homogeneous isotropic helical turbulence in compressible liquid [6, 7]. Further studies of the helical turbulence in temperature-stratified liquid have shown its considerable importance in the convective instability re-building and generation of large-scale structures [8].

In all those cases, there are significant reasons for isolation of such turbulent fields. In fact, all fields can be conventionally subdivided into two classes, namely, trivial and non-trivial ones. Let the fields having force lines coupled together be considered as non-trivial ones. For hydrodynamic media, the conservation of such couplings at any motions of an ideal non-compressible liquid was first established in [9]. The further studies resulted in that similar invariants were revealed in all hydrodynamic media [10, 11] ad their relation to the Hopf topologic invariant was established [10–12]. In a certain sense, such topologically non-trivial fields, being only tridimensional ones due to existence of topologic conservation laws, hinder the energy pumping into the small-scale region, thus favoring the large-scale structure formation in many cases. The passive impurity transfer in a helical turbulence can be taken as another non-trivial example [13]. In this case, the helical character only does not result in new effects due to a high symmetry of the diffusion item. Under existence of a non-uniform middle flow, however, an anomalous convective flow arises resulting in new transfer effects transversely to the average flow velocity direction. A similar effect was found at the particle motion in helical force fields under an