
Reviews

The theory of turbulence in stratified media

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by Andrzej Icha (ed.), Institute of Oceanology PAS, 1994, 227 pp., 2 figures, (in Polish).

Towards the end of 1994 the monograph ‘The theory of turbulence in stratified media’ by Andrzej Icha was published by the Institute of Oceanology PAS, Sopot, in its series ‘Rozprawy i monografie’ 5/1994.

The bulk of the work concentrates on the modelling of the turbulent processes of exchange and transfer of a passive admixture in a medium characterized by its negligibly small compressibility and non-homogeneous distribution of physical properties – density, temperature and passive admixture concentration. A sea basin is just such a medium. In its largest areas (oceans) the scales of turbulent fluctuations range from the Kolmogorov scale for the fluctuations in the velocity of parcels of water and the Batchelor scale for temperature fluctuations, to a scale equal to the horizontal dimensions of the basin. For certain values of the Reynolds number these scales can differ by six orders of magnitude. The modelling of this kind of turbulent flow fields and their associated diffusion processes is still an open problem, one, it has to be stressed, which is taken up with reluctance owing to the enormous natural complexity of these processes in a stratified basin and the considerable methodological difficulties involved. The author of this monograph holds the view that the theory of turbulence in such a medium should be developed within the framework of probabilistic functional analysis, *i.e.* within the framework of the theory of probabilistic distributions on function spaces. It is in this methodology that the author perceives the possibility of a deeper understanding of the generation and dissipation of turbulent states in the environment. In this view the author is supported by the subject literature, which consists of papers by himself and others published in the leading worldwide journals in 1988–1994. These achievements of world science and those of the author himself make up the content of the monograph under review.

I must admit to having been rather sceptical towards probabilistic functional analysis as a research tool. After the works by Hopf, Monin and the other creators of this method its cognitive possibilities seemed to me to have been largely exhausted, and that the achievements of empirical studies in

the field of marine turbulence suggested that the problem would be fathomed more rapidly by the employment of semi-empirical methods. However, having studied Andrzej Icha's monograph, I have had to modify my opinion. I believe that semi-empirical methods are simply easier to apply, and that is why they are much more widely used at the present time. Nevertheless, I accept the author's view that a really profound understanding of the phenomenon of turbulence is only possible on the basis of mathematical methods, among which the analysis of the set of thermohydronechanical equations in the Oberbeck-Boussinesq approximation has made such a significant contribution, as this monograph emphatically testifies.

As I have already indicated, the monograph is a concise presentation of the current state of world knowledge in the field of turbulence in stratified media. Against such a background, the author presents his own, original research contribution, the chief cognitive significance of which applies to turbulent diffusion processes. The work is written in a clear, even elegant style, and contains a whole range of interesting commentaries, addenda and appendices, as well as an extensive list of source literature; the detail is meticulous. It consists of five chapters: 1 – Dynamic equations of a stratified medium; 2 – Processes of turbulence generation; 3 – A functional formulation of the problem of fully-developed turbulence; 4 – The spectral characteristics of turbulence in a stratified medium; 5 – Turbulent diffusion processes in a stratified medium. To each of these chapters are appended very valuable commentaries, as well as bibliographic and historical notes. The monograph concludes with a summary, a list of source literature, and an English language summary.

In the subject literature and for further research, this work is of essential importance. The author's unique research contribution can be briefly summarized under the following headings:

- the generalized solution to the problem of diffusion in operator, power-series and double-continual-integral form;
- the formulation of a variation principle for the functional diffusion equation in the spatial description;
- the demonstration that if molecular diffusion is ignored, turbulent diffusion models are very considerably limited;
- the obtaining of an overt expression for the spatial functional characteristic of the velocity and induction fields in the form of a functional power series;
- the formulation of and solution to the problem of the turbulent diffusion of a passive suspension in the marine environment, assuming

that the diffusion coefficient is given in the form of a power function of the concentration gradient of the suspension.

I regard all these achievements as fundamental in this particular research subject. Some of them are more of interpretational significance, others are almost of practical importance, while yet others may inspire further research (*e.g.* equation 5.22). One could, of course, discuss the merits of each of these achievements and have numerous comments to make as a result of the ‘insufficiency’ of the information, because the essence of the subject on which the author is working using the functional analysis method is still an unknown quantity. For precisely these reasons, then, I consider every attempt to get closer to the natural realities in this field as worthwhile and every new formal or cognitive result as a basic achievement. In this respect, Andrzej Icha’s monograph is a highly significant contribution.

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