Book review

Homogenous Turbulence Dynamics

Pierre Sagaut and Claude Cambon. Cambridge University Press, New York, USA, 2008, ISBN: 978 0 521 85548 8, £73-00, 480 pp.

This book summarises recent theoretical, computational and experimental results dealing with homogeneous turbulence dynamics. A large class of flows is covered including flows governed by anisotropic production mechanisms and flows without production but dominated by waves. Compressible turbulent flows are also considered as well as details on linear theories and non-linear closures. The emphasis is on homogeneous flows including interactions of rotation, stratification, shear, shock waves and acoustic waves. The theories are widely applicable in branches of applied science ranging from aerospace engineering to astrophysics and earth sciences.

The introduction describes the hierarchy of embedded turbulence theories and closures from linear theory to wave-turbulence theory to nonlinear theories. Chapter 2 outlines the statistical background of homogeneous turbulent flows and discusses the basic principles behind the deterministic equations of conservation, compressibility, circulation and vorticity before elaborating on statistical and probabilistic approaches. Reynolds stress, anisotropy, spectral analysis, helical modes, non-linearity and non-locality are introduced.

Chapter 3 concentrates on incompressible homogeneous isotropic turbulence noting its energy decay regimes, coherent structures, symmetry and invariants, self-similarity and scaling effects. Topological analysis of the vortex tube, self-amplification and depletion of non-linearity are also considered. Pure rotations in the incompressible homogeneous isotropic turbulence are discussed extensively in chapter 4 in which a number of non-dimensional numbers are investigated before a full discussion is given on the exact non-linear equations. Incompressible homogeneous anisotropic turbulence is further investigated with emphasis on strain three-dimensional irrotational flow and coherent structures in strained homogeneous anisotropic turbulence. Chapter 6 considers pure shear in incompressible homogeneous anisotropic turbulence including length scales, Reynolds stress tensors, algebraic growth, self-sustaining and local isotropy.

Chapter 7 continues the study of incompressible homogeneous anisotropic turbulence on buoyancy and stable stratification. The main subjects are

propagating and non-propagating motion, collapse of vertical motion and layering, simplified equations, eigenmode decomposition, toroidal cascade, pancake structures and Kelvin–Helmholtz instabilities. The coupled effects of rotation, stratification, strain and shear are considered in chapter 8. Topics covered include rotating stratified turbulence with mean shear, rapid distortion theory applied to baroclinic instability, elliptic flow and classical instabilities. Compressible homogeneous isotropic turbulence is studied in chapter 9 which examines modal decomposition, energy balance, and structures in physical space.

Chapter 10 investigates compressible homogeneous anisotropic turbulence in terms of compressibility effects in free-shear flow, a quasi-isentropic approach to homogeneous compressible shear flow, incompressible turbulence with compressible mean flow, and topological analysis of coherent events. Chapter 11 describes isotropic turbulence/shock interaction with emphasis placed on destructive interactions, and linear and non-linear non-destructive interactions. The linear interaction approximation for shock/perturbation interaction is investigated in chapter 12, including a description of the shock and its emitted fluctuating field, and the reconstruction of second-order moments.

Chapter 13 presents some linear theories ranging from rapid distortions theory to Wentzel–Kramers–Brillouin variants and subgrid-scale dynamic modelling. Chapter 14 investigates anisotropic non-linear triadic closures. Topics include canonical homogeneous isotropic turbulence, dependence on eddy damping, random and averaged nonlinear Green's functions, different levels of Markovianization, rotating turbulence, connection with self-consistent theories, and several open numerical problems. Finally, chapter 15 gives some conclusions and perspectives.

The book gives a unified presentation of the most recent results obtained from experiments, numerical simulations and theoretical analysis, and discusses advanced linear and non-linear theories/models with deep analysis of the remaining open problems. A vast range of practical topics is covered. The book should be useful for researchers interested in turbulence modelling and practising engineers.

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