Preface

The "Reviews of Plasma Physics", Vol. 24, contains two reviews. This book, as well as the previous volumes, presents reviews for specialists interested in plasma physics theory. In the review by V.A. Rozhansky, the problem of currents and self-consistent electric fields in the magnetized fully ionized plasma is considered. The situation in fully ionized plasma is completely different from that in solid state, gases, or partially ionized plasmas, where the current density is proportional to the electric field. In contrast, in a fully ionized magnetized plasma, a homogeneous electric field causes drift both for electrons and ions, while a current in the direction of the electric field is absent. A perpendicular current arises when the electric field is temporary or spatially dependent. Various mechanisms, when the perpendicular currents are driven by inertia, collisions with neutrals and different components of viscosity tensor are analyzed in the review. Current systems in a vicinity of a biased electrode are studied in connection with such applications as probes, unipolar arc formation, pellets, where two-dimensional or three-dimensional currents systems determine plasma dynamics, shielding properties, and current–voltage characteristics.

Since the end of 80th it became clear that self-consistent electric fields play the key role in the formation of improved confinement regimes (H-regimes) in tokamaks and stellarators. The poloidal drifts suppress the turbulence and hence the turbulent transport coefficients so that the transport barriers with steep density and temperature gradients and reduced transport coefficients are created. It is demonstrated that the electric field structure is consistent with the experimental observations.

More complicated issues when a radial current is generated in fusion devices are also considered. In a group of experiments performed on several tokamaks, an electrode was installed into the plasma (inside the separatrix or last closed flux surface), and the voltage was applied between this electrode and limiter or divertor plates. The current–voltage characteristic of such a system, the value of the effective transverse conductivity, and related problem of toroidal rotation generation in the plasma are analyzed in the review. In the last few years, new methods of radial current generation are widely discussed. One of them is connected with the formation of a stochastic magnetic layer in a separatrix vicinity by special coils (resonance magnetic perturbations). The aim is to suppress the edge localized modes, and this issue is rather critical for the successful operation of the International Thermonuclear Experimental Reactor (ITER). A radial current of electrons in a stochastic magnetic field should be accompanied by the same radial current of ions similar to the biasing experiments. As a result, the radial electric field, density, and temperature profiles are significantly

modified, and edge modes are stabilized. The effective electron perpendicular conductivity in a stochastic magnetic field and the ion perpendicular conductivity, which are the key players in this situation, are also discussed in the review.

In the second review "Correlations and anomalous transport models" by O.G. Bakunin, numerous aspects of turbulent transport are considered. This review is intended to summarize the recent results from the multidisciplinary field of anomalous diffusion in turbulent plasma. A description of turbulent transport in the presence of coherent structures, convective rolls, zonal flows, and stochastic magnetic fields is a very complex problem.

From the methodological point of view, this review focuses on the general use of correlation estimates, quasilinear equations, and continuous-time random walk approach. The structure of some derivations, when they may be useful for more general purposes, is given in detail. Thus, the review provides a fairly informative treatment of seed diffusion effects in the framework of the correlation description. The relationship between Lagrangian and Eulerian correlation functions is discussed, and the problem of relations between stochastic instability and transport effects in a stochastic magnetic field is analyzed.

The author reviews in details the percolation approach to turbulent transport. Both the monoscale representation and multiscale approach are considered. The relationships between the transport and correlation exponents are derived. Nonlocal and memory effects in the framework of the continuous-time random walk model are treated. The kinetic (phase-space) approach describing ballistic modes of anomalous transport in complex systems is studied.

The topics to be discussed include renormalized quasi-linear equations, the Levy–Khintchine distributions, and intermittency effects. The author focuses on scaling arguments that play an important role in obtaining estimates of transport effects. A careful analysis of more important results obtained in this field is presented in this review.

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