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Editorial

Editorial for Special Issue Symmetry in Physics of Plasma Technologies

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This Special Issue collected papers on hot topics in the field of controlled thermonuclear fusion (CTF), including review papers and research articles. In general, presentations can be divided into two groups.

The first is related to the problem of plasma-facing components in CTF devices. In recent decades, the center of gravity of the global CTF program has shifted to this problem. The goal of achieving energy production is now being realized through the construction of ITER in France (https://www.iter.org/, accessed on 15 December 2022), which is the largest international scientific project in world history. Based on the concept of magnetic confinement of high-temperature plasma in a facility called a tokamak, this project has won strong competition between various magnetic-confinement concepts (tokamaks, stellarators, open magnetic traps, reversed field pinches, etc.) and other concepts, including inertial and magneto-inertial compression of condensed matter targets in, respectively, laser (including the National Ignition Facility at Lawrence Livermore National Laboratory, USA and similar facilities in France, Japan and Russia) or magnetized-plasma-sheath pulsed systems (including Z Pulsed Power Facility at Sandia National Laboratories, USA and similar facilities in the UK, USA and Russia). The problem of plasma-facing components in magnetic-confinement CTF systems for power generation is so serious that the concepts of systems for the production of fusion neutrons (fast neutrons compared to slow neutrons generated in fission reactors for heat production) proposed in the 1950s of the last century for the production of nuclear fuel are being revived and developed. These systems are called fusion neutron sources (FNSs) and aim to close the fuel cycles in the nuclear power plant industry and are promising, since the requirements for plasma-facing components in FNS systems based on the plasma magnetic confinement have already been practically met. For both programs aimed at the production of fast neutrons, respectively, for the direct generation of electricity and for the production of nuclear fuel for nuclear power plants, the problem of the lack of sources of fusion neutrons is overcome by testing candidate materials with other sources of material damage, including fast ion beams generated by accelerators and plasma fluxes generated by an electric discharge.

The review article [1] summarizes the results of many years of experimental research conducted at the National Research Center "Kurchatov Institute". The results of both of the above methods for testing candidate materials are presented. The surface layer of various materials (from three to hundreds of micrometers) was studied and it is shown that changes in the crystal structure, loss of their symmetry and diffusion of defects to grain boundaries play an important role.

The second paper in this group, the research paper [2], is devoted to the universality of stochastic clustering of materials irradiated with plasma in thermonuclear fusion devices. The phenomenon of the observed self-similar structuring is interpreted by the action of a stochastic electromagnetic field excited by a near-wall turbulent plasma.

The third paper in this group, the research paper [3], reports a new theoretical method for describing the anisotropic diffusion of radiation defects (RDs). The strain depen-

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dences of the RD diffusion tensor for various types of strain states are calculated using the molecular dynamics method. The proposed approach was used to study the diffusion characteristics of RDs, such as di-interstitials in FCC copper used in plasma-facing components of fusion reactors under development.

The second group of articles in the Special Issue is related to promising methods for diagnosing thermonuclear plasma. Approaching the final goals of fusion makes the diagnostics of plasma parameters even more relevant, and elucidation of the mechanisms of plasma dynamics and energy confinement remains one of the key issues.

The review article [4] provides an overview of the development of unique diagnostics for thermonuclear plasma—heavy ion beam probing (HIBP) in application to toroidal magnetic plasma devices. The review covers a wide range of devices, including tokamaks and stellarators. In particular, a comparison of the results of two machines with similar dimensions and plasma parameters, but with different types of magnetic configuration, the T-10 axisymmetric tokamak and the TJ-II helically symmetrical stellarator, is of particular interest from the prospective of a thermonuclear fusion program.

The second article in the diagnostic section of this Special Issue [5] reports on the development of a general theoretical method for describing stochastic nonlinear processes, including turbulence, and the derivation of a practical formalism for interpreting the results of cross-correlation reflectometry of thermonuclear plasmas obtained from spectral and spatial correlations of scattered diagnostic electromagnetic waves. The proposed data-processing algorithm makes it possible to identify the non-local character of plasma turbulence within the framework of the concepts of Levy flights and Levy walks.

The success of this Special Issue indicated the relevance of its continuation.

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