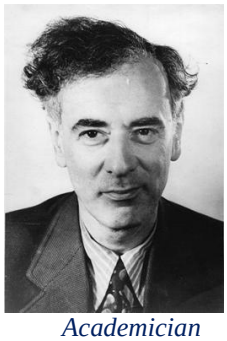
TO THE 25-th ANNIVERSARY OF THE INSTITUTE OF PLASMA PHYSICS OF THE NATIONAL SCIENCE CENTER "KHARKOV INSTITUTE OF PHYSICS AND TECHNOLOGY"

The plasma physics research in Ukraine has strong background and long history. Theoretical investigations on plasma physics were started in NSC KIPT (at that time named "Ukrainian Institute of Physics and Technology") by the famous works of L.D. Landau on collision of particles with Coulomb interaction (1936), A.I. Akhiezer and Ya.B. Fainberg, who invented the beam-plasma instability (1948), A.I. Akhiezer and L.E. Pargamanik on kinetic theory of plasma oscillations in the magnetic field, who predicted the possibility of electron cyclotron resonance. Experimental research on plasma physics and controlled fusion were launched in 1956 on the initiative and under the leadership of K.D. Sinelnikov.

Participation of NSC KIPT in solving the problem of controlled fusion and international cooperation in this field gave the powerful impulse for plasma research. The works of K.N. Stepanov, V.I. Tereshin, V.T. Tolok, O.A. Lavrentyev, V.F. Aleksin, O.S. Pavlichenko et al., which brought respect and recognition to the Kharkov school of plasma physicists, became famous all over the world.

Founders of Plasma Research in KIPT

Academician K.D. Sinelnikov



Academician L.D. Landau

Academician A.I. Akhiezer

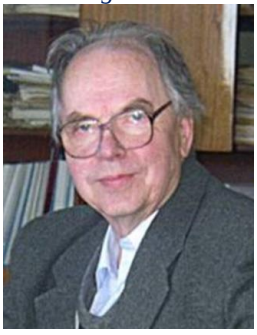
Academician Ya.B. Fainberg

Founders of the Main Scientific Directions in IPP NSC KIPT

Corr. Memb. NASU V.T. Tolok, head of plasma division. Stellarator research. Development of plasma technologies

Prof. O.S. Pavlichenko, first director of IPP Physics and diagnostics of high-temperature plasma

Corr. Memb. NASU V.I. Tereshin. High energy plasma dynamics and plasma accelerators



Corr. Memb. NASU K.N. Stepanov. Plasma theory, electrodynamics of plasma

Dr. Sci. O.A. Lavrentyev Pioneer of fusion research in USSR, proposed concepts of hydrogen bomb and plasma confinement, electromagnetic traps

The Institute of Plasma Physics was the first among the NSC KIPT institutes that was established on the basis of the plasma physics division on 3 January, 1994.

Currently, the Institute of Plasma Physics (IPP NSC KIPT) is a modern scientific center on plasma research covering the fundamental problems of high-temperature plasma physics and controlled fusion, high-energy plasma dynamics, applied and innovative developments in the field of low-temperature plasma, development of the plasma diagnostics methods and novel plasma technologies.

Structure of IPP NSC KIPT:

- Department of Engineering Support (Head of department V.P. Eremin)
- Department of Stellarators (Head of department Ph.D. V.E. Moiseenko)
- Department of Plasma Theory (Head of department Dr. Sci. D.L. Grekov)
- Plasma Dynamics Department (Scientific head of department Corresponding Member of NAS of Ukraine, Prof., Dr. Sci. I.E. Garkusha)

The Main Directions of IPP Research Activity:

1. Fusion oriented studies including plasma confinement in stellarators, high-frequency plasma heating, diagnostics of high-temperature plasma.
2. Various aspects of the fusion reactor ITER (problems of materials for the first wall, divertor, mirrors etc.).
3. Development and application of high-power quasi-stationary and pulsed plasma accelerators.
4. Plasma technologies (multi-layer coatings and surface modification, combined discharges, DBD ozone generators and sterilizers etc.).
5. Fundamental problems of plasma physics.

Stellarators

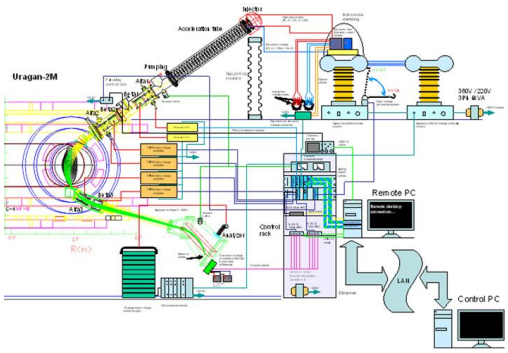
The main program of U-3M is focused on RF plasma production and heating, physics of plasma confinement in stellarators, investigation of divertor in stellarator-reactor concept. Methods of wall conditioning and cleaning the surfaces of fusion facilities with high-frequency plasma discharges were proposed and implemented. An important contribution to the understanding of divertor physics is discovery of the vertical asymmetry effect for the divertor plasma flows in helical divertor.

Stellarators Uragan-3M (left), Uragan-2M (central) and magnetic surfaces in Uragan-2M (right)

Stellarator Uragan-2M was put into operation in 2006. Large number of magnetic windings in Uragan-2M provides varying magnetic configuration parameters within a wide range and thus allows studying the influence of helical magnetic field inhomogeneities on plasma confinement.

Diagnostics of High-Temperature Plasma

Diagnostic method and the unique set of equipment for plasma probing by heavy ion beams were developed. The developments were implemented on number of fusion facilities in the world: TJ-I and TJ-II (CIEMAT, Spain), WEGA (IPP, Germany), TM-4 and T-10 (IAE, RF), Tuman-3 (LFTI, RF). Using this diagnostics the IPP team participates in joint studies on the role of electric fields in plasma confinement.



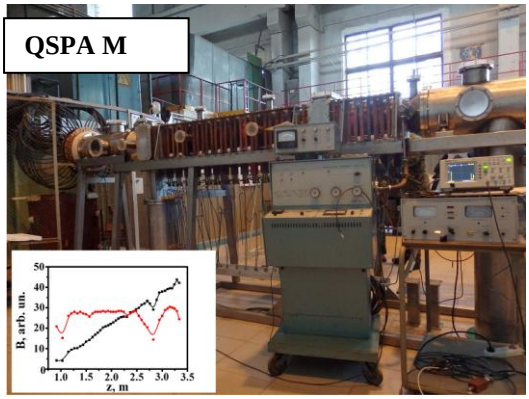
Scheme of HIBP diagnostics and dual HIBP at CIEMAT

Plasma Theory

Comprehensive studies on various aspects of plasma production, heating, equilibrium and stability in magnetic traps are carried out. Analysis of instabilities and the resulting anomalous transport in plasma with highly inhomogeneous poloidal rotation was performed. The numerical codes were developed for three-dimensional simulation of plasma transport in presence of resonant magnetic perturbations to suppress the edge localized modes. Prospective scenarios for RF plasma production and heating in stellarators were proposed.

Plasma Accelerators

Experimental simulations of the transient events in the international thermonuclear reactor ITER are carried out with powerful quasi-stationary plasma accelerator QSPA Kh-50. The supersonic flows of dense magnetized plasma with velocities up to 500 km/s, ion current of 10 MA and energy density up to 40 MJ/m^2 were obtained. This plasma accelerator is unique for adequate modeling experiments on the interaction of plasma with fusion reactor materials. New generation quasi-stationary plasma accelerator has recently been constructed to achieve qualitatively new and previously unstudied range of plasma parameters providing extreme energy and particle loads to the materials. New experimental stand QSPA-M allows studying the irradiation effects on materials used in fission and fusion power engineering.



QSPA plasma accelerators

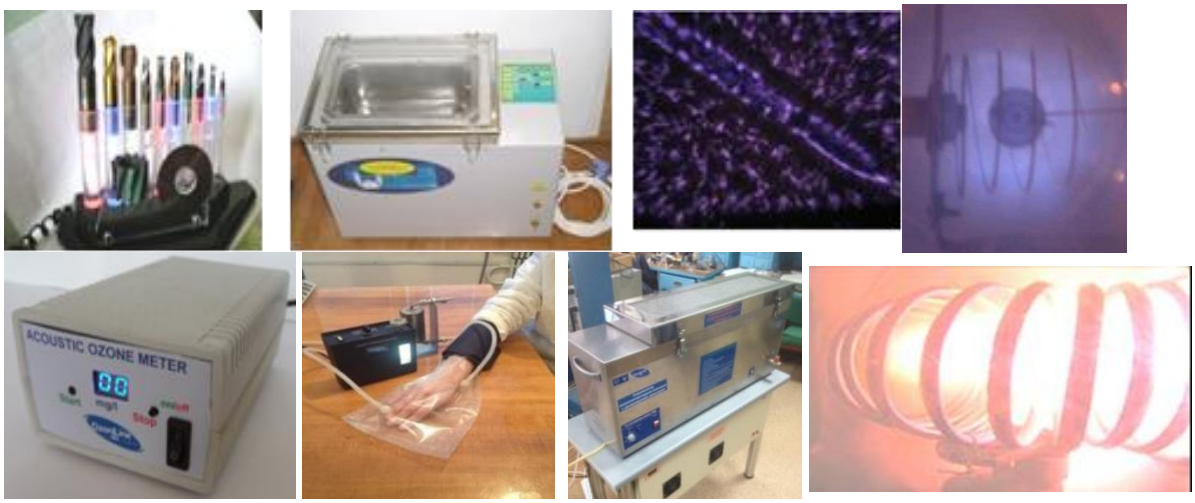
Plasma Dynamics

The powerful plasma generators of extreme ultraviolet radiation and soft X-rays were developed.

The combined technologies for modification of materials and the methods for plasma alloying using the pulsed flows of dense plasma were proposed. The advanced pulsed plasma guns are used to modify the surface layers and to obtain the materials having unique physical properties.

Advanced Plasma Technologies

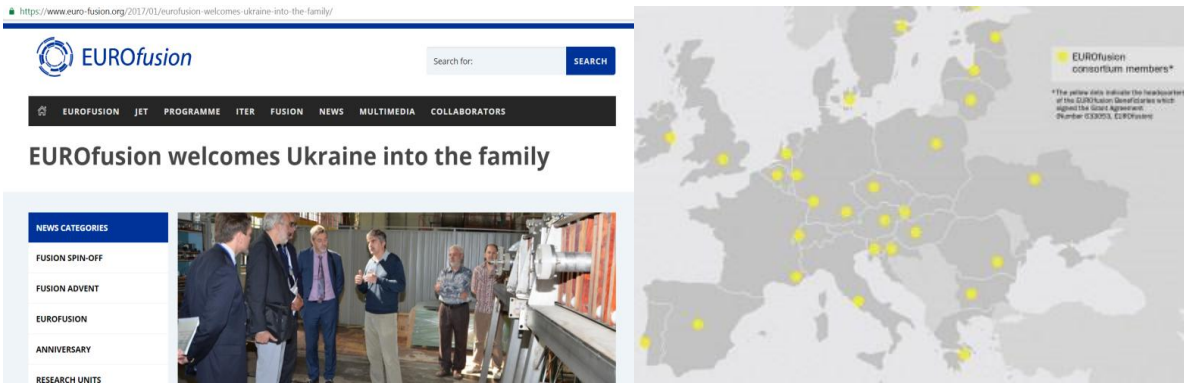
Technologies for deposition of multilayer and composite coatings in the combined arc and RF discharges have been developed. Application of high frequency allowed substantial reduction of the surface temperature and production of coatings with excellent adhesion on metals and dielectrics, including the inner surfaces of items. The compact ozone generators using the dielectric barrier discharge were developed. On the basis of these ozone generators, the high-efficiency low-temperature sterilizers with ultrasonic cavitation were designed for medicine and industry.



Examples of plasma technology developments based on vacuum- and atmospheric pressure discharges

IPP Integration into the International Research Programmes

Since 2017 IPP NSC KIPT is involved to the EURATOM fusion programme, in particular, to EUROfusion research on stellarators, plasma-facing components, medium size tokamaks, liquid metals, education etc. NSC KIPT is beneficiary of EUROfusion consortium and it represents Ukrainian Research Unit in European fusion programme.



International collaboration of IPP is carried out with 25 research centers from the USA, Japan, Spain, Austria, Germany, Belgium, Poland etc. IPP is member of the International Energy Agency (IEA) Implementing Agreement on “Stellarator-Heliotron Concept”, participant of IAEA coordinated research projects and STCU international cooperation projects, participates in activity of the International Center for Dense Magnetized Plasma (Warsaw, Poland).

IPP Awards

13 staff members of IPP were awarded with State prizes and that of the National Academy of Sciences of Ukraine.

In 2004 the K.D. Sinelnikov Prize of the National Academy of Sciences of Ukraine was obtained O.A. Lavrentyev and V.A. Maslov for "Development of the concept of a thermonuclear reactor and a neutron source based on a multislit electromagnetic trap".

The State Prize of Ukraine in the field of science and technology for 2005 was awarded to E.D. Volkov, S.V. Kasilov, N.I. Nazarov,

A.I. Skibenko, K.N. Stepanov, V.V. Chechkin, O.M. Shvets for the series of works “Collective mechanisms of plasma heating and transport in toroidal magnetic traps”.

In 2007, the State Prize of Ukraine in the field of science and technology was awarded to I.E. Garkusha, D.G. Solyakov, V.I. Tereshin, V.V. Chebotarev for the series of works “Physical principles, development, creation and use in radiation physics of powerful and super-powerful accelerators of ions and plasma”.

International Conferences and Schools on Plasma Physics and Controlled Fusion

IPP NSC KIPT is organizer of the world-famous series of International conferences-schools on plasma physics and controlled fusion, ongoing since 1998. The conference recognized by official status of the European Physical Society "EPS sponsored conference" and it is one of the key forums for controlled fusion, plasma physics and technologies. Over 160 scientists from 10 countries participated in recent conference in 2018.

I.E. Garkusha
Corresponding Member of
the National Academy of Sciences of Ukraine,
Doctor of Sciences (Phys. and Math.), Professor,
Deputy Director General of NSC KIPT,
Scientific head of IPP NSC KIPT