A Short History of the Ioffe Institute

Welcome to St. Petersburg

The contribution of St.Petersburg to the ITER project is an important one, as more than half of the Russian engagements are being met here on the banks of the Neva. As you walk across the city you will see palaces with twisted cast-iron gates, branches of the canal heading off into the distance, admirable statues. In the northern industrial part of the city, as you walk along Polytechnic Street, you're likely to remark a beautiful yellow building in the style of an old manor, set back from the street by a tall fence.


The Ioffe Institute

This is the prestigious Physical and Technical Institute ("Phys-Tech") named after A.F. Ioffe. It has been home to Nobel prize winners Alferov, Landau, Kapitsa, Semionov and Tamm and distinguished Russian scientists Kurchatov, Alexandrov, Khariton. Currently the "Phys-Tech" Institute is playing an important role for ITER by developing complex plasma diagnostics. It is one of the oldest (if not the oldest) scientific-research organizations of the country, having recently celebrated its 90th birthday. Today, it is a world-class research center covering many scientific areas: solid-state physics, astrophysics, plasma physics, physics of semiconductors, and others.

Russian physics research began here

The history of the Ioffe Institute began in 1918. Under the initiative of Professors M.I. Nemenov and A.F. Ioffe, the State Roentgenologic and Radiologic Institute was founded under the People's Commissariat on Education of RSFSR (currently the Ministry of RF). In 1921 the physical and technical department became an independent Institute. Abram Ioffe was named as its first Director - a position he would hold until 1950.

The Bolsheviks in power at the time completely understood the necessity of developing what was then a relatively young science in Russia – physics. There was a shared understanding that this science could help improve the country's defense and manufacturing technologies. During these years that were difficult for so many, Soviet authorities did everything possible to keep leading physics researchers away from poverty and hardship. Considerable funds were spent to purchase research equipment from abroad and to found new research organizations. The current Ioffe Institute building on Polytechnic Street, originally an alms-house, was given to the Institute in 1922, and furnished with objects from the Winter Palace.

The Physical and Technical Institute in the 1930s

It would be an exaggeration to say that the early scientific efforts of the Institute lead to immediate results. It took until the mid-century for the Soviet school of physics that began here - supported by the endless enthusiasm and ingenuity of A.F. Ioffe and others – to become a player on a global scale, recognized by physicists in the UK, France, Germany, and the USA. In some areas of physics, Russian scientists took the lead, thanks to its team of young, talented and ambitious scientists.

It was within this Institute that the Russian Atomic project – Laboratory 2 - was established in 1943. (Laboratory 2 later became the Kurchatov Institute.) Affiliates of the "Phys-Tech" were established in Kharkov, Sverdlovsk, Dnepropetrovsk, and Tomsk that later became independent Institutes, significantly influencing the development of decentralized research throughout the country. The "Phys-Tech" Institute survived through the period of Stalin repressions and, following the collapse of the Soviet Union, continued through difficult times to celebrate its 90th birthday in 2008.

Today, the Ioffe Institute is developing diagnostic systems for ITER. Plasma diagnostics are very complex systems from a scientific and technical standpoint. They will have to operate in extreme conditions, with a plasma heated in excess of 150 million °C, high radiation and strong magnet field. Their successful

The diagnostic group on neutral atoms

development requires a whole spectrum of experience and knowledge gained throughout the long history of fusion research. Research in Russia in the area of controlled nuclear fusion began in the 1950s, and is very closely connected to B.P. Konstantinov, the second Director of the Ioffe Institute.

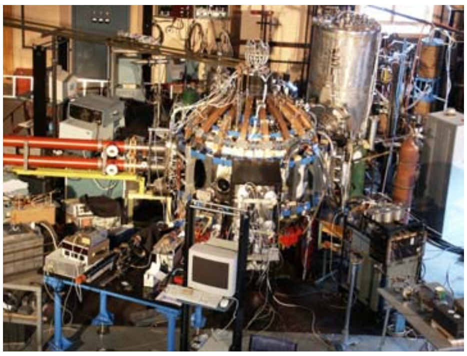
The Alpha experiment and early plasma diagnostics

At the end of the 1950s, a large toroidal facility - Alpha - was built on the initiative of I.V. Kurchatov near St. Petersburg. Built in only six months, its objective was to investigate the feasibility of a controlled thermonuclear reaction in a toroidal self-constricted pinch. The lack of proper diagnostic tools to get the most out of the project was keenly felt, and the Institute started to work in parallel on methods of plasma diagnostics. The first publications in this area by B.P. Konstantinov followed rapidly. One of them suggested the use of a corpuscular diagnostic using neutral particles that are emitted by plasma, a method that turned out to be very successful and was widely used in plasma research centers around the world. Work also advanced on super high-frequency, optical and other diagnostic methods headed by B.Ye. Golant. As the result of these activities, the “Phys-Tech” Institute became known as one of the leading centers for plasma diagnostics worldwide.

Although the Alpha experiment was not successful for controlled nuclear fusion, two important consequences resulted. It provided the momentum for work on hot plasma diagnostic methods, and opened the way towards the triumph of the Soviet tokamaks, which were soon to obtain outstanding results.

The Ioffe Institute today

The present generation of researchers works hard to maintain the status of the Institute as a leader in plasma diagnostics. A spherical tokamak - Globus-M - was recently designed and built at the “Phys-Tech” to carry out important plasma experiments, including those for ITER. In March this year, the development team for “Globus-M” received a government award in the area of science and technology.



The Globus-M spherical tokamak

The facility also houses three diagnostic systems developed by the Institute for ITER. Neutral diagnostics aim to measure and control the deuterium-tritium fuel ratio for optimum burning conditions in ITER, and are based on the analysis of charge-exchange neutral particles emitted by plasma. Gamma-ray spectroscopy diagnostics are necessary for measuring the distribution and the dynamics of high energy ions in the poloidal cross-section of the tokamak; controlling these high energy ions is one of the main objectives of ITER plasma diagnostics. The developers of gamma-ray spectroscopy diagnostics from the Ioffe Institute were awarded the RAS prize named after L.A. Artsimovich in 2010. And finally, Thompson scattering diagnostics are used to measure electron temperature and density spatial distribution in the most problem domain of ITER – the divertor, where the main plasma-wall-interactions occur. Control of the plasma parameters for optimization of the diverter operation modes is a priority, in order to protect ITER from diverter damage resulting from intense plasma fluxes.


Divertor Thompson scattering group

"Phys-Tech" is up to the challenge of developing these systems within the specified characteristics and time period. In the words of Professor M.P. Petrov, head of the Neutral diagnostics work of "Phys-Tech" within the framework of the ITER program: "This is our brainchild, which was invented in this Institute. We have thought it all over, developed the equipment, etc. This is a unique issue and we are still the leaders here." Developers of the other systems could say the same.


X-ray spectrometry group

Employees of "Phys-Tech" admit quite frankly that participation in the ITER project helped a lot in maintaining traditions of the Institute. Financing (which became very low in the post-Soviet times) is now satisfactory and equipment up to date. Due to the Russian Federation's participation in the ITER project, the Ioffe has recruited young specialists. Out of twenty researchers of "Phys-Tech" currently working for development of the ITER diagnostic systems, ten are the young scientists.

And that's the end of our brief history of the Physical and Technical Institute named after A.F. Ioffe. The Institute has a legendary past, an exciting present, and a promising future. By 2016, the diagnostic systems should be installed at ITER. And what about the future projects…? Let's have another look in approximately 90 years!

Alexander Petrov, Russian Domesic Agency

References:

1. D. Holloway. Stalin and the Bomb. Soviet Union and Atomic Energy 1939-1956.
2. Materials from the web-site http://bpkonstantinov.ru/index.html
3. Materials from the web-site http://www.ioffe.ru
4. Ioffe Institute. 1918-1998. Development and Research Activities. St. Petersburg, 1998.
5. Interview with Prof. M.P. Petrov, 2009