DIRECTOR'S REPORT

This report covers the activities of the Laboratory of Neutron Physics in the year from 1 October 1990 to 1 October 1991 in connection with the fact that the neutron sources at LNP traditionally operate for physical experiment from mid-October to mid-June next year and have a scheduled shutdown for improvement and maintenance from June to October.

The past year was a difficult year for the Laboratory. Nevertheless, on the whole, it was a successfull and reassuring year.

Neutron Sources

The pulsed reactor of periodic operation IBR-2 still remains the most high flux pulsed neutron source in the world. Both in 1990 and 1991 the reactor worked faultlessly. It has run 2570 hrs in 10 cycles for physical experiment. Pulsed reactors of periodic operation produce high neutron fluxes and are, at the same time, very economic. So the active core of the IBR-2 is designed for about 20 years of continuous operation in the present regime. In a shorter period of 5 years the moving reflector must be replaced, having worked out its radiation resource. Next time it is to be replaced in 1993. In 1991 work went on manufacturing the moving reflector of a new design to allow reduction of the neutron pulse width by a factor of 2.

The main task of the 1991 year program for upgrading the IBR-2 was to manufacture a solid methane cold moderator. After testing it will be installed to bring a tenfold increase in cold neutron flux. As the result, on three channels (No. 4,5,6) the cold neutron flux will be 10 times higher than that from the ISIS, for example. The present state of things allows one to think that in autumn 1992 the moderator will be installed on the IBR-2 reactor.

The IBR-30 booster with the linear electron accelerator LUE-40 as the injector serves mainly nuclear physics experiments. In the reported year its running time amounted to 2240 hours in 9 cycles. In prospect the booster will be replaced by the new High Resolution Neutron Source (HRNS) that would generate up to 2×10^{15}n/sec with a pulse width of up to 0.5 μsec. In 1991 the Laboratory in cooperation with the Institute of Nuclear Physics of the Academy of Sciences of Russia (Novosibirsk) and NICIET (Moscow) were carrying out design work on the linear electron accelerator and the target.

Research Program

The Laboratory's three main areas of research are fundamental and nuclear physics, condensed matter physics and applied research (use of nuclear physics facilities and methods for analysis of industrially produced materials, development of manufacturing technologies of new HTSC materials and design and construction of advanced physical instruments). Scientists and engineers of the Electronics and Computing Department take active part in development of the spectrometers suit of the Laboratory. They are also responsible for upgrading and operation of the Laboratory's Computing network. The main scientific results obtained by scientists of the Laboratory are reviewed per areas. Here are just some of them.

Theoretical investigations went in close connection with main experimental programs. Measurement of the neutron lifetime using ultracold neutrons (discovered in 1968 by a team of LNP scientists led by late Prof. F.L.Shapiro) is presently the most perspective direction of research. A theoretical study of interaction processes of UCN's with trap's walls has shown that uncertainly in τ value could reach 6 sec due to gravity corrections. High temperature superconductivity remains one of the intriguing problems of the physics of condensed matter. Calculations made in the past year evidenced in a most convincing manner in favour of the correspondence between the Superconducting Glass Model and the behaviour of oxide superconductors in external magnetic fields at temperatures higher than $\sim$0.7 T_c.

An original method for measuring the neutron lifetime proposed at LNP has yielded the most precise for today value of $\tau_{1/2}$=888.4 sec. This result was obtained in joint measurements carried out by LNP and PINP scientists at the reactor in Gatchina. Further advance in precision is limited by UCN flux density (10 n/cm^3). In 1991 a project formed to build a new facility on the high flux reactor of aperiodic operation at the Institute of Experimental Physics (Arzamas), earlier used for industrial purposes only, to enable production of UCN's with a density of 5×10^5 n/cm^3 (note, for comparison, that ILL, Grenoble, avails of 10^2 n/cm^3).

A number of new results were obtained in a study of compound states of nuclei. Observation of γ-cascades following thermal neutron capture of Gadolinium-157 evidenced for possibility of single particle transitions between 4S and 3P neutron shells at the energy of 2 to 3 MeV. It is impossible to observe these effects with the other nuclear spectroscopy methods. The joint efforts of theorists and experimentalists have successfully promoted investigation of fission processes.

A systematic study of the structure of yttrium high temperature superconductors on copper substitution has yielded a curious result: the substitution site (in a plane or a chain) is not of so a crucial importance as it was believed before. The important role play purely structural properties (e.g. the bond length) that need to be further investigated.

The neutron diffractometer for real time measurements DN-2 and the texture diffractometer NSVR open vast possibilities for applied neutron diffractometry.

To promissing results, though requiring further analysis, belong the results of SANS investigations of micellar systems. The SANS method gives the possibility, offered by no other method, of extracting new information on the physical chemistry of solutions.

The time-of-flight spectrometer on polarized neutrons provides for an efficient way of studying properties of surfaces. This spectrometer operates in two modes: polarized neutrons reflection from and transmission through a sample. The transmission mode appeared extremely informative also in the study of the dynamics and electromagnetic properties of HTSC's.

The past year saw the startup of the new inverted geometry spectrometer NERA-PR for inelastic neutron scattering studies with a higher resolution than it was provided before by the KDSOG-M spectrometer of analogous design. The new spectrometer allowed refinement of the data on phonon spectra of yttrium high temperature superconductors. This method of inverted geometry comes out to be highly efficient in studying magnetic excitations in f-electron systems.

In the field of applied research there should be especially emphasized the efforts of the scientists of the Low Temperature Physics Division in investigating the problem of building SQUID's from HTSC materials.

An extended front of investigations were carried out by the neutron activation analysis method. For them a specialized air-operated system REGATA for sample transportation was installed on the IBR-2. The time of transportation of a sample after irradiation to a detector is 12 sec. The Van-de-Graaf machine serves element analysis experiments with single charge ions of H, He, C, N, O accelerated to energies from 0.7 to 6 MeV.

In 1991 work continued on modernization of existing and construction of new spectrometers. The attention of the Lab's directorate concentrated mainly on the construction of two diffractometers on channel 5: the High Resolution Fourier Diffractometer and the Powder Diffractometer for Time Resolved Studies. Their construction is planned to be completed and first experiments started in spring 1992.

Construction of the HRFD is a conceptually important task. Mastering Fourier-analysis technique would give reduction of the neutron pulse width down to 7 μsec and a resolving power of $\Delta d/d = 5\times10^{-4}$ at the high time-averaged flux on the sample of 10^7n/cm^{2}sec. New possibilities will open and to real-time experiments: resolution of up to 300 μsec and the averaged flux of 5×10^7n/cm^{2}sec.

The reconstruction of the POLYANA spectrometer for experiments with polarized neutrons and nuclei has been accomplished this year. On it experiments will continue on the study of enhanced parity violation effects in resonances discovered by the L.B.Pikelner's group in 1982.

Scientists of the Laboratory reported on the results of their studies at many an international conferences and meetings. Some of them were hosted by the Laboratory and some were organized with its participation. The largest was the VI International School on Neutron Physics, one in a series of regular meetings hosted by the Laboratory every four years since 1969. The important result of these Schools is extending international cooperation. So at the VI School it was decided to organize two workshops on the scattering of neutrons in condensed matters, one in USA and the other in France.

Training Center

At the beginning of the 1991 year the Dubna branch of the Moscow State University that started work in 1961 on the initiative of Prof. D.I.Blokhintsev, the first Director of the JINR, has been reorganized into the Training Center at the JINR. To two earlier courses of training, in the physics of elementary particles and in the physics of nucleus, there added two more, in nuclear methods as applied to condensed matter research and in radiation biology. The founders of the Training Center are the JINR, the Moscow State University and the Moscow Engineering Physical Institute. Students of these and other high schools live and study in Dubna during their two senior years to have specialized knowledge and training for work on modern nuclear reactors and accelerators. This specialized training is especially important for future investigators of condensed matters. The Training Centre is open to students from any country and not only from the JINR Member States.

Personnel

During the past year there were some changes in the organization of the Laboratory, including the formation of two new research divisions - the Low Temperature Physics Sector (head B.V.Vasiliev) and the Radiation Research and Neutron Activation Analysis Sector (head V.M.Nazarov).

In June 1991 the Scientific Council of the JINR has appointed by election Prof. Yu.P.Popov and Dr.I.Natkaniec to serve their second three-year terms as Deputy-Directors of LNP. Dr.I.Natkaniec supervises work of the Condensed Matter Physics Department and the Electronics and Computing Department. Prof. Yu.P.Popov directs work of the Nuclear Physics Department, Applied Research Department and the Radiation Research and Activation Analysis Sector. Dr. V.G.Tishin was appointed to head the Electronics and Computing Department.

The number of staff decreased by 30 peoples mainly due to reduced number of scientists from the JINR Member States (except for those from the hosting State of the JINR) to amount to the total of 580 peoples on 1 October 1991.

On 15 July 1991 the JINR and BMFT have signed agreement on scientific cooperation and participation of Germany in scientific research in Dubna.

This year the Laboratory of Neutron Physics had a heavy loss. Dr. V.N.Efimov, the leading scientist of the Nuclear Physics Division who was with the Laboratory for over 30 long years died in September 1991. Dr. V.N.Efimov was a noted theorist who made a valuable contribution to the theory of few-nucleon systems. His name is written in the history of the Laboratory for ever.

V.L.Aksenov