

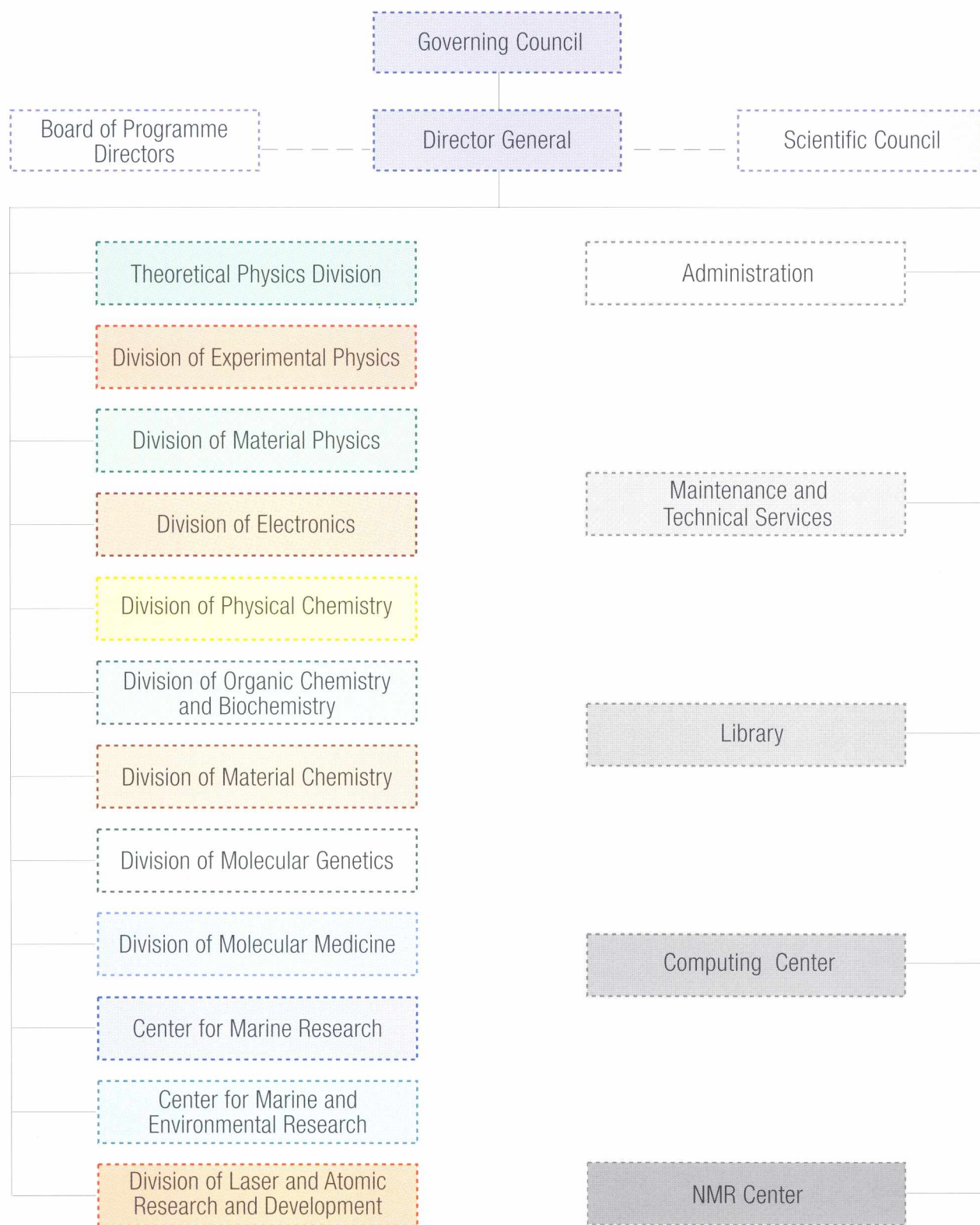
Established 1950.

*Ruđer
Bošković
Institute*



Zagreb, Croatia

Internal organisation



Ruder Bošković Institute

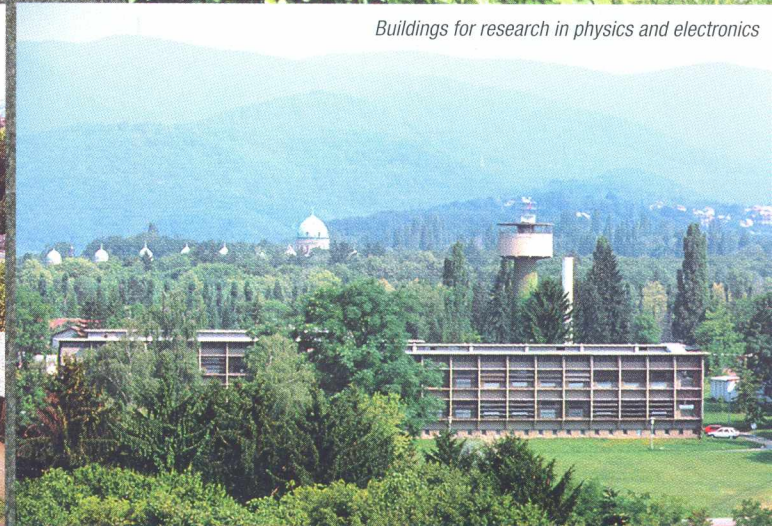
Director General: Dr. Nikola Zovko



Panoramic view



Buildings for research in physics and electronics



The Ruder Bošković Institute in Zagreb was founded in 1950 by the initiative of Ivan Supek and its vigorous pursuit by him and several other professors of the University of Zagreb.

The Institute was named after the famous Croatian 18th century scientist Josip Ruder Bošković (*18.05.1711-†13.02.1787), who was born in Dubrovnik, Croatia, and received education at the Jesuit Collegiums in Dubrovnik and Rome. He was the first to realize that the interatomic forces were something else than a sheer gravitation. His



Mural by Edo Murtić in the physics building



Buildings for research in material chemistry and environment

ideas exerted a strong influence on the leading physicists and chemists of the 19th century.

The Institute is a centre of excellence for natural sciences, which enables a synergistic interdisciplinary approach in solving the intricate and demanding scientific problems of our modern age. Present research activities are centered and organized within 12 divisions, namely, Theoretical Physics, Experimental Physics,

Materials Physics, Electronics, Physical Chemistry, Organic Chemistry and Biochemistry, Materials Chemistry, Molecular Genetics, Molecular Medicine, Laser and Atomic Research, Environmental and Marine research. A part of the marine research is carried out at the Adriatic Coast in Rovinj.

Since its first days, the Institute put a lot of emphasis on the excellence in fundamental research focusing on important scientific issues for discerning the properties of matter and by disclosing laws of nature. Concomitantly, stringent international criteria have been implemented and employed in evaluating scientific projects and in selecting new young scientists. A tradition of a high quality research and a system of scientific values based on internationally established standards, carefully cherished for a period of fifty years, are important hallmarks of the Ruder Bošković Institute. The scientific achievements and myriads of research results, accomplished at the Institute, have been published in leading international scientific journals (over 300 scientific articles per year) which has led to a significant international recognition and high reputation.

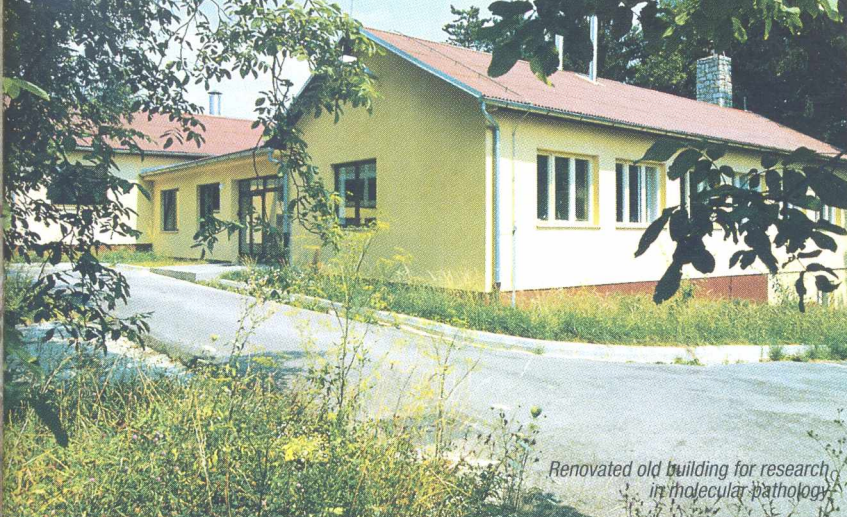
In parallel with fundamental scientific investigations, the Institute has exercised applied research, collaborating with other institutes and industrial units in various branches of production of goods, and by cooperating with a number of governmental institutions related to national defence, health care, food production and environmental protection. Additionally, the Institute offers expert



Research vessel Vila Velebita



A building in Rovinj



Renovated old building for research in molecular pathology

environmental protection. Additionally, the Institute offers expert advice and training courses for industrial engineers and serves as a reference for a quality control of various products as well as for standards and measures related to science and technology. A large variety of scientific and expert problems addressed by researchers has been enabled by a well organized infrastructure, which includes the largest library in natural sciences in Croatia, a computing center, animal facilities, and a large number of valuable experimental devices (Tandem Van de Graaff, EPR, X-ray, NMR, core facility for molecular genetics, MS, IR, Raman spectrometers).

Since there is no good science without good education and vice versa, pedagogical work is one of the Institute's priorities. A large number of researchers participate in graduate and postgraduate studies at Croatian Universities. Moreover, the postgraduate study in oceanology is carried out entirely by the Institute. It is noteworthy that Ruder Bošković started the first postgraduate studies in Zagreb together with the University in 1953. It is, therefore, not surprising that almost 1000 B.Sc., M.Sc. and Ph.D. theses have been completed at the Institute so far.

International cooperation is another salient feature of the Institute. It is very broad and intensive and plays an important role in executing modern scientific research. It embodies joint venture projects involving bi- or multi-lateral research groups. Extent of the international collaboration affirms the high quality of our research. This is encouraging because our participation in

international research programs is necessary for successful and creative transfer of knowledge to our community. Another form of cooperation is realized by our leading experts acting as visiting professors and/or scientists at foreign universities. Within this category falls organization of numerous international congresses and symposia, which represent significant contributions to the scientific progress in the world. The same holds for books and monographs written or edited by our researchers and printed by well known international publishing houses.

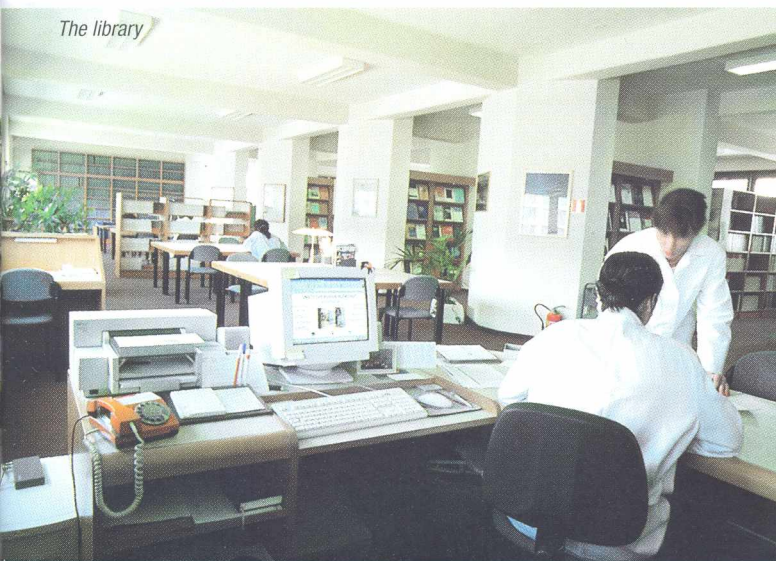
Last but not least, our scientists serve as members of the Editorial Boards of international journals, as officers in international scientific societies and as United Nations experts. It follows that our science



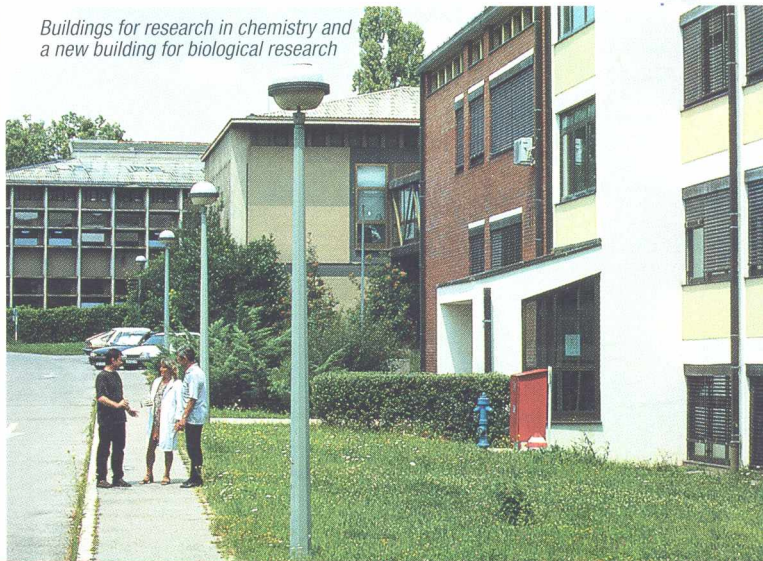
Institute's park

is deeply involved in the modern global research system.

In conclusion, it should be pointed out that the rich scientific experience at Ruder Bošković Institute is a valuable resource of expertise, methodology and creative imagination for future "high-tech" development in 21st century.



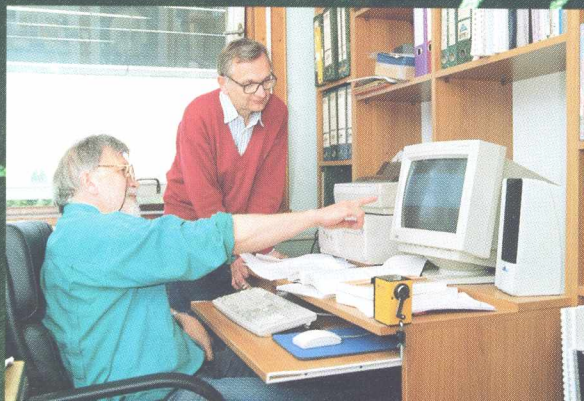
The library



Buildings for research in chemistry and a new building for biological research

Theoretical Physics Division

Head: Dr Branko Guberina



The research in theoretical physics started fifty years ago when the Ruder Bošković Institute was founded with the Theoretical Physics Department as the first department of the Institute. A few years ago it was renamed to the Theoretical Physics Division. From the very beginning, a close relationship between the Theoretical Physics Department and its counterpart at the University of Zagreb was established and has since proved to be very successful both in research and teaching.

Presently, the research performed in the Division is mainly theoretical high-energy physics (particle physics, general and mathematical physics, astroparticle physics and cosmology) and condensed matter. Recently, the theory group has started a new activity by applying nonlinear dynamics analysis to various biomedical problems to study the presence of chaotic behaviour and fractal structure.

From the very beginning, members of the Division have lectured at undergraduate and postgraduate studies at the universities in Croatia, mostly at the University of Zagreb. A number of students presently perform their B. Sc., M. Sc., and Ph. D. theses. The Division numbers presently 17 scientists and 9 students and postdocs.

Presently, 12 professors at the universities in Croatia are former members of the Theoretical Physics Division. A certain number of former members of the Division is employed in engineering, banks, insurance companies, etc., mostly in the USA.

Research in the Solid state theory group is centred on the physics of surfaces, thin films and low-dimensional and strongly correlated systems in general. The scattering of atoms and molecules on solid surfaces is investigated, in particular the charge and energy exchange, as well as properties of chemisorbed species. This research topic aims towards the understanding of surface reactions and other processes at surfaces. The study of electromagnetic response of thin films and microstructures, their electric, thermal, and other properties, increases the knowledge about various homogeneous and heterogeneous films and structures. The properties of correlated electronic systems is investigated, using the Holstein-Hubbard model and other approaches. Photoabsorption spectra of isolated and embedded atoms, as well as of several model systems are studied.

The proposed investigations in Particle and mathematical physics group are expected to contribute to the theoretical knowledge of fundamental particles and their interactions. The investigations are based on the description of nonperturbative effects using vacuum condensates (heavy-quark decays), on perturbative QCD (exclusive processes), Monte Carlo simulations of lattice QCD, $1/g$ and $1/d$ expansions (quark-gluon plasma, gluonic fusion, chiral condensates, etc.). The proposed research is expected a) to investigate nonperturbative effects in c - and b -quark decays, b) to improve the calculation of penguin processes, c) to investigate radiative B-meson decays and



CP violation, d) to investigate mechanisms of symmetry restoration, appearance of QCD plasma and $1/g$ and $1/d$ expansions in lattice QCD, and solution of controversy con-

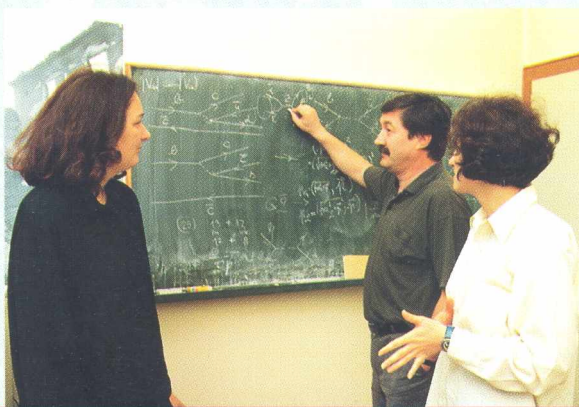
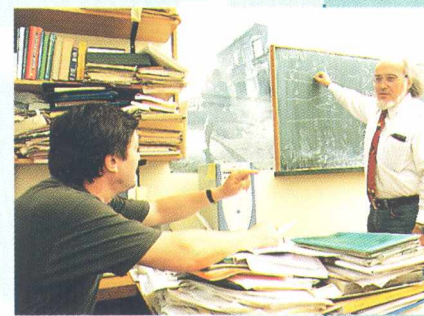
cerning disoriented chiral condensates, e) to calculate exclusive processes in order to obtain new knowledge of scaling and spin properties of quarks and gluons, and new contributions to the understanding of the electromagnetic structure of hadrons. In astroparticle physics and cosmology a proposal is to study the phase transition in the system of gravitating massive fermions (neutrinos, neutralinos) and quasi-degenerate fermion stars, and the role these compact dark objects could play in structure formation in the early universe.

eralized statistics, particularly a unified approach to types of statistics, their classification, internal consistency and study of fundamental physical properties of generalized statistics are considered. Quantum dynamics and energy spectra of collective fluctuations around soliton configurations in the Calogero-Sutherland and the Chern-Simons systems are investigated. Investigations of the normalization of Wilson operators in Minkowski space and the problem of analytical extension from Euclidean to Minkowski space are continued. The alternative symmetry breaking mechanism based on the assumption of the noncontractible spacetime and its impact on high-energy data, as well as the consequences for the cosmology of the Einstein-Cartan gravity are studied.

The nature and the type of dynamical fluctuations in many-particle production processes in heavy ion collisions are investigated in the central and the fragmentation region of the phase space. In this respect the application of the disoriented chiral condensate (DCC) model to pion production processes is studied.

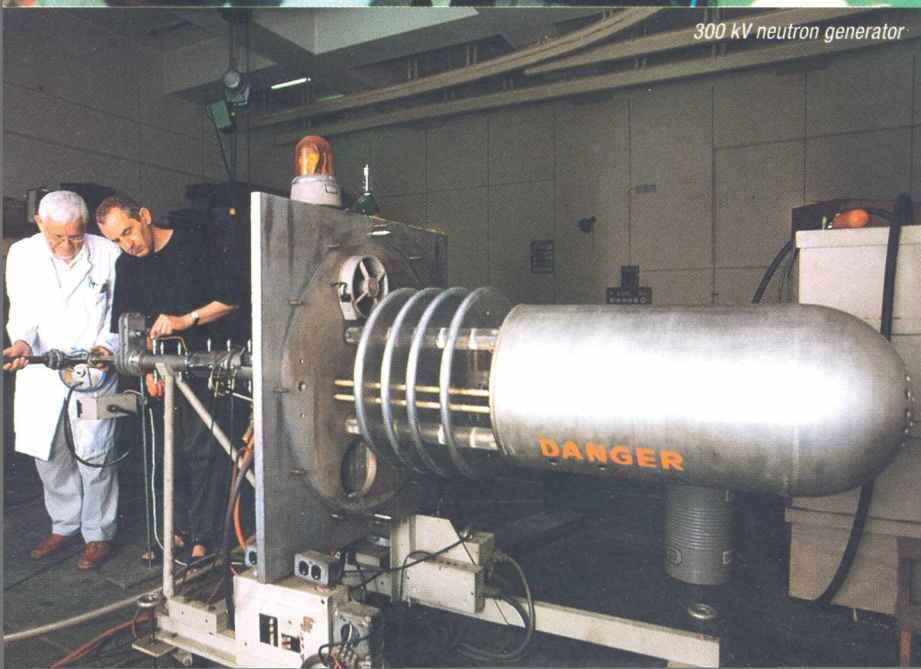
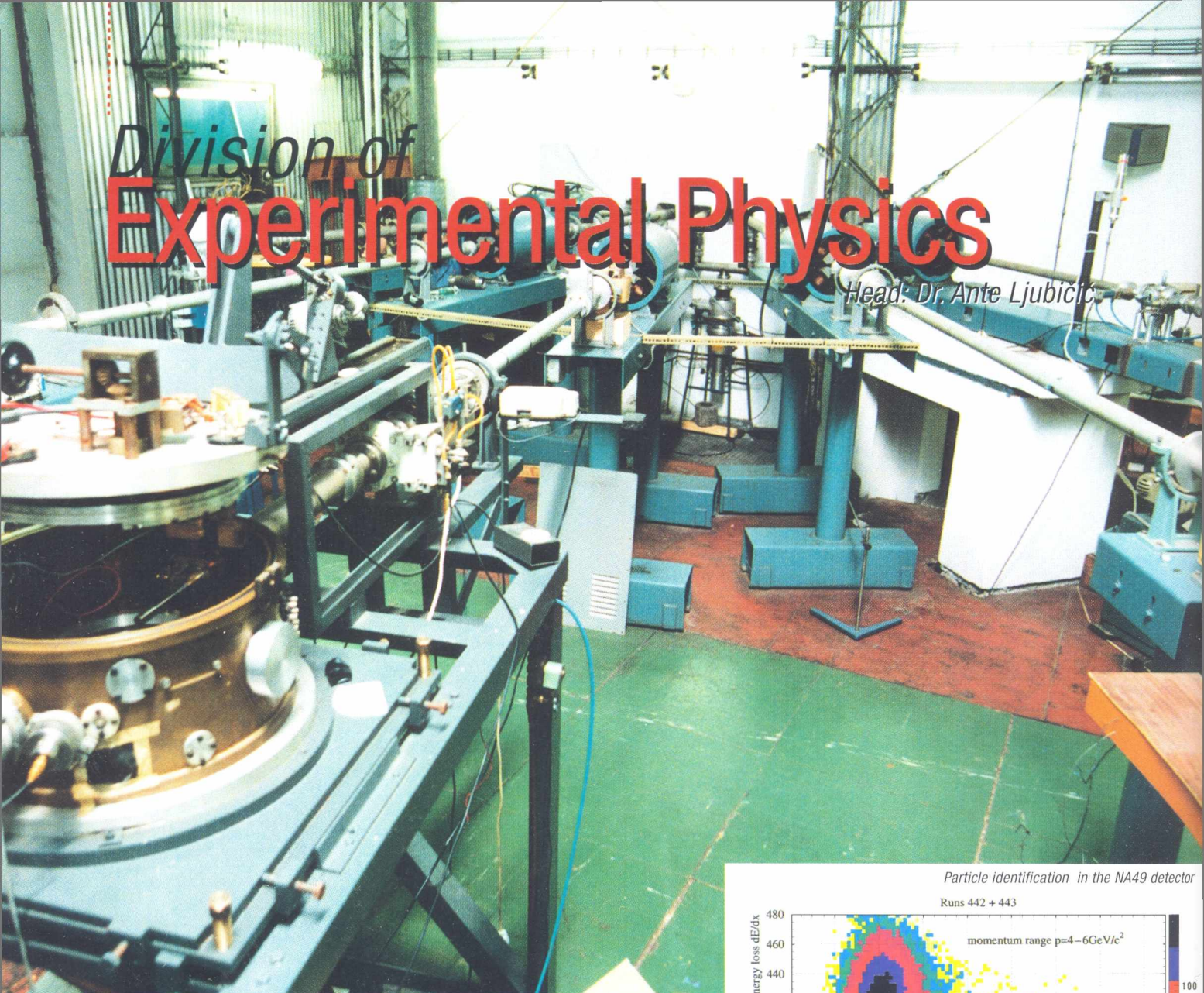
Fractal analysis of suspended aggregates of particles in seawater is studied as well as various, theoretical models of fractal molecular

organization. The methods of nonlinear dynamics including fractal structure and chaotic behaviour is applied to investigate the behaviour of nonstationary time series that appear in medicine such as ECG and EEG in order to improve diagnostic predictabilities.

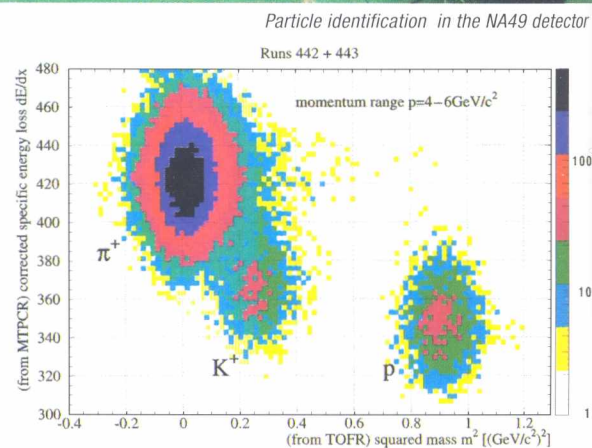


Division of Experimental Physics

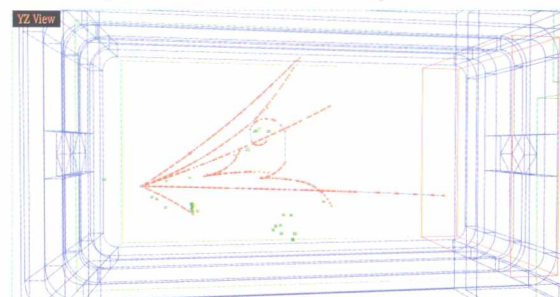
Head: Dr. Ante Ljubicic



300 kV neutron generator

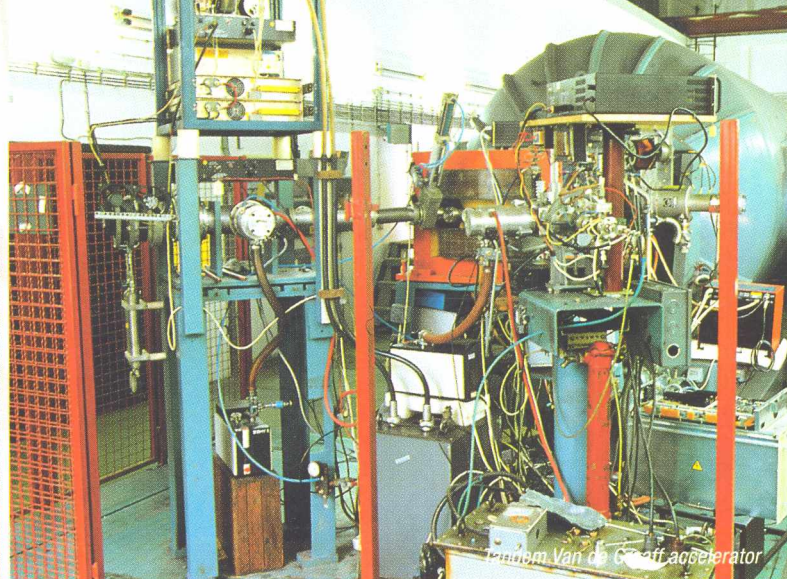


Signal of a neutrino-nucleon scattering in the NOMAD detector

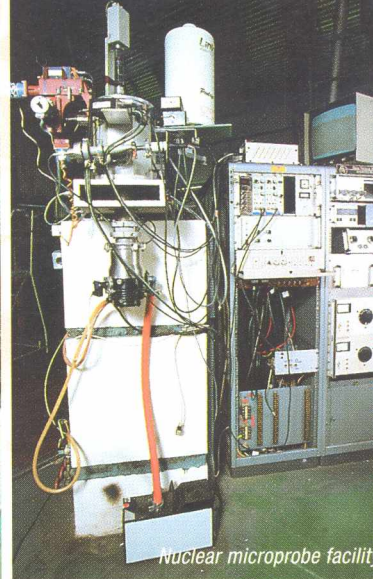




Search for solar axions



Tandem Van de Graaff accelerator



Nuclear microprobe facility

The Division of Experimental Physics was established in early 1950's when the Ruder Bošković Institute was founded as the main Croatian research center for nuclear sciences. The main research activities were based mostly on 200 keV Cockcroft-Walton accelerator used as a generator for fast neutrons, 16 MeV deuteron-energy cyclotron for isotope production and the use of radioactive sources. In 1987 a 12 MeV Tandem Van de Graaff accelerator was installed and it became the major experimental facility of the Division.

The Division's priorities lie in areas of basic research with a strong application-oriented component. At present the research activities of the Division are carried out in various fields of nuclear, particle and atomic physics and their applications in technology, energy, medicine, geology and environmental and radiation protection. The Division employs 23 scientists, 9 researchers, 7 graduate students and 9 technicians and administrators.

Low energy nuclear and atomic physics research is concentrated around the Tandem Van de Graaff accelerator. The nuclear reactions are studied to explore special structural properties of light nuclei as well as to get information important for understanding stellar evolution. Ion beams are also used as a tool for elemental characterization of material with the proton microprobe, the PIXE and the heavy ion RBS. In medium and high energy physics our scientists are actively engaged in experiments at European and US research centers, investigating nuclear forces and behaviour of nuclear matter under extreme temperature and density conditions. In the ultrarelativistic heavy ion collision experiments at CERN (NA-44, NA-49, and ALICE collaborations) they are looking for the signal of the

quark-gluon plasma, the primordial soup from which today's matter has been condensed. Also at CERN, a group of physicists engaged in NOMAD experiment are searching for the neutrino flavor oscillations, as the possible answer for the solar neutrino puzzle and the missing mass of the Universe.

Experimental and theoretical investigations of electromagnetic and weak interactions traditionally play a significant role in the Division's research activities. Higher-order electromagnetic processes in nuclear and atomic transitions, neutrino emission from neutron stars and in supernovae explosions, and the existence of elementary particles beyond Standard model are some of the topics in current research.

Research on low activity radiation measurements is also pursued and applied to ^{14}C radiocarbon and $^{230}\text{Th}/^{234}\text{U}$ dating techniques and to measurement of tritium in the environment. Division of Experimental Physics has been involved in many application activities in areas of its research, concerning the peaceful use of nuclear energy and radiation (such as measuring nuclear data of interest for nuclear fission and fusion technologies, recovery of uranium from coal, etc.), influence of neutron radiation on living organisms, development and application of different analytical methods for elemental composition analysis of materials, dating techniques of archaeological, geological and hydrogeological samples and measurements of tritium activities.

Most of the Division's scientists have been included in education, mostly through the postgraduate studies, resulting in a number of B.Sc., M.Sc. and Ph.D. degrees made in its laboratories.

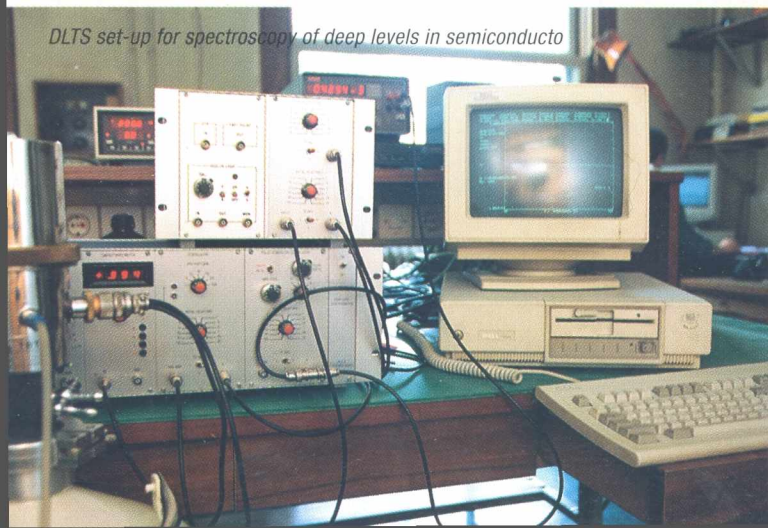


Multiparameter data acquisition

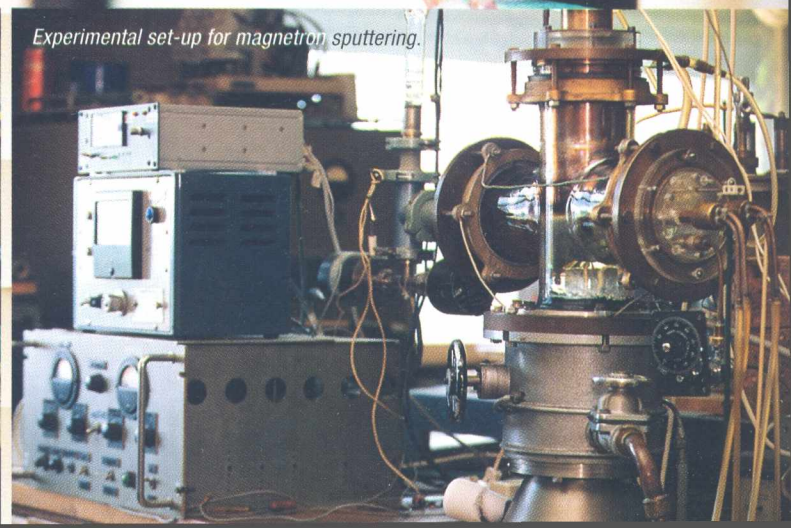
Division of Materials Physics

Head: Dr. Branko Pivac

DLTS set-up for spectroscopy of deep levels in semiconductors



Experimental set-up for magnetron sputtering.





Experimental set-up for thermal desorption measurements.

The Division of Materials Physics was formed during reorganisation of the Institute in 1997. It continues the tradition and the research organized and performed in the former Division of Materials Development and later Division of Materials Research and Electronics.

The present Division of Materials Physics is focused mainly on fundamental and applied studies of physical parameters and processes that describe and connect microscopic and macroscopic properties of condensed matter and molecules.

Research program is focussed on the following subjects:

- study of fundamental characteristics of defects, their mutual interactions, as well as their impact on the relation between microscopic and macroscopic properties of materials in simple (Si), binary (GaAs, GaN, CdS), and multinary semiconductors and complementary oxides. Study of nanophase and glassy material characteristics.
- study of amorphous thin films produced by non-thermodynamical processes (magnetron sputtering), particularly Al-W and WC films. Study of processes in plasma obtained during laser ablation of metallic and non-metallic materials.
- fundamental research in the field of molecular and solid state physics with special emphasis on vibrational spectroscopy. The systems under investigation vary in their origin and composition - from metals, semiconductors, and ceramics on one side to the molecular crystals and biological samples on the other.

Research on the long term basis:

- a) to develop and apply new techniques for characterization of the wide range of material properties (such as: electrical, optical, nuclear, magnetic, etc.), building up expertise for specific applications.
- b) Studies of non-thermodynamical processes suitable for materials modification.

The results of the research may find a direct application in:

- electronic industry,
- machine and ship construction,
- energetics,
- radiation waste protection,
- medicine,
- defense.

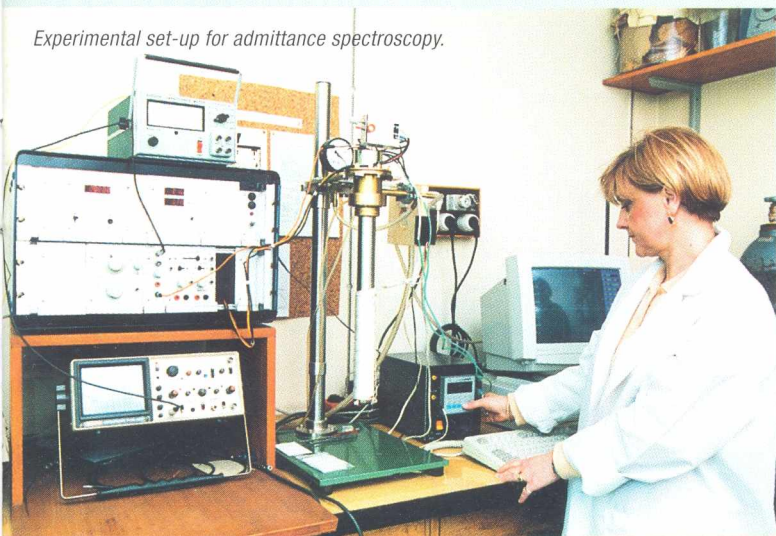
The researchers of the Division have been teaching at graduate and post-graduate levels at different universities in Croatia and abroad. Numerous Ph.D., M.Sc. and B. Sc. theses have been done as parts of our research projects.

Currently there are 15 researchers, 5 post-docs, 2 PhD students, 1 technician, 1 administrative secretary in the division.



Experimental set-up for thermally stimulated current measurements

Experimental set-up for admittance spectroscopy.

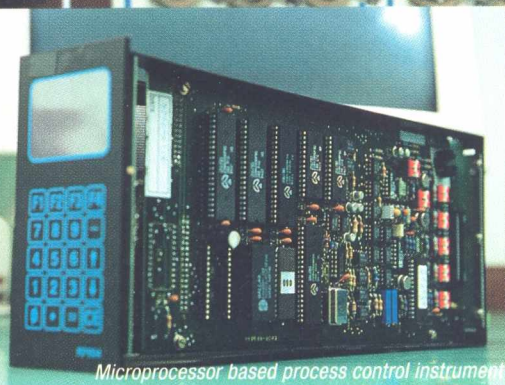


Raman spectrometer with microscope and He closed cycle cryostat for low temperature measurements.



Division of Electronics

Head: Dr. Nikola Bogunović



Microprocessor based process control instrument



On-line system measurement



Division of Electronics is a long-standing unit of Rudjer Boskovic Institute, active since 1950 when it was founded. Its main mission is to assist industry across Croatia to improve competitiveness through excellence in information technology by supporting and undertaking focused, application oriented research in systems and software. To achieve this mission Division of Electronics advances and contributes to the essential theory and practice in producing complex software and hardware systems that, to a high degree of certainty, have the intended structural and behavioral properties.

Its further mission is to educate researchers and practitioners to assume leadership roles in engineering, business, industry and other professional endeavors. The research-education synergism contributes to the development of critical thinking, and the ability to synthesize knowledge with a creative design process. The Division of Electronics long-term research program is focused on process modeling by intelligent computer systems. The program pursues fundamental science and technology goals as defined in the Croatian National Science and Research Program, with particular emphasis on supporting the progressive development of highly productive economy, capable for generating, accepting and diffusing scientific and technological innovations. The program strives to investigate and develop new modeling, optimization, and automated diagnostic procedures of technical processes by designing and utilizing intelligent, computer based systems. Process model construction is based on automated inductive procedures that discover relations within measured or simulated data sets. Automated model-based reasoning employs formal symbolic logic and theorem-proving methods, augmented with fuzzy variables, uncertainty measures, probabilistic causal networks, and case-based reasoning. Such advanced, structurally adaptive modeling techniques sustain decision and control procedures that enhance process efficiency by minimizing energy and material consumption, and maintenance downtime.

Prerequisites for optimal process modeling are first-rate primary signal processing methods that build upon classical deterministic and stochastic techniques, and aspire to enhance these methods by employing artificial neural networks and genetic algorithms. The presumption on probabilistic features of signals includes inherent process characteristics and all perturbations in its amplitude (energy) and time domain.

The activity within the Division of Electronics is conducted in laboratories and groups, which are equipped with the latest computing and instrumentation facilities. Present structure of



Complex measurement set-up

Division of Electronics encompasses two laboratories and one group. Laboratory for information systems (LIS) embodies four senior scientific researchers, two assistant researchers and grad-

uate students, and a technician. The core laboratory research is focused on model based computing (automated process model construction and reasoning on its non-obvious attributes). This computing paradigm is enhanced by the tight integration of models with real-world databases or physical processes.

Laboratory for stochastic signals and processes research (LISSP) embodies four senior scientific researchers, two assistant researchers and graduate students, and a technician. The research is focused on novel measurement procedures and techniques that identify essential and significant process parameters. In particular, serious attention is paid to the measurement and processing of multidimensional (1D and 2D) signals, as well as fundamental data structures and processing algorithms. The Group for Optoelectronics and Hypermedia Systems embodies one senior scientific researcher and two assistant researchers.

The fundamental research results are reported in the best international refereed journals and conferences. Numerous systems and software are applied as innovative solutions across the industry.

In addition, researchers from Division of Electronics are engaged, as adjunct professors, at the University of Zagreb, contributing to

the curriculum of undergraduate and graduate studies.

They are teaching undergraduate courses: Techniques of expert systems, and Optoelectronics, and graduate courses: Knowledge representation paradigms, and Programmable logic devices.



Research and development of instrumentation systems



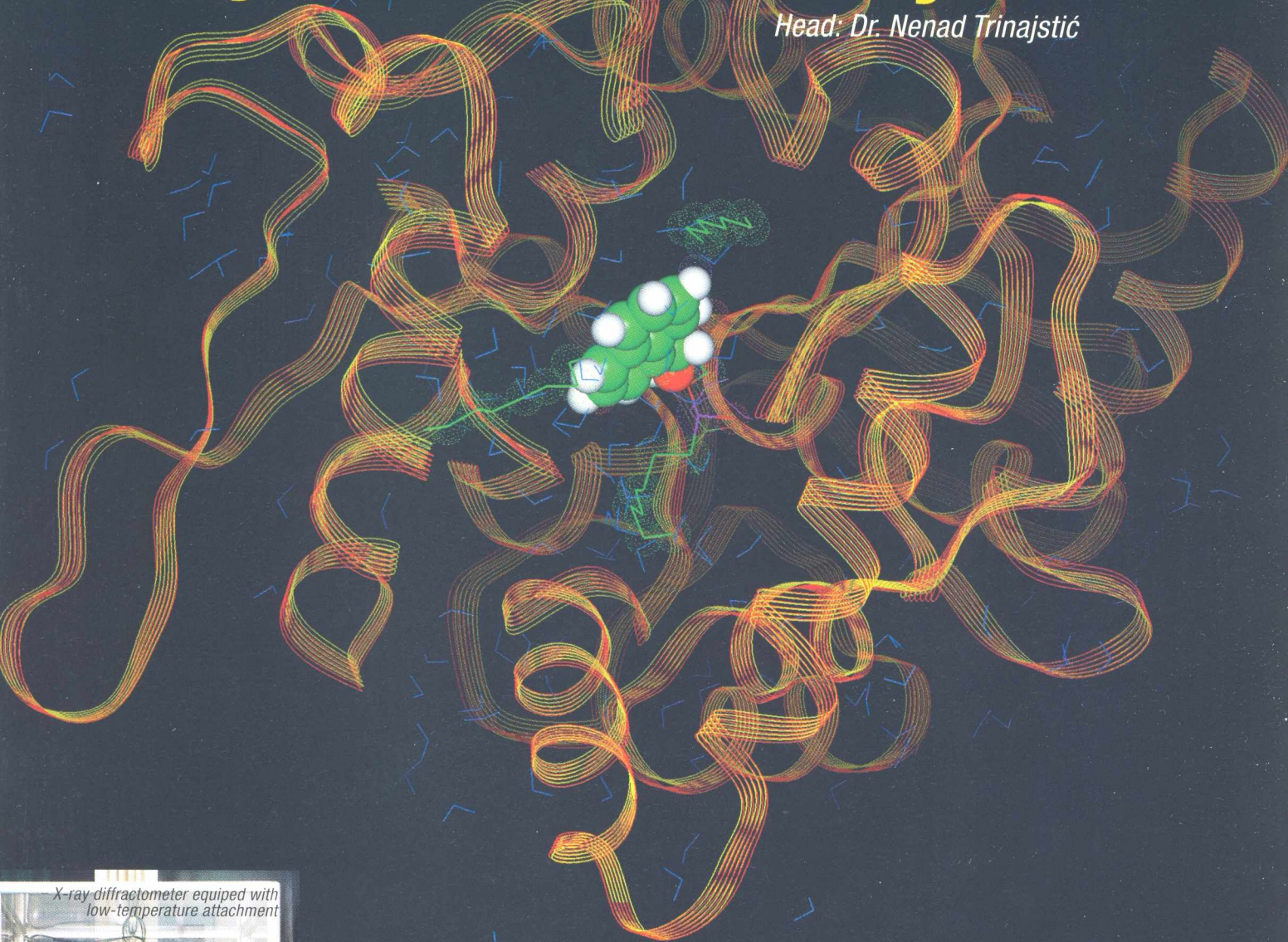
Hypermedia systems development



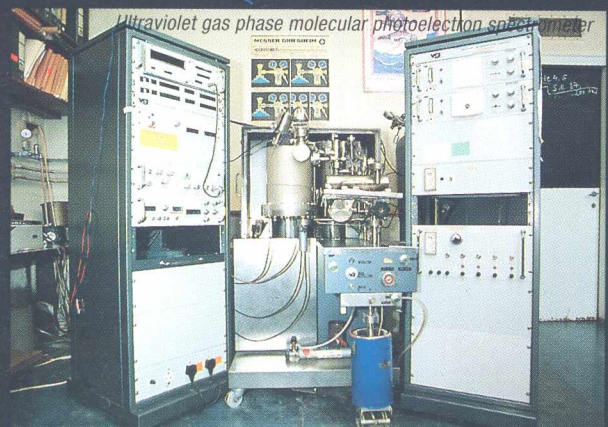
Satellite data acquisition system

Division of Physical Chemistry

Head: Dr. Nenad Trinajstić



X-ray diffractometer equipped with
low-temperature attachment



Ultraviolet gas phase molecular photoelectron spectrometer



Computer modelling of an enzyme active site

The Division was founded in 1951 and initially research was mainly in the field of colloid chemistry because the founder of the Division was a well-known colloid chemist, Professor Božo Težak.

During the time an interdisciplinary approach has been used in the study of correlation of molecular structure and dynamics and molecular properties. A large variety of new substances has been synthesized including supramolecular, inorganic and organic compounds, and organometallic complexes as well. Some proteins have been isolated and crystalized in order to study their structures and functions.

For molecular structure determination, various spectroscopic methods have been applied: photoelectronic, NMR, ESR, DMESR, IR-FT, PFS, mass spectrometry. X-ray structure analysis has been used to unambiguously determine the molecular and crystal structures of small molecules and proteins.

Investigations of magnetic and microwave properties of high temperature superconductors and crystal lattice dynamics of magnetic, ferroelectric and other systems have revealed properties of industrial importance. The molecular probes used in dynamics studies by ESR and NMR methods on synthetical polymers and biopolymers exhibit system properties that determine their application modes.

The experimental results obtained have been extended by theoretical procedures based on great possibilities of computational chemistry and extensive data bases in order to establish structure-property-activity correlations (QSPR/QSAR) for various groups of compounds, and to understand the mechanism of chemical reactions at the atomic and molecular levels. QSPR/QSAR models based on the connectivity and distance indices and a novel approach to descriptor selection have been developed and tested. Computer modelling has been applied in the molecular recognition approach in order to understand the chemical reactivity of pollutants, particularly atmospheric, and various biological systems. Molecular dynamics simulations have been used to study conformational stability and substrate binding to the active site of a protein receptor. QSAR based on modified Free-Wilson method and energy binding analysis has been used to explore DNA interactions and protein-specific binding of transcription factors, essential for gene regulation.

Formation, destruction and transport of ozone and photooxidants in Croatia and some locations of Mediterranean and Europe were studied.

Chemical graph theory has been used to define different classes of molecules or their



Spinning drop tensiometer

aggregates. Useful theoretical models describing various molecular properties have been established. Very successful theoretical studies of atomic and molecular collisions, particularly dynamics

of a decay of Ar-HF dimer, were performed.

Structure-property-activity modeling, one of our major interests, is of great importance in other branches of chemistry as well as in structural and molecular biology, agronomy, pharmacy, biomedicine and ecology. Expertise in this kind of modelling has prepared

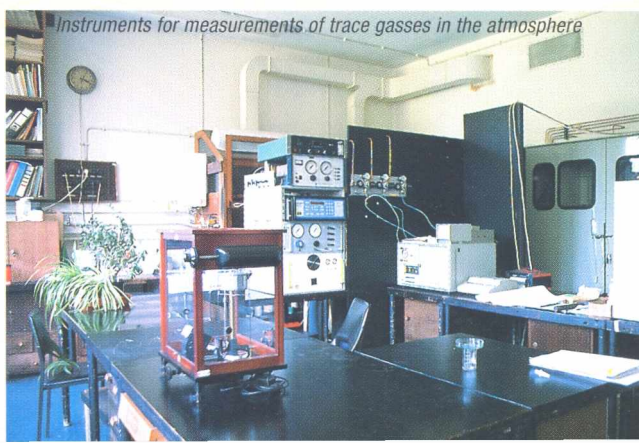
this Division for interdisciplinary research. Scientists of the Physical Chemistry Division have developed fruitful international scientific cooperation with many universities and research institutes, which has resulted in a number of joint scientific publications. International collaboration within the project EUROTRAC related to monitoring and research of air pollution in Croatia and Europe is of high significance. Long lasting cooperation with the Research Institute of pharmaceutical industry PLIVA is based on our scientific achievements. Methods for identification of biological minerals for needs of hospitals and medical institutions have been developed. Classical analytical methods and modern spectroscopic techniques have been used for identification of various compounds and substances of importance in industry. Members of the Division are involved in teaching undergraduate and graduate courses at all four universities in Croatia. Moreover, they are regularly mentors for undergraduate, graduate and Ph. D. students. Currently there are 35 researchers, 8 technical personnel and 11 Ph. D. students in the Division.



3-D molecular structure of buckminsterfullerene



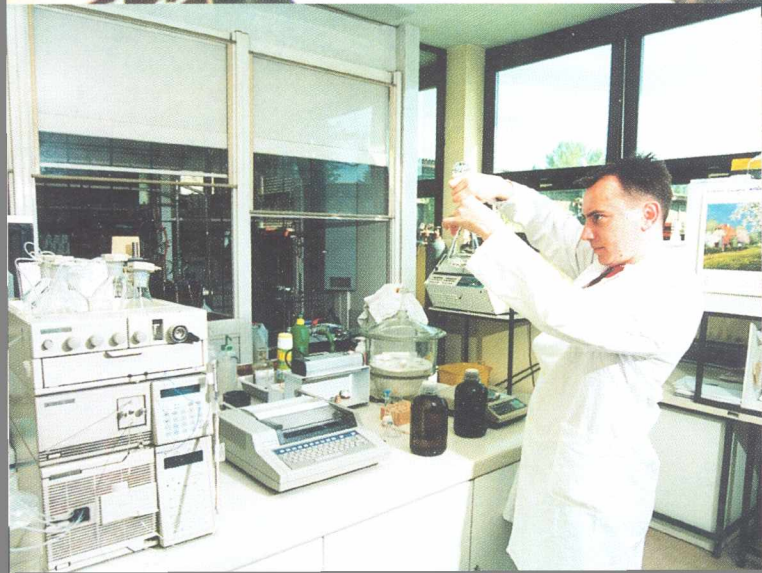
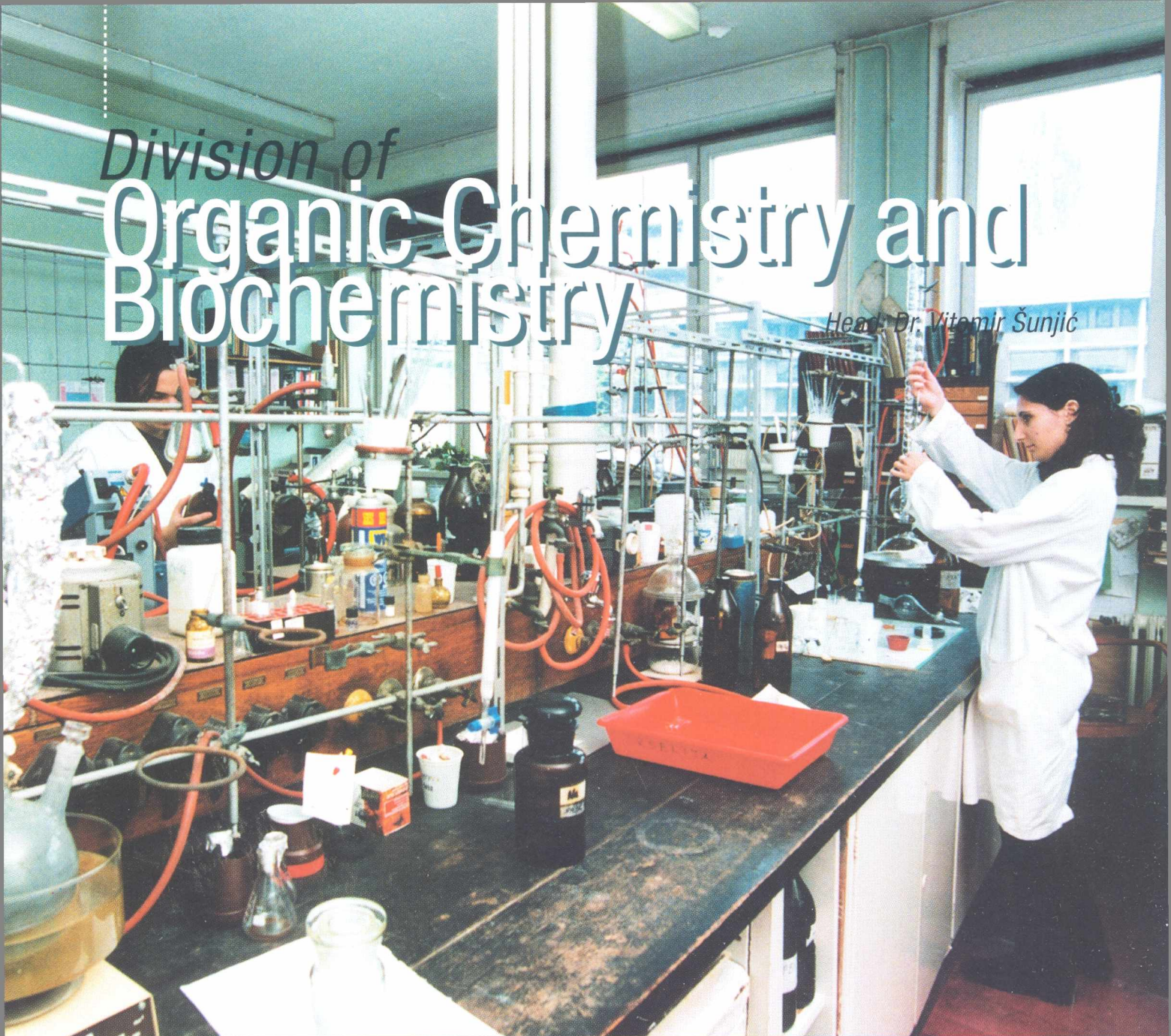
3T Fourier transform mass spectrometer



Instruments for measurements of trace gasses in the atmosphere

Division of Organic Chemistry and Biochemistry

Head: Dr. Vitoimir Šunjić

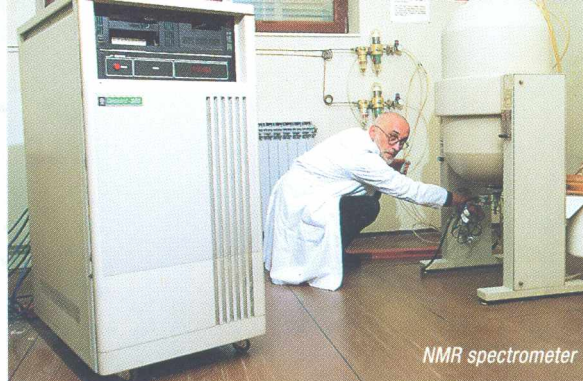


The Division of Organic Chemistry and Biochemistry was founded in 1958, at the same moment when research in many other areas of natural sciences were introduced at the "Ruder Bošković Institute. Initial projects were oriented towards application of radioisotopes in bioorganic chemistry, in order to keep the line with a general trend of the Institute's activity in nuclear research at that time. However, development of synthetic methods in the field of antibiotics, nucleosides, nucleotides and oligosaccharides has been set forth too, in order to develop and to keep going a collaboration with the Research Institute of the "Pliva" Pharmaceutical Works.

Soon after these initial phase research projects were established, physical organic chemistry and in particular a project on the isotope effects in kinetics of organic and bioorganic reactions received a strong impetus. More recently, computational organic chemistry and molecular spectroscopy and in particular supramolecular chemistry, glycoproteins and stereoselective catalysis gained a strong momentum.

Currently two Programs are running within Division: *Selective Processes on Molecular and Supramolecular Level* - Program director Dr. Vitomir Šunjić and *Electronic Structure and Dynamic of Organic Molecules* - Program director Dr. Mirjana Eckert-Maksić.

Work on stereoselective catalysis and biocatalysis, supramolecular chemistry, preparation of glycopeptides and proteins, isolation of enzymatic proteins, and a study of function and biological activity of all indicated classes of structure characterizes the first program. Biologically active compounds are regularly screened in collaboration with pharmacological laboratories in Croatia and abroad. Combining organometallic catalysis and biocatalysis in solving problems of original or economic syntheses of enantiomerically pure compounds (EPC) is well, established, and recently has been broadened to development of the first supramolecular chiral catalysts and ion-transfer crowns. These last achievements are result of collaborative research of several laboratories in the Project. Extensive work in the field of acid-base chemistry, molecular spectroscopy, and quantum organic chemistry is a hallmark of the second program. Conspicuous research on the electrophilic substitution reactivity of aromatic compounds, computational tailoring of patent organic superbases and investigations of the electronic structure of alpha-amino acids and small peptides should be underscored. The work within this program is also concerned with introduction and application of innovative techniques, such as the high pressure and



NMR spectrometer

examination of the NMR parameters in organic and bioorganic systems with particular emphasis on the influence of isotope effects should be mentioned.

The organization of the Division characterizes full academic freedom of both scientific Programs as well as of single Laboratories in creating scientific policy and the research process, in particular in making decisions concerning long-term scientific interests. The same holds for collaboration with the third parties from the academic world and industry.

Thanks also to highly cooperative relationship between the heads of the Laboratories and colleagues at the University of Zagreb, in particular with Departments of Chemistry at the Faculty of Natural Sciences, Faculty of

Chemical Engineering and Technology, Faculty of Pharmacy and Biochemistry, and Faculty of Nutritional Technology and Biotechnology, this Division continues to educate large number of B.Sc., M.Sc., and Ph.D. students. In the last 5 years about 50 students have fulfilled the re-

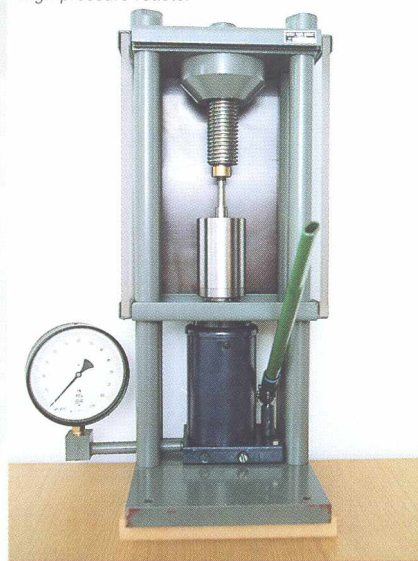
quirements for their degrees in the Division. Presently, 32 scientists, 24 PhD students, and 12 technical staff are employed. Intensive educational activity has many positive consequences for the Department. Good relations with many domestic companies is based on collaborative and private contacts between senior scientists of the Division and their former students, now active in these companies. Besides, during their stay in our Department students and young scientists contribute to a fresh, creative and enthusiastic atmosphere. Let us just mention regular seminars held by research students, where the state art topics are discussed.



CATEB collaborators

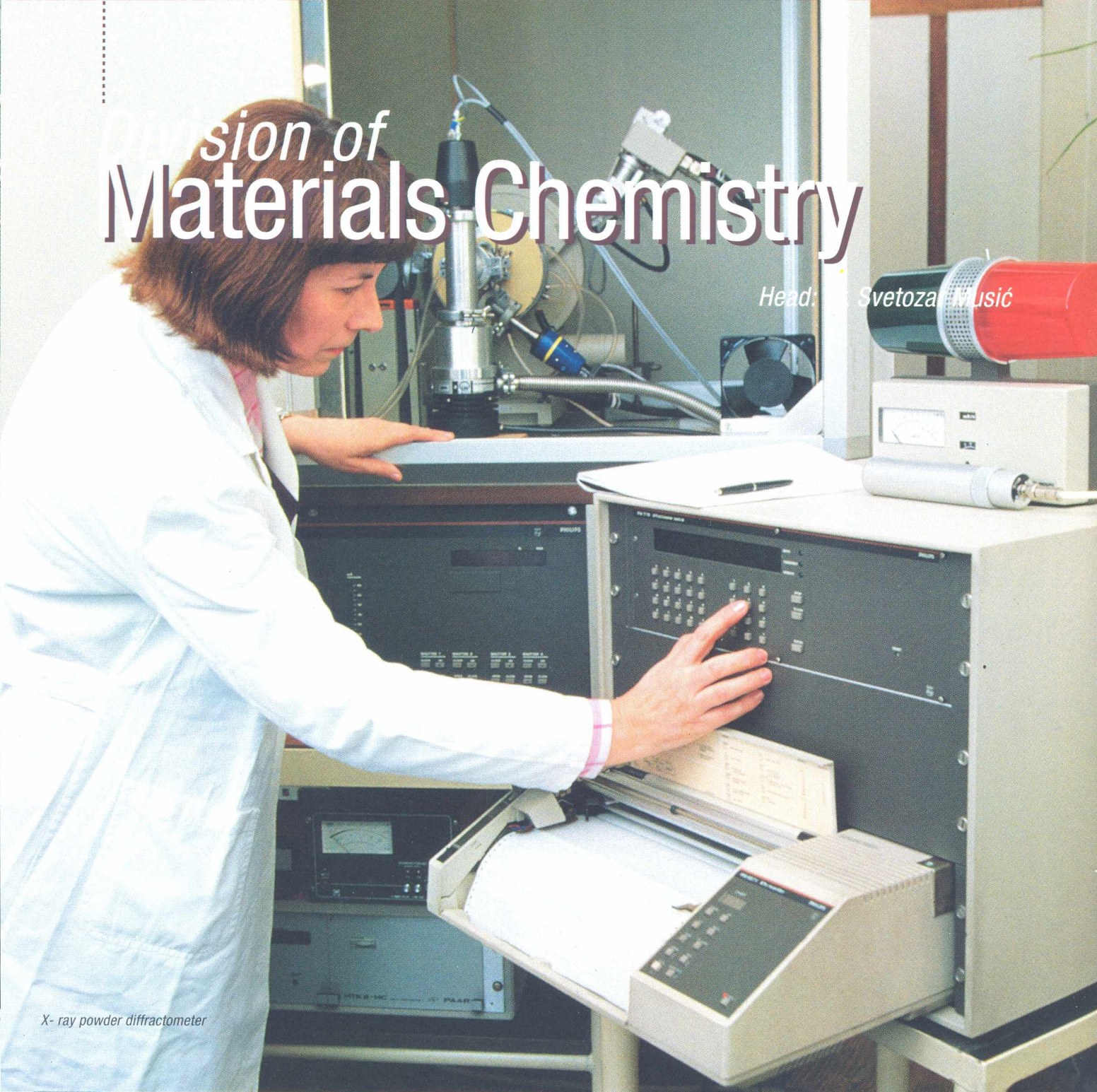
The main merit of Division is its overall scientific output, reported in numerous papers published in the well-recognized, SCI and CC cited, scientific journals. In addition, there are many contributions from the members of Division in the scientific monographs, as scholarly review articles, invited lectures at conferences etc. The latter are usually results of successful international collaboration; let us mention here bilateral and multilateral projects with laboratories in USA, UK, Germany, Austria, Slovenia, France, Italy and Hungary, as well as participation in the European COST cooperation. Over 20 such collaborative projects were put in effect in the last 10 years.

High pressure reactor

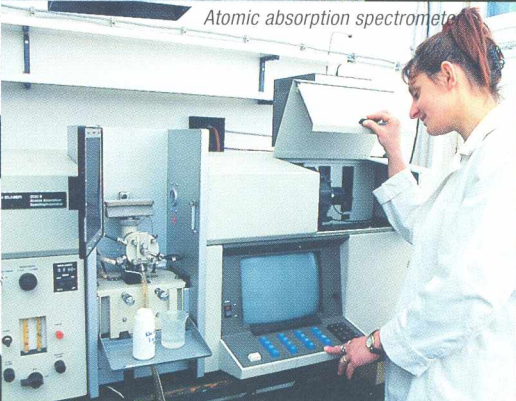


Division of Materials Chemistry

Head: *Svetoza Misić*



X- ray powder diffractometer



Atomic absorption spectrometer



Differential scanning calorimeter



Synthesis of complex compounds

The Division of Materials Chemistry consists of five laboratories. Main research activities are located on the program "Science and Technology of Materials", financially sponsored by the Ministry of Science and Technology of the Republic of Croatia. There are also numerous activities in cooperation with different industries, hospitals, state institutions and faculties.

Radiation Chemistry and Dosimetry Laboratory was founded in 1958, and was focused in two directions: (a) investigation of fundamental mechanisms of the interactions of ionizing radiation and matter and (b) investigation of the possibilities to apply biological and chemical effects of irradiation. On the basis of own investigations, two chemical dosimeters, one for low and the second for high doses, were developed. We have measured the natural radiation background in numerous locations in Croatia, as well as exposure of medical professionals and patients to irradiation in medical uses of radiations. These measurements provided a quantitative basis for the development of radiation protection in Croatia. Further research in radiation chemistry of polymers has attracted considerable international interest, such as radiation crosslinking and radiation grafting of polymers, as well as radiation polymerization and co-polymerization, in general.

The Laboratory for Synthesis of New Materials has focused its research activities on metal oxides, oxide glasses and zeolites. Systematic investigation of metal oxides started in the early 70s during a search for desirable colloidal metal (hydrous) oxide particles as carriers for short-lived radioisotopes, which were used in diagnosis of malignant diseases. Current investigations involve magnetic oxides such as spinel-, hexagonal- and garnet ferrites. We also study mechanisms of the formation of various metal oxides such as ZrO_2 , HfO_2 , SnO_2 , TiO_2 , WO_3 and Rh_2O_3 . Special attention is focused on the synthesis of nanosized oxide particles with superior properties for the applications in advanced technologies. We have strong background in the investigations of oxide glasses, glass-ceramics and corrosion processes of different materials. Further the investigations in the chemistry of zeolites started with the synthesis of zeolite-A for application in the detergent industry. On a basis of the knowledge of mechanisms and kinetics of the critical processes and their interdependence, many properties and behaviour of zeolites, which found important applications as ion exchanges, molecular sieves, absorbents, catalysts, food supplement etc., can be anticipated.

The Laboratory for Precipitation Processes was founded in 1968. Apart from precipitation systems at equilibrium conditions, the investigation of kinetics and mechanisms of precipitation



Crystal growth, dissolution and phase transformations

transformation of thermodynamically unstable forms into stable ones. The extensive investigations on calcium phosphates, oxalates, carbonates and sulphates have been carried out.

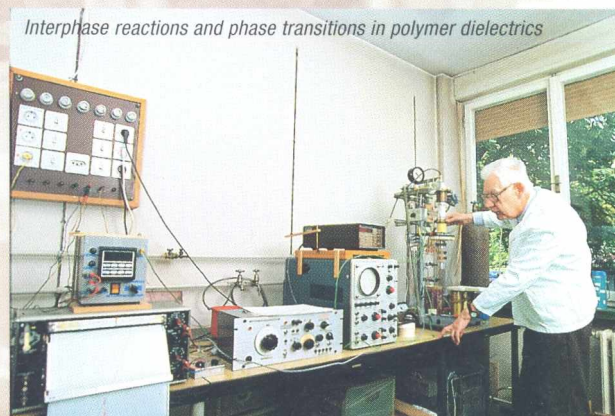
The field of metallic materials has always played an important role in the research activities of the Laboratory for Solid State Chemistry. It has a long tradition, and was started in the Department of Structural and Inorganic Chemistry at the very beginning of the Ruder Bošković Institute. The first work was lined to semiconducting materials, followed by a period of intensive research into nuclear fuel materials. Current research is mainly focused on the reactions of intermetallic compounds with hydrogen or oxygen. These materials can be used as catalysts, for hydrogen storage as ecologically acceptable source of energy, in rechargeable Ni/MH batteries, where metallic hydride (MH) replaces toxic cadmium, etc.

In early 70's the intensive investigations in chemistry and stereochemistry of the transition metal complexes compounds have started in the Laboratory for Complex Compounds Chemistry. Compounds with direct chemical bond between metal atoms were developed parallel with other investigations. The experience gained in the studies of the transition metal complexes has been successfully applied in the investigation of high-temperature superconducting oxides in the systems La-Sr-Cu-O and Y-Ba-Cu-O, as well as Bi-Ca-Sr-Cu-O, (Ln, Ce)-(Nb, Ta)-Sr-Cu-O and Hg-Ba-Ca-Cu-O. The investigation of high-temperature superconducting oxides is interdisciplinary with participation of a number of home and foreign scientific institution.

Members of the Department are involved in undergraduate and postgraduate studies. A number of students have accomplished their Bsc, Msc and PhD thesis from different topics of fundamental or applied research activities at the Division. Currently there are 34 researchers, 10 technicians and 9 PhD students involved in Division's activities.



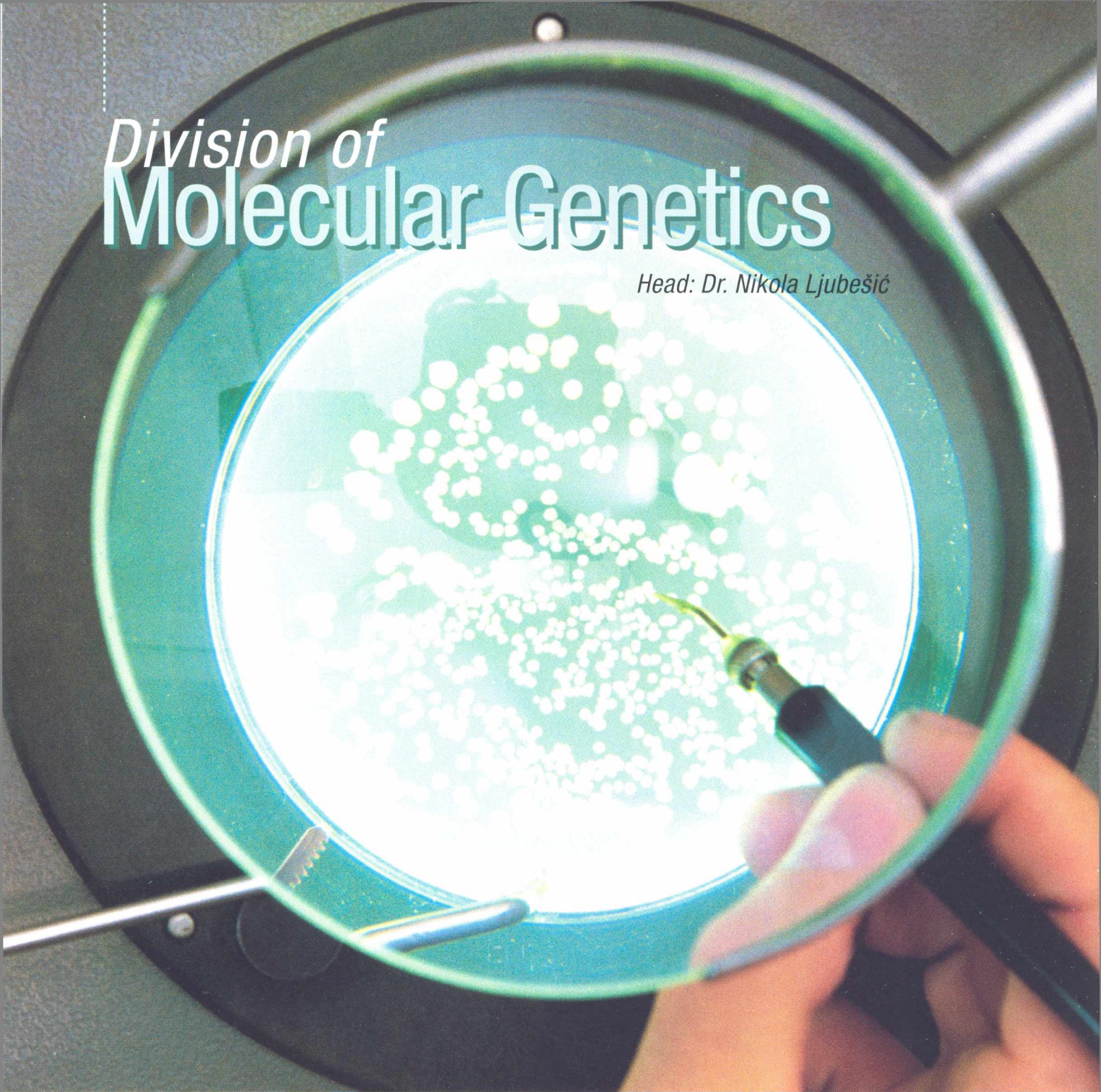
The facility for gamma irradiation



Interphase reactions and phase transitions in polymer dielectrics

Division of **Molecular Genetics**

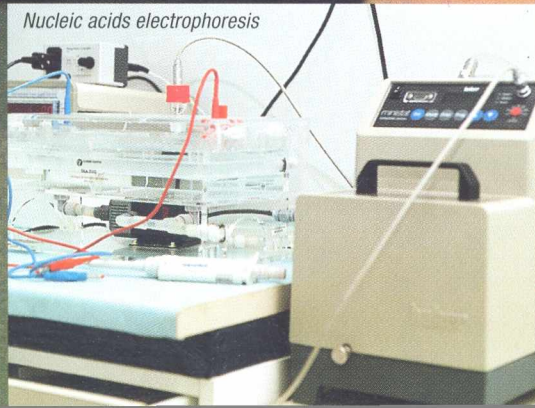
Head: Dr. Nikola Ljubešić



Plasmids isolations



Nucleic acids electrophoresis



DNA isolation



Over forty years ago the Laboratory for Cellular Radiobiology in the Department of Biology of the Ruder Bošković Institute was founded. At that time, the era of molecular genetics had already been born. Genetics coalesced with biochemistry. The genes were no longer considered as purely hypothetical units of heredity. It became evident that the deoxyribonucleic acid, usually called by its abbreviation - DNA, carries genetic information.

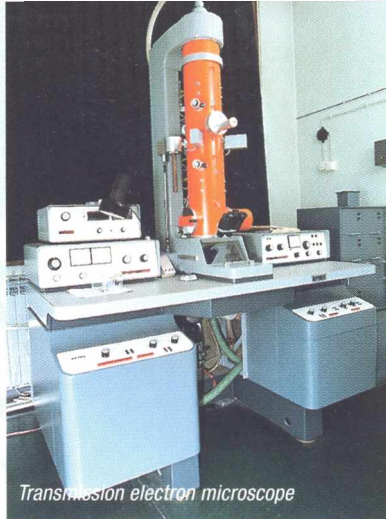
The geneticists therefore turned their attention to DNA. The same was true for young and enthusiastic scientists - a group of chemists, biologists, agronomists, veterinarians, and physicians - in the Laboratory for Cellular Radiobiology. They studied the effects of radiation on DNA metabolism in simple experimental systems (the intestinal bacterium *Escherichia coli*, bacterial viruses, animal cells in culture). In Croatia, just as in many other countries, radiation experiments played a seminal role in the development of molecular genetics.

Unfortunately, the socio-political events during the 1970's and the early 1980's were dominated by the philosophy of "associated labour". This philosophy was unfavourable to science, particularly to molecular genetics. There was no significant increase of our molecular genetics although the recombinant DNA revolution began in the mid-seventies. New methods for dissecting, cloning, and amplifying genes were discovered.

The scientists in the Laboratory for Cellular Radiobiology decided to familiarize our chemists and biologists with these new powerful methods. In 1979, they organized the first course on recombinant DNA in Croatia. This course no doubt had a strong influence on the further development of our molecular genetics. In addition, some of the molecular geneticists obtained professorships at the University of Zagreb (Faculty of Natural Science and Mathematics, School of Pharmacy). More importantly, nearly all of them taught varied postgraduate biological courses. These courses were an eye-opener for most students who became aware of marvellous new discoveries, to which recombinant DNA procedures had led.

In the mid-eighties, molecular genetics finally was given an established place in Croatian science. The Ministry of Science and Technology of the Socialistic Republic of Croatia then wanted to organize the University Center of Molecular Genetics. A large number of postgraduate students, who intended to work in the Center, received a fellowship from the Ministry. The laboratories of the Center were expected to be well equipped for the experimental studies in molecular genetics.

In 1991, the Division moved to



Transmission electron microscope

a new building, in which it now occupies a smaller space than was initially planned. Also, it is deplorable that the links between the University and the Institute are not formally regulated. In spite of this, the collaboration of our Division and the Faculty of Science and Mathematics is very successful. Scientists from both institutions working together in our Division actively contribute to the rapidly advancing front of the knowledge of modern genetics.

The research programme includes studies of the:

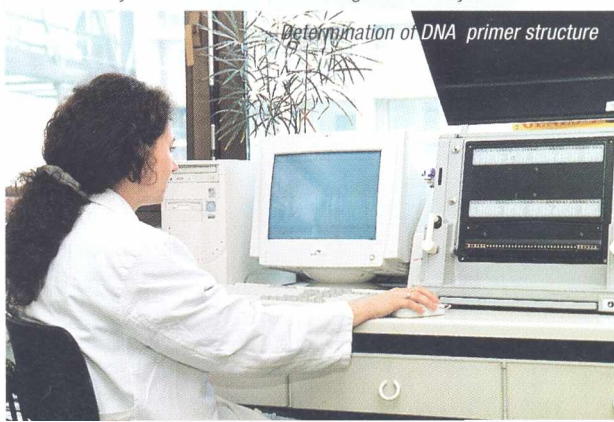
- genetic molecular mechanisms and regulation of genetic recombination in bacteria, bacteriophages and plasmids.
- role of RecBCD enzyme in the bacterial growth, plasmid maintenance, DNA repair and Hfr-mediated recombination.
- plant cell transformation and regeneration of transgenic plants.
- activation and expression of the cellular oncogenes and oncogenic viruses.
- plastid differentiation and the effect of growth substances and specific herbicides on these processes.
- structure, organization and mode of expression of genes in *Streptomyces* and *Porifera*.
- structure, organization and evolution of satellite DNA's and heterochromatin in different insect species.
- transfer RNA recognition by aminoacyl-tRNA synthetases
- regulatory mechanisms and the control of transcription initiation in eukaryotes
- studies of the molecular mechanisms of phytohormones and peptidoglycans
- cell response to genotoxic agents
- neurochemistry and molecular biology of serotonergic transmission
- phytocenoses, holophytes, marine Algae, mycoflora and their degradation by man and wind in Adriatic Island and Croatian Coast



Computer analysis of electrophoresis



Insects gonad isolation

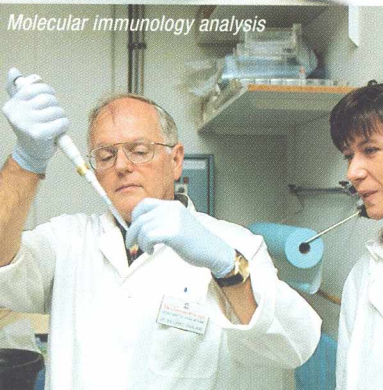


Determination of DNA primer structure

Currently there are 64 scientist, 34 Ph.D. students and 8 technical stuff in the Division.

Division of **Molecular Medicine**

Head: Dr. Krešimir Pavelić



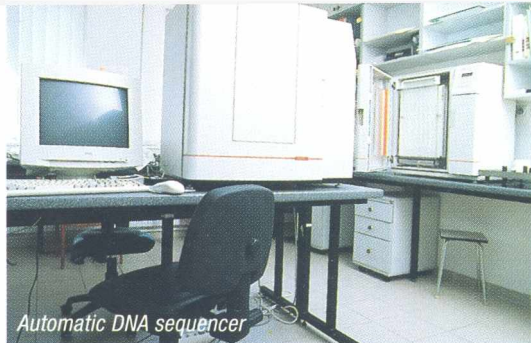
Molecular immunology analysis



Tumor cell culture



Loss of heterozygosity in tumor suppressor genes



Automatic DNA sequencer

Research in biology started around 1958. At that time the Department of Biology was founded and was renamed to the Department of Experimental Biology and Medicine in 1971. A part of the Department evolved in the Division of Molecular Genetics and the other in today's Division of Molecular Medicine in 1996.

The Division of Molecular Medicine is the largest and best equipped Croatian institution for basic and applied research in the field of molecular medicine, human molecular genetic and cancer research. According to scientometric criteria the Division is a center of excellence in biomedicine having the biggest international impact among all Croatian biomedical institutions.

Major interest is directed toward the genetic mechanisms involved in the pathogenesis of human cancer. Ongoing research includes:

- expression and role of growth factors;
- oncogenes and tumor-suppressor genes in malignant tumors;
- gene therapy of cancer;
- T lymphocyte development and differentiation from hematopoietic stem cells;
- gene activation and transcription factors in leukemia, molecular biology of chronic lymphocytic leukemia, acute leukemia's and lung tumors;
- combined treatment of tumors disease in experimental animals by using classical approaches (surgery, chemotherapy, radiation) and particularly defined components isolated from plant and animal tissues; photodynamic therapy of tumor - experimental and clinical approaches;
- neuroendocrine control of hematopoiesis and immunity; adhesion molecules in hematopoietic cell proliferation and differentiation;
- intracellular Ca ion in the transmission of opioid signals; oxidative stress; the role of free radicals (O_2^- , NO, lipid peroxides) and opioid peptides in homeostasis and stress;
- neuroendocrine factors and adhesion molecules in epithelial cell differentiation;
- investigation of the mechanisms of action of enkephalin and peptidoglycans on cellular and some subcellular structures;
- mechanisms of etiology and pathogenesis of experimental diabetes mellitus syndrome at the animal, cellular and molecular levels;
- the relation between experimental diabetes and tumor growth

and necrotic processes;

- role of NO in beta-cell death during autoimmune process of cell

destruction or tissue rejection;

- design and preparation of vaccines based on viral subunits and peptides for both anti-viral protection and therapy of tumors and autoimmune diseases;
- theory of molecular recognition and experimental characterization of peptide presentation pathways;
- antitumor screening of newly synthesized drugs;
- quantitative and qualitative characterization of viral subunits and specific antibodies;
- molecular detection and linkage analysis of different inherited diseases and cancers; molecular diagnosis of malignancy;
- molecular virology;
- oncolytic activity of particular viruses;
- the application of lymphocyte transformation and oxidative stress in clinical practice;
- tests of pharmacologically active substances for the pharmaceutical industry.

Croatian human tumor and DNA bank, established jointly by the Croatian Academy of Sciences and Arts, as well as animal facility are located in the Division.

Besides the activities in fundamental and applied research, members of the Division have lectures at undergraduate and postgraduate studies at several universities in Croatia. In the Division's laboratories, numerous student are performing their B.Sc., M.Sc. and Ph.D. thesis respectively.

Currently there are 32 scientists, 20 Ph.D. students and 14 technicians included in the activities of the Division.

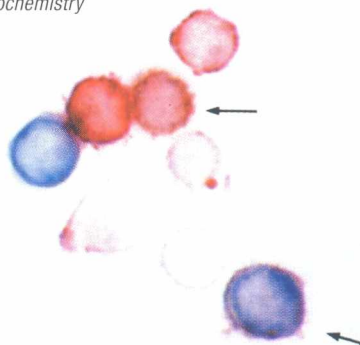
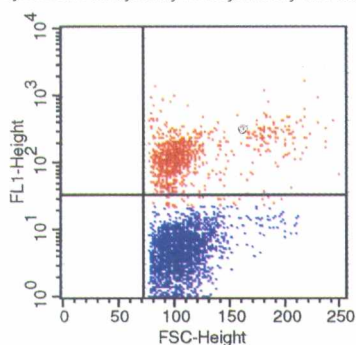


Experimental animals handling



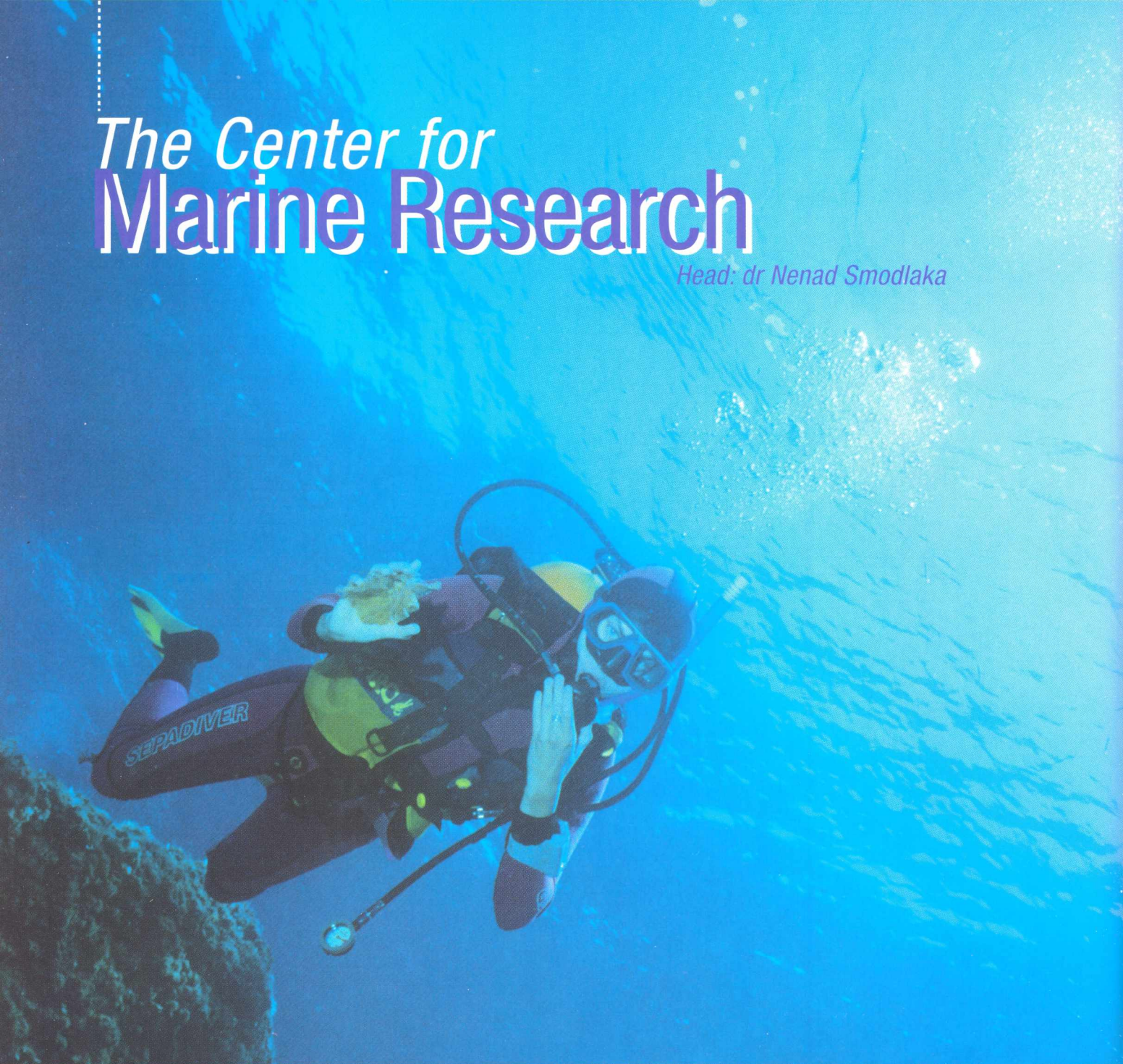
Tumor cell injection

Lymphocyte analysis by flowcytometry and immunochemistry



The Center for **Marine Research**

Head: dr Nenad Smodlaka



The aquarium



Research vessel "Vila Velebita"

The Center for Marine Research is a department of the "Ruder Bošković" Institute. It is situated outside the main Zagreb campus in the old town of Rovinj on the coast of the

Istrian peninsula. The Center, as its name indicates, deals exclusively with marine science. Marine research in Rovinj has a long history, dating to 1891 when the Berlin Aquarium established a field station to collect plants and animals. The station immediately attracted scientists from various parts of Europe. Despite political changes over the years, marine research has continued to the present in Rovinj, with some short interruptions during the two world wars.

During its history, the marine station in Rovinj has experienced peaks and valleys of activity. By entering the "Ruder Bošković" Institute in the late 1960s, the station has experienced its best times, and today it is one of the most important marine institutions in the Adriatic region.

The Center for Marine Research continues a tradition of research that focuses on field studies in benthic ecology and biodiversity, and on water column processes in the northern Adriatic. Complementary laboratory research in marine ecophysiology and ecotoxicology have also been an important emphases for many years. Research also addresses the identification and taxonomy of marine organisms, a very important traditional field of study that needs new expertise. Modern and advanced approaches of molecular biology and genotoxicology have been introduced in marine environmental research in the middle 1980s, and research in ecophysiology and ecotoxicology has concentrated on molecular, cellular and integrative levels under normal and stressed conditions.

Global interest in the environment today puts a stronger emphasis on marine research as people are increasingly aware that the oceans play an important role in the overall balance of the Earth. Moreover, problems in coastal regions are increasing as the population increases in that vulnerable part of the ecosystem. To address these issues, the Center is also oriented toward applied ecological research, especially in the area of local community needs. This does not mean that a broader regional approach is neglected. Rather, the Center is actively involved in various regional projects and activities in cooperation with the neighboring states of Slovenia and Italy, and is also involved in international programs (e.g., UNEP, IOC). Active international collaboration has also



The library

been established with other countries, including the US, Germany, France, Austria, and the Netherlands.

At present, marine research in the Center is conducted by 22 Ph.D. scientists, 8 with M.Sc. degrees and

5 with B.Sc. degrees. The Center employs a total of 49 persons. Special attention is paid to the training of young scientists. To

house them, the Center built 16 apartments near the station. As part of their postgraduate education, the students are actively involved in international projects to provide them with exposure to the broad scientific community. For field research, scientists have access to a well-equipped research vessel, "Vila Velebita", that serves as a 26 m "floating laboratory" with 30 square meters of laboratory space. A smaller vessel, the 9 m "Burin", serves the needs of scientists doing nearshore research. The laboratories of the main building are relatively well equipped with instrumentation, although modernization is needed to keep pace with recent developments. The Center has a specialized library consisting of some new journals and many very old ones, and containing

a rich collection of volumes on the flora and fauna of the Adriatic Sea. The Center also organizes courses in marine biology at the graduate level, attended by students not only from Croatia, but also from Germany and Austria. A public aquarium with a long history displays northern Adriatic marine life and is visited by many residents, tourists and visiting scientists throughout the year.



The currentmeter



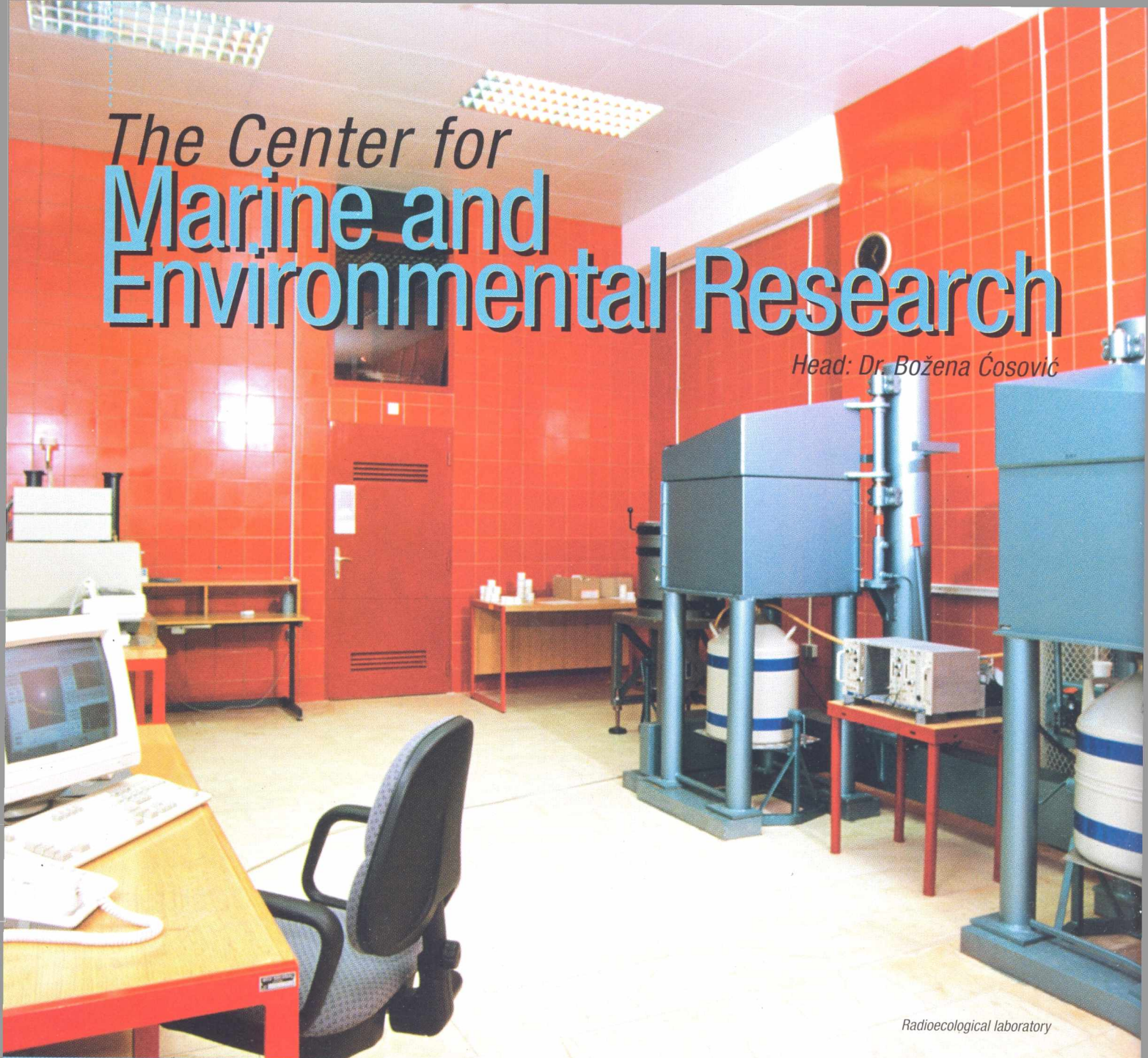
Ready for marine research experiments



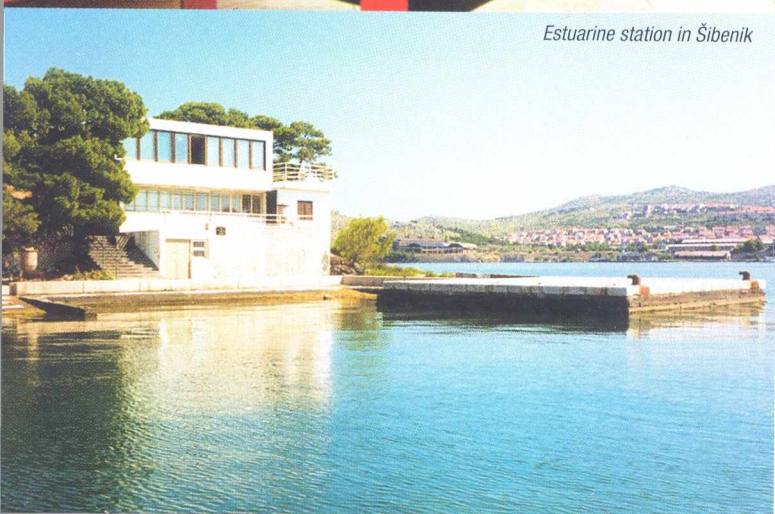
The main building

The Center for **Marine and Environmental Research**

Head: Dr. Božena Čosović



Radioecological laboratory



Estuarine station in Šibenik



Electrochemical approach to sulfur speciation in the Rogožnica Lake

The Center is a department of the Ruder Bošković Institute. It was founded in 1969 as Center for Marine Research (CMR) which until 1980 included laboratories in Zagreb and in Rovinj (Eastern Adriatic coast). The expansion and diversification of environmental activities led to the formation of two separate divisions in Zagreb and Rovinj. CMR Zagreb has equipped a new marine station at Martinska - Šibenik where it has begun multidisciplinary research in the Krka River Estuary (Eastern Adriatic coast). Center has also intensified investigations in the freshwater systems of the continental regions of Croatia. The new name, the Center for Marine and Environmental Research (CMER), since 1997 reflects the present broader scope and scientific interests of the Center aimed at providing new knowledge for environmental management, water quality management and water use in Croatia.

The long-term research programme of the Center, contracted by the Ministry of Science and Technology of the Republic of Croatia, is focused on investigation of the biogeochemical cycles of inorganic and organic constituents and natural characteristics of the Adriatic Sea and freshwater systems in Croatia, evaluation of anthropogenic influence by modelling distribution and behaviour of substances and their speciation in water and at natural phase boundaries, and assessment of the impact of inorganic and organic pollution on biological species and communities (ecological risk assessment) using methodology of exposure biomarkers and effect biomarkers and monitoring health condition of aquatic organisms. The programme comprises 12 research projects:

- Biogeochemistry of organic compounds in natural waters
- Physical and biogeochemistry of trace metals in aquatic systems
- Nature and reactivity of organic substances in marine and freshwater systems
- Electroanalytical chemistry
- Digital simulation of physical and chemical processes in water and at solid/liquid interfaces
- Organisms as bioindicators of quality of the water in which they live
- Surface-chemical and electrochemical properties of the solid/liquid interface
- Eutrophication and interfacial processes
- The behaviour of radionuclides and microelements in environmental samples
- Multixenobiotic resistance in environmental risk assessment
- Biomarkers and the biological effects of metals on organisms
- Jeopardized water with war wastes in karst region

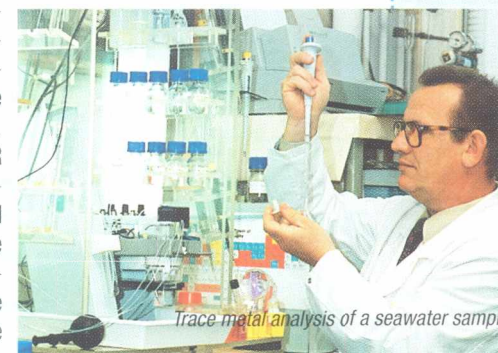
CMER permanent staff consists presently of 47 researchers and 17 technicians, while the non-permanent personnel of about 20 people are mainly PhD students and postdoctoral positions. Laboratory and field research facilities exist in Zagreb and Šibenik. Multidisciplinary and interdisciplinary approaches in research and education are developed with special attention to the education of young scientists in Oceanography.

The Center has a long experience and had a pioneering role, which



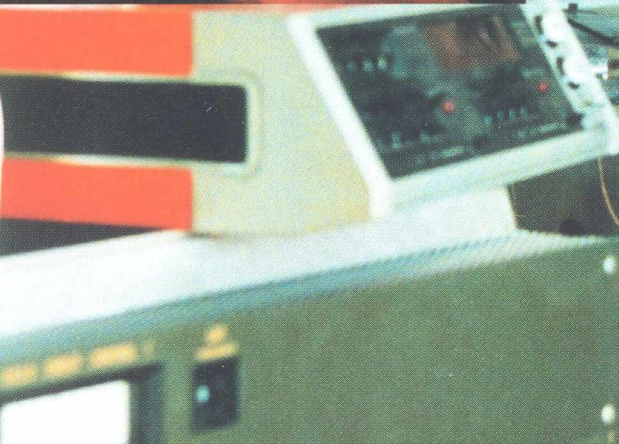
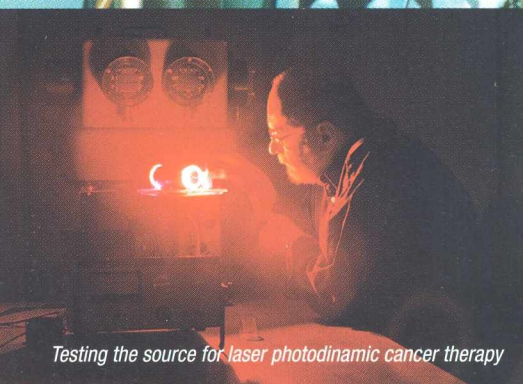
is internationally recognized, in developing electrochemical methods for research and pollution control in marine, estuarine and freshwater systems - particularly in trace metals analysis and speciation, characterization of surface active substances and adsorption and aggregation studies. It has one of the best equipped and experienced specialized laboratories in the region for radioactivity measurements in environmental samples. The laboratory is engaged in several applied monitoring programmes of international significance. CMER strongly contributed to development of aquaculture technologies and their application in Croatia. Further, the Center has since 1989 been appointed as authorized national reference laboratory aimed at maintaining high standards of the national laboratory network for water quality control in Croatia. Based on a long tradition of development of the use of information and communication technologies CMER has a leading role in telematics application within the Danube Environmental Programme.

Scientific staff of CMER has been continuously engaged in graduate and postgraduate courses at the University in different disciplines of natural science and technology. In 1970 the Center initiated postgraduate study in Oceanography and since then the Ruder Bošković Institute had a leading role in creating the programme of the study and its realization in collaboration with other marine institutions and laboratories and university departments. A number of students have accomplished their BSc, MSc and PhD theses while working on various scientific topics of fundamental and applied research programmes of the Center. In its previous and future developments CMER has the advantage of sharing the facilities and experiences in fundamental and applied research with all departments constituting the Ruder Bošković Institute. CMER views its future within the multilateral European and Mediterranean network of institutions promoting advanced environmental studies aimed to enhance the scientific knowledge needed to prevent and alleviate pollution caused by toxic chemicals and radionuclides - the processes, impacts and remedies.



Division of Laser and Atomic Research and Development

Head: Dr. Antun Peršin



The research on laser physics started in the Institute in 1963. Since these times the activities of the Laser and Atomic R&D Division have been based on the permanent scientific activity in the field of "Optronics Defense Systems".

The mission of the division is:

- research and development of the optical systems and components for support in defense, medicine and energetics,
- performing basic research and its transfer to scientific and engineering concepts in photonic technologies and optical and optronical systems,
- care for excellence in the research in the fields of physical and instrumental optics, thin films optics and laser physics, including development, characterization and evaluation of new optical and optronical systems,
- merging the science with optical engineering
- education of graduate and postgraduate students in the relevant fields of science and engineering.

As a part of the division there are:

Laboratory for optics and thin films, which supports the following activities:

- research in the field of instrumental optics, thin films optics and laser physics,
- design of optical imaging and non-imaging systems using the SIGMA 2000 and ZEMAX software,
- design of mechanical assemblies using the AutoCAD and MEGACAD software.
- design of electrical assemblies using PCAD and PROTEL computer software,

Prototype workshops of the Division:

- mechanical workshop: production of mechanical parts and assemblies for optronic systems,
- optical workshop: production of custom designed optical components
- electronical workshop: production of electronical parts
- photolithographical laboratory: production of optical reticules.

Artillery compass



Optical systems control

Results and Achievements:

- research, development and evaluation of the system for automatic aiming using the COMMANDO mortar - COCOS.
- development, evaluation and organisation of production of the CN-4 elbow aiming devices for mortars.
- development of compact aiming devices.
- research and development of expert system for evaluation of the "Spigot" rocket launcher.
- development of the optical block for "Spigot" training device.
- research of the method for disabling of disturbance of a second-generation rocket system - application of the blind signal separation theory.
- research and development of the optical filters with extreme optical densities.
- research and optical design of afocal optical systems having large field of view, resolution and magnification.

The division offers the following services:

- expertise in the field of instrumental and thin films optics.
- custom development of optical and optronical devices.
- services of optical, mechanical and electronical CAD.
- production and delivery of optical components and simple lenses, doublets, triplets and complex optical systems.

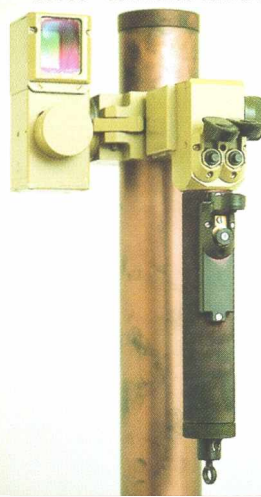


Lens design and parameters measurement



Optical workshop

COCOS - Commando Control System



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Ruđer Bošković Institute

Buildings

Divisions

I	ZTF, ZEF, ZFM, ZE, ZMG, B, RC
II	ZTF, ZEF, ZFM, ZE, ZOKB, B
III	ZOKB, IMO, ZKM, B
IV	ZOKB, ZIMO, NMR, ZMG
V	ZMM, ZMG, B, RC
VI	ZFM, ZKM
VII	ZKM
X	ZIMO, ZKM
B1, B2	ZMM
CK	ZEF
CK1	ZMG, ZIMO
CK2	ZEF, ZKM, ZIMO
C	ZIMO
L	ZLAIR
VDG	ZEF Van de Graaff accelerator
A	administration
P	entrance
R1, R2, R3	workshops
r	restaurant

Legends

ZTF	Theoretical Physics Division
ZEF	Division of Experimental Physics
ZFM	Division of Materials Physics
ZE	Division of Electronics
ZFK	Division of Physical Chemistry
ZOKB	Division of Organic Chemistry and Biochemistry
ZKM	Division of Materials Chemistry
ZMG	Division of Molecular Genetics
ZMM	Division of Molecular Medicine
ZIMO	Center for Marine and Environmental Research
ZLAIR	Division of Laser and Atomic Research and Development
NMR	NMR Center
B	Library
RC	Computing Center

