Redefining Roles

S. Krupička, President of the Physical Section of the Union of Czech Mathematicians and Physicists, reports on the status of physics in the Czech Republic, starting with basic research.

Basic Research

Academy of Sciences

Most of the Czech Republic's basic research in physics is carried out in institutes of the Academy of Sciences, with a small amount in the universities and only very rarely in other research institutions. The Institute of Physics in Prague is the Academy's largest centre. It has about 600 employees of which about one-half are research physicists (scientists). Its research programme centres on solid-state physics and materials research, but also covers particle physics (in cooperation with CERN and DESY) as well as optics and lasers. Other Academy institutes, notably the Nuclear Physics Institute, the Institute of Plasma Physics and some institutes working in more interdisciplinary or applied fields such as the Materials Physics Institute and the Institute of Radioengineering and Electronics, complete the spectrum of research activities in physics in the Academy (see Table).

The Academy's experimental facilities include several medium-sized installations. An important item is the PERUN laser system in the Institute of Physics (an iodine photo-dissociation laser chain of four amplifiers pumped by quartz-Xe flash-lamps). It produces 300 ps/50 J pulses of 1.315 μm radiation giving a power density on the target of 5 x 10 MW/cm². A relatively short repetition rate of about 15 minutes and the possibility of conversion to the 2nd and 3rd harmonics make the laser extremely useful, even for experiments at an international level (plasma shutters [1]; laser plasma as a source of highly charged heavy ions [2, 3]).

The U-120 M isochronous cyclotron with a maximum proton energy of 36 MeV is the Nuclear Physics Institute's main experimental facility. The machine has been upgraded recently and provided with a new axial injection system having a novel design [4, 5]. Further staged improvements are planned, with the aim of obtaining recognition as a Centre of Excellence in the framework of the Central European Initiative. The cyclotron is used at present for both basic research (nuclear reactions and spectroscopy) and applications (production of radioisotopes, mostly for medical purposes, *etc.*). Located on the same site is equipment for nuclear spectroscopy and other types of analyses that makes up a complex of neutron physics facilities using the LWR-15 research reactor belonging to the Nuclear Research Institute. The CASTOR tokamak in the Institute of Plasma Physics is too small to serve for research aimed directly at thermonuclear fusion in hot plasmas. Nevertheless, it is successfully used in studies of turbulence effects in hot plasmas and the non-inductive generation of currents by radio-frequency waves.

An interesting novel project is the building up of a laboratory for dielectric spectroscopy in the Institute of Physics. The aim is to cover a very broad frequency range (from 10^{-4} Hz to about 100 GHz) in combination with Fourier-type far-infrared spectroscopy and measurements at shorter (optical) wavelengths that include Brillouin and Raman scattering. A femtosecond pulse technique using an advanced Ti-sapphire laser is being developed in parallel.

Universities

In the university sector, the most important research is carried out in the Mathematics and Physics Faculty of the Charles University in Prague (theoretical, solid-state, nuclear, and subnuclear physics, optics and optoelectronics, physics of molecular and biological systems), the Faculty of Nuclear Physics and Physical Engineering of the Czech Technical University in Prague, and in the faculties of natural sciences of Masaryk and Palachy Universities in Brno and Olomouc, respectively (see insert). Smaller active research groups exist in physics departments in other faculties and/or universities, but they are usually oriented towards interdisciplinary or applied topics.

Since 1990 the numbers of employees in the institutes of the Academy has declined by about 30 to 40% owing to restrictions in the state budget. There has also been an evaluation of the level and efficiency of scientific capabilities in which institutes oriented towards physics received a good classification (first or second on a scale of five). According to new Academy regulations, evaluation by an international expert commission should become a normal, periodic procedure.

Pure & applied research in institutes of the Academy of Sciences

Institution	Site	Research field	Numbers*
Inst. of Physics	Prague	condensed matter; materials research; elementary particles; lasers; low-temperature physics	670/369
Nuclear Physics Inst.	Rez	nuclear physics at low- and medium-energies, incl. β- and γ-spectroscopy; nuclear reactions and hyper-nuclei	230/130
Inst. of Plasma Physics	Prague	plasma in tokamaks; low temp. plasmas; plasma technologies	115/55
Inst. of Physics of Materials	Brno	mechanical properties; structure studies	120/55
Inst. of Radio Engng. and Electronics	Prague	optoelectronics: components and systems	150/75
Inst. of Scientific Instruments	Brno	instrumentation principles in NMR; electron microscopy and quantum light generation	115/50

Institutes carrying out research in related and interdisciplinary fields: Astronomical Inst. (Ondřejov), Geophysical Inst. (Prague), Inst. of Atmospheric Physics (Prague), Inst. of Thermomechanics (Prague), Inst. of Hydrodynamics (Prague), Inst of Biophysics (Brno), Heyrovský Inst. of Physical Chemistry (Prague).

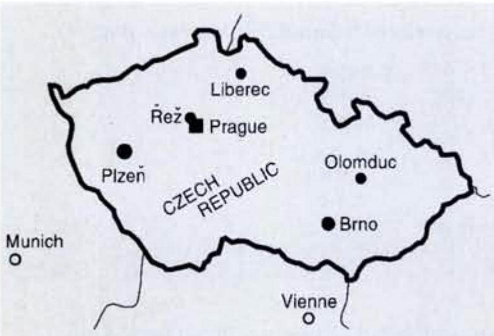
*total number of employees/scientists (incl. part-time staff)

Physics in the Czech Republic

The total number of physicists actively working in R&D, in industry, as academics or as specialists in various laboratories amounted to about 2000 at the end of the 1980s. The number today is maybe about 30 to 40% smaller. This reduction is related to economic reform, including the privatization of industry, and roughly mirrors figures for employment in R&D as a whole.

The important factor in this decline has been the restrictive state policy towards funding R&D activities and the resulting low salaries of scientists. This may be illustrated as follows: In 1993, the total expenditure on R&D in the Czech Republic has been estimated as 1.06% of Gross Domestic Product (GDP) according to the OECD methodology (as yet unpublished 1994 data are expected to lie within 5%); other estimates usually lie within 0.8 to 1.2% of GDP. The 1.06 % level corresponds to 70-28 $US per capita when taking 1 $US = 12 Kc or 30 Kc, respectively. The purchasing power of the Czech currency is strongly dependent on the kind of commodity (12Kc for 1 $US was the 1993 estimate for the mean domestic rate, equivalent to the purchasing power, while 30 Kc corresponds to the official exchange rate for business). Hence, when buying for instance, imported equipment, the official exchange rate of about 30 Kc per1 $US is be better assumption, while for wages or the cost-of-living, the rate of 12 Kc per 1 $US is more appropriate.

Compared to the value of 1.06% of GDP for all R&D, the estimated percentage spent on basic research in the Czech Republic is much lower (about 0.19% of GDP). The physical sciences represent, very approximately, some 15% of this amount.



Main research centres in the Czech Republic

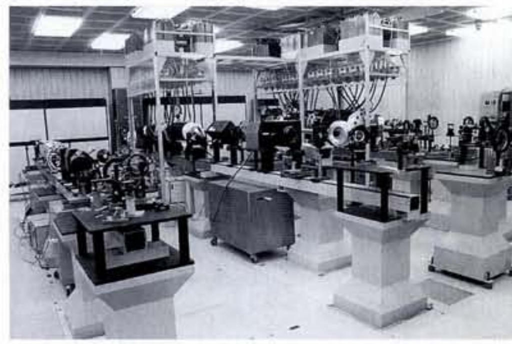
A rather different picture is encountered in the university sector, which essentially remains untouched by restrictions on personnel. On the contrary, some new employment possibilities have appeared through the creation of several new universities, mostly by completing existing individual or branch faculties. It is too early for most to contribute to basic research, although there are exceptions.

The old system of the state planning of science has been abolished in both the Academy and universities and a competitive grants system introduced. The main advantages are greater freedom to choose the research problem and/or the partner as well as an increase in effectiveness and flexibility in using funds. The grants have influenced very positively collaboration between university groups and Academy institutes and, in the case of the international grants (bilateral, European Union, *etc.*), cooperation at the international level.

Increasing the proportion of the overall science budget set aside for grants at the expense of institutional financing could be a dangerous tendency, because once a certain critical level has been surpassed a destabilizing effect may arise. In order to prevent such difficulties a new type of "large-scale" grant has been proposed which should help stabilize high-priority research and allow for larger projects. It is felt, however, that owing to institutional budgets, a large part of these grants will have to be spent on overhead (maintaining buildings, institute infrastructure, *etc.*).

International Collaboration

An increasing involvement in international collaboration as well as a substantial increase in mobility are surely very positive features of recent developments within the Czech physics community. We can see this most clearly in particle and nuclear physics, especially in the Czech Republic's full membership of CERN, which has created very favourable conditions for collaboration. Eight institutions from the Academy and universities take an active part in CERN collaboration from the Czech side. The degree of integration is high, and most of the participating Czech physicists are recognised as fully competent partners within large international research groups. Besides the programmes in basic research, participation in CERN R&D projects generates important opportunities for cooperation with Czech companies. This has led to new opportunities for Czech industry which, in its turn, has proved successful several times in tenders to supply CERN. Another surely very positive aspect of the Czech collaboration with CERN is that it has also stimulated local research activities outside particle and nuclear physics, such as a study of highly ionized heavy ions from laser plasmas, research into new detectors - both semiconducting and scintillation types - and new techniques in computational physics.



The PERUN iodine laser facility

In contrast to the CERN situation, relations with other large European facilities (the ILL and ESRF in Grenoble, EUROATOM, *etc.*) have not yet been established on a similar official basis. An attempt to overcome this gap by building up one's own experimental stations at large European installations such as the Elettra synchrotron in Trieste have only been a partial success. Moreover, solid-state physicists, who are in the majority in the Czech physics community, usually try to find their way into the European community on a rather more individual basis using personal relations and/or possibilities offered by bilateral agreements or European Union (EU) research programmes. Many grants have been awarded to support such relations, and they increased considerably the mobility of scientists. For instance, the number of visits abroad each year by the staff of the Academy of Sciences' Institute of Physics increased from 424 to 596 during 1989 - 94 in spite of a roughly 25 % decrease in the number of active physicists.

Increased international cooperation gives the opportunity to benefit from access to top-level equipment in many foreign laboratories. It must be stressed, however, that a continuing partnership always needs a corresponding commitment on both sides. This is impossible without the existence of good experimental facilities at home. Unfortunately, the various forms of help from the West to east and central Europe following the collapse of the communist regimes - including the EU programmes - have not adequately supported modernization of laboratory equipment. There has essentially been a complete failure in this regard.

Conclusions

In conclusion, the present situation of basic research in physics is not as bad as it might be, although it is still not fully stabilized. The main problems which remain are the lack of modern equipment and low salaries, especially for young scientists. Both add to the more-or-less programmed reduction in research capacity mentioned above by creating a spontaneous outflow of young physicists, either abroad or to careers requiring fewer qualifications but offering better remuneration. On the other hand, a highly positive trend is the increasing participation in EU programmes and other international grant schemes.

Applied Research

Before the economic reforms starting in 1989, applied R&D was mostly carried out in a large number of specialised research institutes or by industrial institutions and groups. Only a very small part was, and still is, performed in the Academy institutes or at universities (mostly the technical universities). Applied R&D was also strongly reduced during the transformation process, and the decline has been more pronounced than in basic research. Moreover, while the Academy was reduced in size in a more-or-less orderly fashion, changes in the applied sector were more catastrophic and resulted in the destruction of many institutions and research groups. The reason was their intimate dependence on large industries, which had entered a difficult period of transformation without – at least temporarily – any long-term plans.

Svatopluk Krupička is the President of the Physical Section of the Union of Czech Mathematicians and Physicists which he helped found. Formerly Director (1990-93) of the Institute of Physics of the Czech Academy of Sciences and head of the Institute's Department of Magnetism, he remains a member of the Institute's research staff.

Czech universities accredited to award PhD degrees in physics

Charles University	Prague
Czech Technical University	Prague
Masaryk University	Brno
Technical University	Brno
Palacký University	Olomouc
Technical University*	Liberec
West-Bohemian University*	Plzeň

*: newly accredited

Before 1990, there existed a scheme for the "scientific & technical development of industrial enterprises" which obliged Directors to contribute to R&D programmes. The majority of industrial research connected with applied physics was paid from funds originating under the scheme. This scheme was abandoned with privitisation that started in 1989 and the corresponding funding for R&D disappeared, or was reduced considerably. As a result, many physicists left industry or ceased to do research work; many took new jobs, in the computer industry for example, and as bank officials, *etc.*

Most industrial laboratories which had their own R&D programmes have been closed. Of the few that survived, most were strongly reduced in size. Some applied research institutes try to keep going as joint-stock enterprises, but they can scarcely do real research work. One of the largest research institutions that has been transformed into a joint-stock enterprise is the Nuclear Institute at Řež near Prague. It runs the LWR-15 research reactor which after modernization and upgrading that finished in 1990 now has a nominal power of 10 MW and neutron flux 1×10^{14} n/cm^2s in the core. It is routinely used as a neutron source for both basic and applied research (partly in cooperation with Nuclear Physics Institute of the Academy of Sciences - see above). The institute and its cyclotron have increasingly been directed towards applications in biology and medicine. Its position has been strengthened by the needs of Czech nuclear power stations and related problems of safety. Recently, a complicated group was established (together with specialists from the Nuclear Physics Institute and from the SKODA company in Plzeň) to take part in activities related to the development of accelerator-driven reactors for nuclear waste disposal.

Elsewhere, prospects seem to be rather uncertain. The Czech microelectronics industry which traditionally employed many physicists has been particularly affected and a possible recovery might well take a long time.

Research oriented towards physics is often seen as a luxury. On the other hand, the involvement of some prosperous foreign firms and/or their competition could bring stabilization and better prospects, even in physics. In fact, it is felt, at least occasionally, that industry, in seeking new knowledge or the results of research, is beginning to become more interested in its long-term perspectives. But to rebuild applied research on a higher level corresponding to that of a free-market economy probably represents a difficult task, where some help from basic and academic research could play a substantial role.

In conclusion, it may be said that the situation of applied research is still rather bad - not only with regard to aspects concerning physics but in general. However, some positive signals are appearing.

University Research Facilities

From among the universties' larger installations or centres one should mention:

Charles University (Prague)

• A Van de Graaff generator in the nuclear centre which is used for target experiments at very low temperatures ($\approx$10 mK) aimed at the low-energy scattering of neutrons on polarized protons
• Facilites in the Department of Low-Temperature Physics for hyperfine interactions studies and a NMR spin-echo spectrometer (for magnetically ordered materials) which is used in combination with other methods such as positron annihilation and Mössbauer spetroscopy.
• Relatively well-equipped optical laboratories for laser spectroscopy and magneto-optical studies in the Institute of Physics;
• The promising tunnelling microscopy group in the Department of Electronics and Vacuum Physics.

Czech Technical University in Prague

• The Faculty of Nuclear Physics and Physical Engineering runs a nuclear reactor for teaching purposes.

Outside Prague

An internationally recognized group of quantum optics at Palachy University, Olomouc, which also possesses experimental capabilities belonging the Joint Optical Laboratory of Palacky University and the Academy's Institute of Physics.

Physics Students

The total numbers of student enrollments in universities in the Czech Republic in 1994 were as follows [6]:
• Maths and physical sciences: 2235 in the five-year course and 316 in the three-year bachelor course (first year only).
• Physics: from these numbers there were 501 in the five-year physics course (including 33 in biophysics, 72 in optics and optoelectronics, 19 in applied physics), and 96 in the physics bachelor course.

Following a considerable decrease in enrolments in 1990-1992, the figures seem to have stablized at somewhat lower level. There were, in addition, 276 PhD students in physics in 1994.

Academic Activities

Several points can be discussed, but the most important are:
• the new Higher Education Act and its consequences;
• the new universities and faculties;
• the study of physics at various levels;
• scientific activities, participation in EU programmes, and the financing of research.

The 1990 Higher Education Act gave the universities more autonomy and power based on the principle of academic liberty. At the same time, it introduced a new system of postgraduate studies (PhD), that should replace the system of aspirants and candidates of science (CSc). Moreover, the right to provide the new form of PhD study was given exclusively to universities, thus setting off a lengthy controversy between universities and the Academy of Sciences. Eventually, an amendment was accepted by Parliament. It is strongly contested by the universities so a new Act is now being prepared.

Some existing faculties have been transformed into full universities. Besides this, several specialised high schools or technical universities have changed their profile by creating new faculties to become more university-like. The Czech Republic now has 111 faculties in 23 centres of higher education (universities, technical universities, *etc.*) compared with 68 in 1989.

Concerning the study of physics, three levels are now offered by universities: the traditional five-year course completed by diploma work and an examination (magister degree), a three- year PhD course following the diploma, and a three-year bachelor's degree. The last was set up very recently and is usually rather

specialised, being oriented towards skills and knowledge for qualified practical activities (medical, technology, applied chemical physics, application of computers in measuring systems, vacuum and cryogenics, photonics) in laboratories and the like.

The numbers of university physics students are given in the insert. Somewhat disturbing is the fact that many young people finishing their PhD studies (and sometimes even before finishing) give up physics to take up less qualified but better paid careers. Moreover, some rapidly developing areas such as information technology and computer science (1310 enrolments) and environmental sciences (647 enrolments) compete directly with physics for students.

The Physical Section

About one-half of working physicists are members of the Physical (Science) Section of the Union of Czech Mathematicians and Physicists. Although having an autonomy that makes the Section practically equivalent to physical societies in other countries, it prefers to maintain the link with the mathematics community provided by the more than 130-year old Union. The Union also encompasses primary and secondary school teachers, who are not usually members of the Physical and Mathematics Sections. The Physical Section has been a member of the EPS since the Society's foundation in 1968.

The Section's scientific activities are mostly focussed on specialised groups similar to those found in EPS. They organize seminars, topical meetings, summer schools, *etc.*, on both the national and international levels. One of the most active is the Computational Physics Group that cooperates very effectively with its analogue in EPS and regularly organizes European summer schools. Every three years, the Section holds a general conference of Czech and Slovak physicists (the next – the 12th – takes place in 1996 in Ostrava). The Section also organizes national meetings on more topical subjects such as science and technolgy policy, physics education, physics and environmental problems, *etc*.

The political transformation since 1989 has naturally influenced the Union and its Physical Section. Reduction in membership and in the amount of voluntary activity, the destruction of contacts with the industry, and an overall lack of funds have all had a negative impact on our work. We feel that new conditions badly need new approaches to almost everything, including the definition of the Section's role. Something similar must emerge in our relations with EPS. To be a member of EPS during the communist era was primarily seen as a manifestation of a link with Europe and the free, democratic world. Now that the barriers between west and east in Europe have been destroyed, this rationale has lost much of its original meaning and a new type of reasoning must appear. I hope, that this can be found in, for example, active support for full integration of Europe's physics community, with the emerging all-Europe union as the final goal.

References

[1] Mašek K. *et al., Laser and Particle Beams* **12** (1994) 445.
[2] Láska L. *et al., Appl. Phys. Lett.* **65** (1994), 691
[3] Mróz W. *et al., Rev. Sci. Instr.* **65** (1994), 1272
[4] Trejbal Z. *et al., Proc. 13th Conf. Cyclotrons and their Applications* (Vancouver, Canada, July 1992) 465
[5] Šturza J. *et al., Proc. Europ. Part. Conf.* (Berlin, Germany, 24-28 March 1992).
[6] Internal publn. of the Institute for Information in Education, Prague (1995).

Union Matters

More "Stimulation"

Jacques Santer, the President of the European Commission (EC), in last November's state of the European Union (EU) address to the European Parliament, said that the EC will aim in 1996 "to stimulate more and legislate less" (it plans 26 major debates, 48 Action Plans and 19 new proposals for legislation). Major issues for science are the next Framework Programme (FP5) and copyright in the information age.

Science in Framework 5

Edith Cresson, the EC science Commissioner, wants to follow the example of the EU's main industrial competitors by concentrating FP5 on a few selected areas of market-oriented research. The EC will examine task-force reports so that in the second-half of 1996Ministers can suggest where best to concentrate future research.

As part of the debate on FP5, the European Science Foundation has sought input from member organizations. The Royal Society's Council recently endorsed a working-group submission that stresses the need for more basic research in FP5 than in FP4, especially outside the basic-science oriented Training and Mobility of Researchers programme (it proposes not less than 10 % of the FP5 budget). For if basic research is starved, "productive applied research will wither within a decade". Moreover, as research becomes more sophisticated , and more expensive, there is a tendency for "less support in areas of basic science with unpredictable or, at best, long-term returns".

Framework 4 Reserve

The main item on the EU's immediate research agenda is clearly whether to release the 700 MECU reserve that was allocated to the present FP4. Edith Cresson wants to start using the funds, but this could push EU spending above the ceiling agreed by Ministers in 1992. Moreover, the EU has since committed itself to helping rebuild the Balkan region. Ministers will need to agree on priorities before approaching the Parliament.

Balanced Cooperation

The EC has said in a communication on international cooperation in research and technological development that "the key task for future policies is to establish a beneficial balance between competition and cooperation". To balance possible job losses with increased markets, it seeks worldwide cooperation in science "to share risk and effort". It also says that the EU "now has an increased responsibility to ensure a stable environment in a wider Europe" where cooperation in science can "upgrade the economic potential of its neighbours".

Edith Cresson visited Israel in January to mark the EU's first comprehensive bilateral science agreement.

The EU signed its first comprehensive bilateral cooperation agreement in science last October. It is with Israel, which is called a "non-European third-country", and by contributing close to 100 MECU for 1996-7, the country's scientists can participate in FP4 non-nuclear R&D programmes and in management committees (without votes). Other agreements, *e.g.*, with Canada and Australia, are for a project-by-project basis. Negotiations are expected to start soon on comprehensive agreements with the US, Japan and South Africa.