IRP identification code
AV0Z10190503

Institutional Research Plan (IRP)

Provider's code	AV0
IRP identification code	Z10190503
Research plan title	Research and development of general mathematical knowledge and its application to other branches of science and practice
Applicant [1]	Mathematical Institute Academy of Sciences of the Czech Republic
Institution [2]	
Principal investigator [3]	Doc. RNDr. Karel Segeth, CSc., Director of the MI AS CR

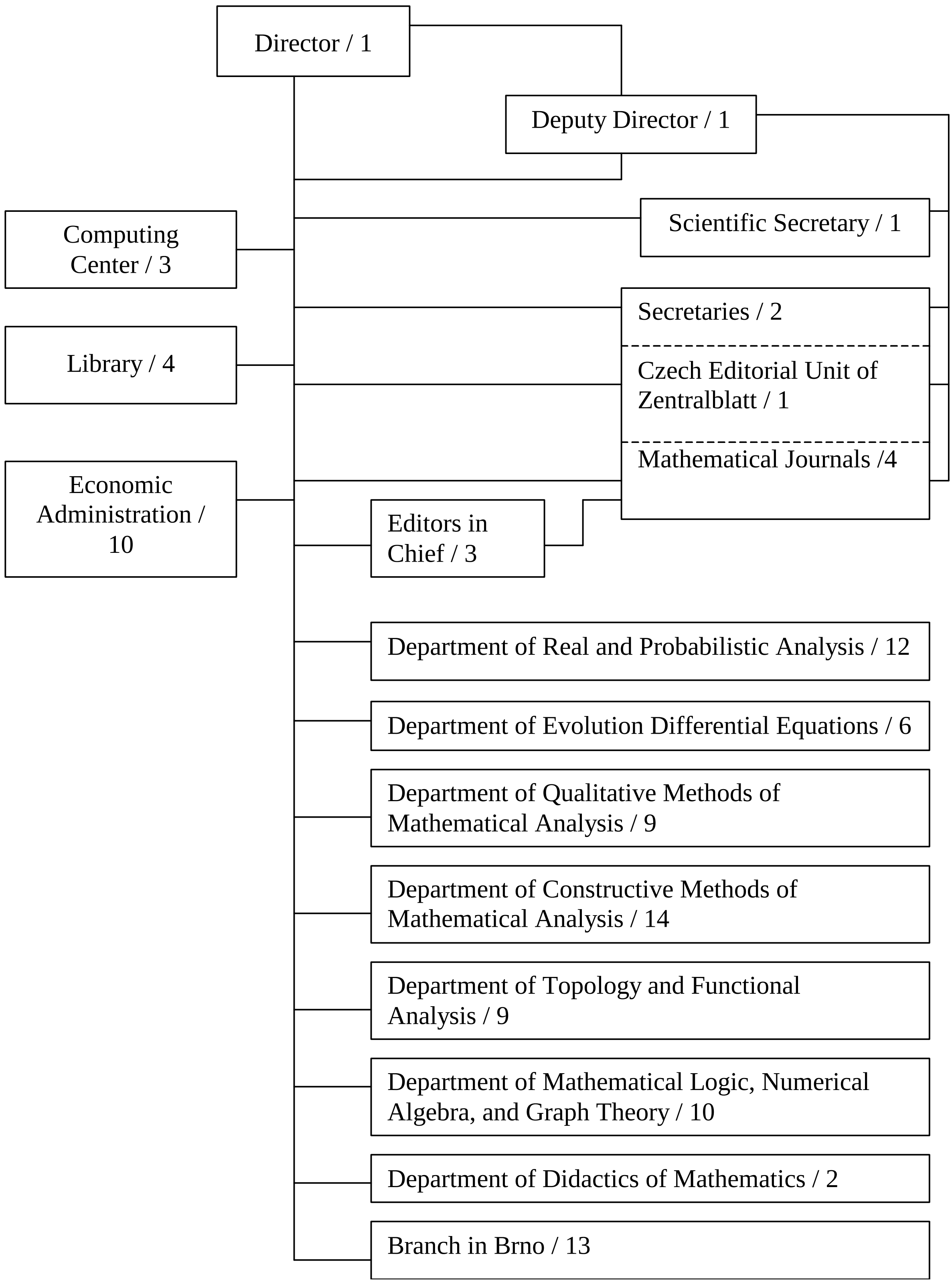
1 Legal name of the applying organisation, legal entity

2 Name of the department or applicant's principal organisational unit, which will carry out the research according to the proposal, if different from "applicant". Applies only if more than one proposal of IRP was submitted by the "applicant".

3 Person in charge, who is responsible, on behalf of the applicant/institution, in scientific and financial matters of IRP

A. General information on the applicant

A1. Organisational scheme of the applicant, including the number of employees in the applicant's units



A2. Governing bodies of the applicant and names of their personnel

Director:	Karel Segeth
Deputy director:	Milan Tvrdý
Scientific secretary:	Helena Severová
Scientific Council:	Pavel Pudlák, chair
	Bohumír Opic, vice chair
	Eduard Feireisl
	Robert Hakl
	Jan Chleboun
	Jan Pelant
	Ivan Straškraba
	Milan Tvrdý
	Pavel Drábek, Faculty of Applied Sciences, University of West Bohemia
	Petr Hájek, Institute of Computer Science, Academy of Sciences of the Czech Republic
	Oldřich John, Faculty of Mathematics and Physics, Charles University
	Luboš Pick, Faculty of Mathematics and Physics, Charles University

A3. Overview or profile of all activities pursued by the applicant

Mathematical Institute carries out scientific research in the field of mathematics, search for possible use of its results, and its application.

A4. Share of research and development in the total activities of the applicant

Indicator	2002	2003
Number of employees of the applicant engaged in research and development	70	80
Total adjusted work capacity involved in research and development (FTE) [4]	57,79	59,28
Share of expenditures on research and development in the overall expenditures of the applicant in percent	100	100

[4] Number of employees, adjusted for full-time-employee capacity (FTE), which is committed to the research and development activities.

B. Information on research and development activities of the applicant/institution

B1. Specification of the principal research and development (R&D) activity of the applicant/institution

The subject of principal activity of the Mathematical Institute is scientific research in the field of mathematics and its applications. The Institute contributes to improvement of the level of cognition and education, and to applications of results of scientific research to practice. It acquires, processes, and disseminates scientific information, publishes scientific publications, journals, proceedings, etc., provides expert opinions, views, and recommendations, carries out consulting and advisory activities. It implements PhD study in cooperation with universities and educates scientific workers. It develops international cooperation in the whole field of its activities, in particular organization of joint research with foreign parties, accepting and sending out research workers for short-term and long-term stays, exchange of scientific knowledge, and preparation of joint publications. The Institute organizes scientific meetings, conferences, and seminars, including international ones. It carries out these activities independently as well as in cooperation with universities and other scientific and research institutions, both public and private.

B2. Contribution of the applicant/institution to the development of knowledge in the disciplines referred to in B1, in national and international context

Members of the Institute significantly contribute to the development of mathematical cognition. In the recent period, they published a lot of scientific papers, mainly in international mathematical journals and proceedings, and are authors or coauthors of monographs that were published mostly by foreign publishers. Response to the publication activities of members of the institute has usually the form of citations in the work of other authors and is extremely numerous.
In addition, members of the Institute have been awarded a lot of foreign as well as Czech prizes of honor in the recent period and took part in the work on a great number of international and Czech grant projects.
Members of the Institute are often invited to research and lecture stays abroad, both short-term and long-term, and foreign researchers also visit the Mathematical Institute. Publishing new mathematical results at international conferences abroad as well as in the Czech Republic is carried out in a successful way, too.
This proves a very high level of results of the research orientation of the Institute that can be well compared with the other leading Czech mathematical institutions (Faculty of Mathematics and Physics, Charles University, Prague, and some other faculties of Czech universities) and with foreign institutions. In mathematics, there are several leading universities, in the U.S.A, Europe & Russia, for which the Mathematical Institute is an equal match. A specific feature of the orientation of the Mathematical Institute consists particularly in its universality (despite the fact that the fields of algebra and probability theory are not significantly represented in the research program at the moment) and in the mutual interaction among the individual fields of mathematics. Such a global approach is rather unique as compared with Czech as well as foreign institutions.

B3. Major R&D results achieved and implemented by the applicant/institution in the disciplines referred to in B1 within the last five years (overall characteristics)[5]

1. Department of Real and Probabilistic Analysis

1.1. The monograph [1-001] is, in the world context, a remarkable source for the research in the field of rank tests, which are very profitable for nature or social sciences. It provides a coherent presentation of both one- and more-dimensional tests and it includes e.g. the following topics: computation of exact null distributions, limiting null and non-null distributions, asymptotic optimality and efficiency of rank tests, rank estimates and asymptotic linearity and miscellaneous topics in regression rank tests.

1.2. In the book [1-002], the space *P* of primitives of HK-integrable functions is considered. The aim is to find the topological characterisation of the so-called *E*-convergence in *P*, which is induced in a natural way by the equi-integrability condition known from the convergence theorems. The main goal is the construction of a topology consonant with the *E*-convergence and such that when *P* equipped with this topology, it becomes a complete topological vector space.

1.3. The monograph [1-003] deals with the topologies on the spaces of functions integrable with respect to various types of Riemannian sums. For each type of admissible Riemannian sum, the corresponding space of integrable functions *Y* and a convergence process E_Y on their primitives P_Y are determined. There is a unique topology that is the finest locally convex topology consonant with the E_Y-convergence. The main results concern the question of the completeness of P_Y for various integration basis *Y*, when P_Y is equipped with this topology. The Lebesgue theory with the variational norm have this property, while the HK-theory with the supremal norm does not.

1.4. Theory of the integration in Banach spaces has been enriched by the sum integrals of the HK-type, see [1-057]-[1-059]. In particular, it was shown that the usual McShane integral is equivalent with the Bochner one if and only if the corresponding Banach space is finite dimensional. Furthermore, concepts of weak and strong McShane integrals were introduced and their positions in the hierarchy of abstract HK-integrals has been localized. Similar subjects were recently treated e.g. by D. H. Fremlin [X1-9] and R. A. Gordon [X1-11].

1.5. Theory of linear equations of the Stieltjes type in spaces of regulated functions with values in a Banach space has been established in [1-052]-[1-055]. In particular, the existence and uniqueness results were delivered. The results concerning the renewal equation were given in such a generality that they are applicable for modelling structured populations, which requires to use the bounded semivarivation instead of the usual bounded variation.

1.6. The method of upper and lower functions has been generalised and new existence principles has been proved for generalised periodic problems for nonlinear second order differential equations problems, see [1-042]. These principles played an important role in the proofs of new theorems on the existence of nonnegative solutions of the periodic problem including also the case that the right-hand side of the differential equation has a singularity in the origin, see [1-047]. Unlike all the previously known papers (see e.g. [X1-25], [X1-7], [X1-14] or [X1-43]), the more difficult case of weak repulsive singularity was solved here, as well. Furthermore, the case that the right-hand side of the differential equation is oscillating in the

[5] Implemented results are those R&D results which have been published, applied in practice and/or protected as an intellectual property according to a specific law (e.g. publications, patents, trademarks, and newly applied technologies).

neighbourhood of the singularity has been solved in [1-043], while new multiplicity results have been presented in [1-048].

1.7. Existence and uniqueness of solutions to stationary Hamilton-Jacobi equation in infinite dimensional state space has been proven in [1-020]. The result was used in solving problems of optimal ergodic control for parabolic stochastic partial differential equations. This extends earlier papers on infinite time horizon stochastic control of partial differential equations (see e.g. [X1-12]). Analogous results in the case of adaptive control have been obtained in [1-015]. The problem of identification of an unknown parameter in stochastic parabolic equation is solved in [1-022]. It has been proven that the parameter estimator based on the maximum likelihood method is strongly consistent. This allowed to conclude that the proposed adaptive control is optimal.

1.8. A new method of verification of the strong Feller property has been proposed in the paper [1-032]. This approach is based on purely probabilistic procedures which may considerably simplify numerous proofs and have extended the applicability of strong Feller property method to new models for which other methods fail, like stochastic nonlinear oscillators, stochastic delay equations and stochastic equations with continuous drift term. Strong Feller property is one of the key notions in the stochastic systems ergodic theory. It yields a detailed description of large time behaviour of Markov processes, for example, it implies uniqueness and global asymptotic stability of a stationary state (cf. the monographs [X1-3], [X1-4] and [X1-2]).

1.9. New basic results on existence and regularity of solutions to linear stochastic partial differential equations where the noise is modelled by a fractional Brownian motion have been obtained, cf. [1-016]. Furthermore, asymptotic properties, convergence of probability laws to a stationary state (which, unlike the classical case with the usual Wiener process, is not an invariant measure of a Markov process) and equivalence of probability laws have been proven. Existence and regularity for semilinear parabolic equations (reaction-diffusion equations) were established by B. Maslowski and D. Nualart in [1-030]. Moreover, in [1-030] the problem of existence and uniqueness of solutions to a stochastic partial differential equation whose diffusion coefficient is nonlinear and state-dependent, has been solved for the first time. Similar equations with additive noise, where the stochastic integral is much easier to handle, have been treated e.g. in [X1-13].

1.10. A new method of proving exponential estimates for stochastic convolutions has been found in [1-050]. It is based on the Zygmund extrapolation theorem which allows to reduce the proof of exponential estimates to the problem of finding sufficiently sharp p^{th} moment estimates for p large enough. These moment estimates were derived by a factorization method and the proof is significantly simpler than some alternative ones (see e.g. [X1-42]). Exponential estimates play an important role in the large deviation theory both for solutions to stochastic evolution equations and their invariant measures.

1.11. Randomly simulated spatial Voronoi tessellations generated by various point processes have been thoroughly investigated, see e.g. [1-040]. In this connection, an extensive software has been developed and the database [1-097] has been systematically built up, made openly accessible in 1999 and completely rebuilt in 2003. (Until the end of October 2003, more than 3300 accesses has been registered.) Now, it includes a wide range of tessellations from displaced tilings up to the most extravagant ones generated by Bernoulli cluster fields introduced and investigated in [1-039]. The graphical classification based on the *w*-*s* diagram, which was invented and studied in [1-037], is well applicable in the metallography: an analysis of the procedures contained in the most important standards for the grain size (ASTM and the majority of national standards) led to the proposal of new more precise procedure and its verifying, see [1-009], [1-010], [1-037], [1-038].

2. Department of Evolution Differential Equations

2.1. Among the most important achievements of the research group Evolution Differential Equations, we may cite in particular new results on the qualitative behavior of solutions to the Navier-Stokes equations describing the flow of compressible and heat conducting fluids. This topic is very relevant for applications and its goal is to determine to which extent these equations constitute an appropriate model for all phenomena occurring in real physical fluids (flow stability conditions, transition from the laminar to the turbulent regime, cavitation, influence of boundary conditions, etc.) (References [2-004], [2-001], [2-025], [2-073]). This research significantly develops ideas suggested in one of the most important monographs [X2-8] related to the mathematical theory of fluid flow.

2.2. Specific effort has been invested into the qualitative analysis of equations of motion for non-Newtonian fluids as an extension of the theory initiated in [X2-5] –[X2-11] from the point of view of thermodynamics and in [X2-3]-[X2-10] where a mathematical setting has been proposed. The study of hydraulic systems and moving bodies in fluids are also part of this class of problems. The main results consist in proving the well-posedness of mathematical models motivated by practical problems in hydraulics, and in developing new methods for the qualitative analysis of their solutions. This work has been coordinated with research laboratories Hydrosystem Ltd. in Olomouc ([2-104]).

2.3. Existence proofs have been given and an analysis of the long-time behavior has been performed for rather general strongly nonlinear and degenerate partial differential and integro-differential equations (items [2-043], [2-038], [2-040], [2-071] in the reference list). Typically, such equations arise in modeling physical processes and evolution of biological populations as described, e.g., in [X2-2] and [X2-4]. Convergence results are partly based on a deep result in the theory of analytical functions [X2-9]. The goal of this research is to establish a theoretical basis for the study of qualitative properties of partial differential equations and strategies in solution methods.

2.4. Members of the research group made a substantial contribution (also in cooperation with the authors of the important monograph [X2-1]) to mathematical modeling of moving interfaces between physical phases (for instance, between the solid and fluid during solidification or melting) by means of balance equations of mathematical physics, like energy and momentum balance, etc. The unknowns in the problem are typically the temperature and stress as functions of time as well as the geometrical shape of the interface. Results on well-posedness and long-time behavior have been published in [2-033] and [2-062].

2.5. A significant progress has been made in the qualitative and quantitative analysis of models for elastoplastic, magnetic, and piezoelectric materials, as well as in economic models, described by evolution variational inequalities representing natural physical constraints. It turns out that many practical problems of computation and optimal control of systems with a large number of one-sided constraints can be solved in an elegant way using the method of hysteresis operators coming back to M. Krasnosel'skii in the 1970's (see [X2-6]) and further developed in the monographs [X2-12], [X2-1], and [X2-7]. This topic is systematically investigated in the

Mathematical Institute and new results have been proved on the stability and further properties of the operators themselves as well as on solution methods for the equation involving these operators. ([2-002], [2-055]).

3. Department of Qualitative Methods of Mathematical Analysis

3.1. Among the results of the Department of Qualitative Methods of Mathematical Analysis, let us present establishing extrapolation decomposition in Lebesgue, Zygmund, and Brézis-Wainger spaces and extrapolation properties of Sobolev and Morey imbeddings of spaces of Besov and Lizorkin-Triebel type with dominating mixed derivatives with the help of Fourier analysis. Their optimal critical imbeddings have been found (see, e.g., [3-014]], [3-042], [3-041]). These results provide another efficient extrapolation method and they are also a topical extension of the theory of spaces with dominating mixed derivatives, established in [X3-9], and currently gaining greater importance in applications (i.e. in problems of existence and regularity of solutions to differential equations, and inequalities with time parameter).

3.2. Existence of smooth bifurcation branches (see [3-025]) and smooth dependence on parameters (see [3-024]) for variational inequalities have been proved. The results have been applied to unilaterally supported beam and to partial differential equations with unilateral boundary conditions, describing a certain control of thermostat type. The results are surprising in some sense because the considered problems themselves are non-smooth. The proofs are based on a non-standard use of the theorem on implicit functions. It turns out that a variational inequality is locally equivalent to a certain smooth equation under some special assumptions and the implicit functions theorem is actually used for this equation. This approach opens new possibilities of the study of variational inequalities in the situations when classical approaches fail, for instance when investigating stability of solutions to variational inequalities. At the same time we expect that the smoothness results will be useful for numerical solutions of unilateral problems.

3.3. In the paper [3-033], a new method of discretization and anti-discretization of weighted inequalities has been established. This method has been applied to norms in classical Lorentz spaces $\Lambda_p(v)$ and $\Gamma_p(v)$. The method turned out to be particularly useful in the case of the $\Gamma_p(v)$ spaces whose norm can be written in the form of Hilbert norm. An important application of the new approach is solution of the old problem to find amenable necessary and sufficient conditions for parameters $p, q \in (0,\infty)$ and a couple of weight functions such that $\Gamma_p(v) \rightarrow \Gamma_q(w)$ or $\Gamma_p(v) \rightarrow \Lambda_q(w)$. Certain criteria for these imbeddings were known earlier but the corresponding conditions, expressed in form of discretizing sequences, did not allow a verification in practice. The second major application of the new method is an integral characterization of the space associated to the space $\Gamma_p(v)$.

3.4. In [3-050], it was proved that there exists a solution (in the distributional sense) to the Neumann problem for the Laplace equation (when the boundary condition is given by a real measure on the boundary of the domain in question) which is continuous on the closure of the given domain if and only if the single layer potential corresponding to the boundary condition is a function continuously extendable up to the closure of the domain. Uniqueness up to an additive constant of this solution has been proved for bounded domains. In the case of a bounded domain it further has been proved that a solution of the Neuman problem (of the Laplace equation in the distributional sense), which is continuous on the closure of the domain is a weak solution of the problem considered. In the literature (see, e.g., [X3-5]), it is possible to find sufficient conditions for continuity on the closure of the domain in question (but not conditions which are necessary and sufficient).

3.5. A comprehensive theory has been established, dealing with imbeddings of Bessel potential spaces modelled upon generalized Lorentz-Zygmund spaces into generalized Lorentz-Zygmund spaces and into spaces of Hölder continuous functions. Optimality of these imbeddings has been proved (see [3-013], [3-055], [3-051]). This fully explains the role of the logarithmic terms in the quasinorms of these spaces. As special cases we get well-known results due to Brézis and Wainger (see [X3-1]) on imbeddings of Sobolev spaces in limiting cases and optimality of these imbeddings. Note that the class of generalized Lorentz-Zygmund spaces contains many well-known spaces important from the point of view of applications: Lebesgue and Lorentz spaces, Zygmund classes, Orlicz spaces with Young function in the form of a superposition of a finite number of exponential functions, etc. The results mentioned also significantly extended our knowledge about imbeddings of Orlicz-Sobolev spaces in limiting situations.

3.6. We have established (apparently optimal) bounds for the coefficient of friction for the existence of solutions to dynamic contact problems with Coulomb friction for material with isotropic viscosity (see [3-012] for the two-dimensional case and [3-062] for the general case). In comparison with earlier bounds valid for arbitrary material this result gives a possibility of significantly broader practical applications. Further, the existence of solutions to certain types of contact problems has been proved, including thermal effects of the friction (see [3-009]). There are no analogous results since the model preserves the unilateral character of the contact condition. The unilateral and non-compact nature of the friction was not taken into account in all the works up to now.

3.7. A characterization of validity of higher order Hardy's inequality for "well defined" classes of functions has been found, and necessary and sufficient conditions established for some classes of "overdetermined functions". Alternative conditions have been found, characterizing validity of "classical" Hardy's inequality, as well as a number of sufficient and also of necessary conditions for the validity of Hardy's inequality of fractional order. The critical exponent for compactness of the weighted imbedding has been found. (See [3-070], [3-030].) The results have been applied to prove existence theorems and spectral properties of non-linear degenerated differential equations, see [3-001].

3.8. An exact analog of the Sobolev inequality has been established in the context of Lebesgue spaces with variable exponent given by a Lipschitz continuous function. Consequently, the corresponding Sobolev imbeddings have been derived (see [3-018]). Currently this area is very relevant since the Sobolev spaces modelled upon the Lebesgue spaces with variable exponent find use in applications (see [X3-7], [X3-8]).

4. Department of Constructive Methods of Mathematical Analysis

General and Special Properties of Methods for Solving Partial Differential Equations

4.1. The monograph [4-004] treats in detail higher-order finite element methods (FEM) including their application to nonlinear problems. Methods have been developed for accelerating numerical computations either by a modified algorithm [4-065] or by taking into account special features of particular domains [4-076].

4.2. The research has been concentrated particularly on special simplicial partitions beneficial to the properties of the FEM: gradient superconvergence in solving elliptic boundary value problems [4-019], tetrahedral mesh refinement techniques avoiding the emergence of obtuse angles [4-056].

4.3. The maximum principle represents a characteristic feature in solving nonlinear elliptic and parabolic second order problems. In [4-058], sufficient conditions are introduced that guarantee the discrete maximum principle for linear tetrahedral elements.

4.4. New a posteriori error estimates have been developed for nonlinear parabolic equations in one space variable [4-085]. A PhD dissertation has been submitted [4-0146]. The estimates have contributed to deeper understanding and better applicability of the FEM. A posteriori error estimates are systematically investigated in the Mathematical Institute. They receive wide attention abroad.

The Worst Scenario Based Analysis of Mathematical Models with Uncertain Input Data

4.5. The existence of worst scenarios, i.e., input data extremalizing (within uncertain inputs) given criterion-based functionals, have been proven in elliptic, parabolic, and contact problems as well as in problems of elastic and elastic-plastic bodies; see [4-040], for example. Also, the convergence of approximate worst scenarios acquired through solving discretized problems has been shown. Coupling of the worst scenario method and fuzzy set theory has been suggested. To solve problems with uncertain boundary, a reformulation of the Neumann boundary value problem was proposed in [4-015]. The results for problems with uncertain input data are resumed in a monograph in preparation. Though the idea of the worst scenario method is not new, a rigorous mathematical treatment analyzing the impact of uncertain data on the solution of sophisticated state problems is rare not only in the Czech Republic but, in authors' opinion, also abroad.

Computational Models of Phase-Change Processes in Semiconductors

4.6. A computational model of the Bridgman growth of semiconductor crystals that includes turbulent phenomena in the melt has been developed and applied to practical technological situations in CdZnTe crystals preparation [4-025]. In fact, the model is applicable to any binary (or pseudobinary) system. It has been shown that the inclusion of turbulence into the model gives the ability to describe and explain some effects observed experimentally that were not treatable by the laminar models used previously, as are the defects in the crystal grown due to the re-melting near the walls of the furnace. The model can provide guidance for the optimum setup of the Bridgman apparatus. The authors are not aware of similar models of this type that would include turbulent phenomena. The model has been designed and tested in cooperation of the Mathematical Institute, Institute of Physics of Charles University, Prague, and Faculty of Civil Engineering of the Czech Technical University, Prague.

4.7. A computational model of laser irradiation of binary semiconducting alloys that takes melting, evaporation, and solidification of the material induced by a pulsed laser into account has been designed, tested, and validated on real experiments with pulsed laser modification of CdZnTe [4-005]. Here, the Mathematical Institute, Faculty of Civil Engineering of the Czech Technical University, Prague, and Institute of Electronics of the Academy of Sciences of Belarus, Minsk, have cooperated. It has been shown in the combination of computational and real experiments that the properties of melt CdTe differ from those of the classical semiconductors represented by Si or Ge, for example. This model is the only one known in the Czech Republic and it has attracted great interest at international scientific meetings.

Mathematical Methods of General Relativity Theory

4.8. Specific solutions of Einstein's field equations were studied. The most important result was the determination of all four-dimensional Lorentzian manifolds with all invariants constructed from the Riemann tensor and its derivatives of arbitrary order vanishing [4-083]. It turned out that corresponding spacetimes are of Petrov types III, N or 0 and of Petrov-Plebanski type N or 0 with common multiple eigenvectors and that the spacetimes also have to belong to the Kundt's class. These spacetimes are also exact solutions in view of the string theory and were already cited by authors from Cambridge, Berkeley, and Stanford; see [X4-3].

General Number Theory, investigation of Fermat numbers

4.9. A relation between natural numbers and directed graphs has been found. Different structures of such digraphs correspond to different types of prime numbers [4-089]. The investigation of Fermat numbers led to the monograph [4-002]. It is not known that anybody else would systematically investigate Fermat numbers in the Czech Republic. The results were obtained jointly with foreign researchers and are important even in international perspective.

5. Department of Topology and Functional Analysis

5.1. One of the most important results is the paper [5-039] characterizing the Banach spaces that admit an equivalent uniformly Gateaux smooth norm as the subspaces of Hilbert generated spaces. The result completes the circle of questions concerning the Gateaux smoothness and uniform Eberlein compacts which originated in the seventies. While it was then proved that a certain “presence” of Hilbert space or of a uniform Eberlein compact implies the existence of a uniformly Gateaux smooth norm, the opposite implication was proved only for spaces with unconditional basis. This additional assumption was now (rather unexpectedly) removed. The result has many interesting consequences. For example, it implies that a compact space *K* is uniform Eberlein if and only if *C(K)* admits a uniformly Gateaux smooth norm. This solves a more than 20 years old problem that has been studied by a number of renowned mathematicians. Another consequence is that uniform Eberlein compact spaces are stable under continuous images. The methods from [5-039] were further elaborated in consequent papers, see [5-040] and [5-041], where various classes of Banach spaces similar to weakly compactly generated spaces were studied. As a typical result let us mention that a Banach space is a subspace of a weakly compactly generated space if and only if it contains a linearly dense subset that splits in a certain manner. Another consequence is a new proof of the Farmaki theorem that characterizes uniform Eberlein compacts sitting in the sigma product of the real line.

5.2. The invariant subspace problem is the most important open problem of operator theory. The problem was solved negatively for operators on Banach spaces but for Hilbert spaces and reflexive Banach spaces it remains open. In the recent years, a series of results was obtained by means of the Scott Brown technique. The strongest result proved by this method is that each Hilbert space contraction whose spectrum contains the unit circle has a nontrivial invariant subspace [X5-2]. In [5-080] this result was improved in two directions. The condition that the operator is a contraction was replaced by that the operator is polynomially bounded (in Hilbert spaces, every contraction is polynomially bounded by the von Neumann inequality). Moreover, the result was reformulated for general Banach spaces.

5.3. A systematic (Markl’s) theory of strongly homotopic algebras [5-066], [5-067] was developed. The theory put stress to the homotopic invariance of these objects and its central concept is the minimal model of an operad constructed in [X5-9]. Immediate consequences of the theory are results about the transfer of algebraic structures as well as a unifying frame for various results of the homological perturbation theory. The theory was used for example by the Fields medalists M. Kontsevic and Y. Soibelman in their works about the deformation quantification, Deligne's conjecture and mirror symmetry [X5-5], [X5-6]. The monograph [5-003] is quickly becoming a standard reference text. Consecutive works open the way to new fields of the homotopical theory of general algebraic structures.

5.4. A detailed description of the asymptotic behavior of weighted (Bergman) kernels on pseudoconvex domains was given in [5-030]; the kernel is a series whose coefficients are certain scalar invariants of the corresponding Riemann metric. These results, which were known only for some particular cases, have an immediate application to quantification on Kaehler's manifolds [5-031], [5-035]. For compact manifolds, similar but a little bit weaker results were obtained by Catlin [X5-3] and Zelditch [X5-18]. As another application, examples of strongly convex domains were constructed for which the Bergman kernel has zeroes; this contradicts to the Lu Qi-Keng conjecture [5-032]. Later these statements were extended also to unbounded domains using the generalization of results about the d-bar Neumann problem (Kohn, Kerzman, Bell) to unbounded domains [5-033].

5.5. By the classical Mazur-Ulam theorem, each isometric surjective mapping between two Banach spaces is affine. In [5-078], the bi-Lipschitz mappings with the corresponding constant close to one, i.e., "almost isometries", were studied. It turned out that the situation differs very much from the case of isometries even for finite-dimensional spaces. In spaces of large dimension there exists a bi-Lipschitz mapping of the Euclidean ball onto itself that almost preserves the distance and yet it is not possible to approximate it by an isometry.

5.6. The axiomatic theory of spectrum of operators and Banach algebras elements was elaborated. The spectrum is one of the most important concepts of operator theory since it provides useful information about the structure of an operator. There are many types of spectra that have been studied in the literature, for example the point spectrum, approximate point spectrum, one-sided, essential, local, or Taylor spectrum. A useful unifying approach to the study of various types of spectra gives the axiomatic theory of spectrum that was introduced for n-tuples of operators by W. Zelazko and Z. Slodkowski [X5-13] [X5-17]. For single operators, a similar approach was suggested in [X5-8], [X5-10]. During the recent years, the axiomatic theory of spectrum has been further developed. A survey of results was given in the monograph [5-004], which appeared in the Birkhäuser Verlag.

5.7. The results of van Mill and Wattel were generalized in [5-014] and it was shown that every countably compact completely regular space with a continuous selection on pairs is a subspace of an ordered space. The result was proved also for pseudocompact spaces if they are scattered, satisfy the 1st axiom of countability or they are connected. It was shown that an infinite pseudocompact topological group with a continuous selection on pairs is homeomorphic to the Cantor set. A zero-selection is a selection on the hyperspace of closed sets, which selects always an isolated point of the set. The results of Fuji and Nogura were extended and it was proved that a (locally compact) pseudocompact space with a continuous zero-selection is homeomorphic to a (open) subspace of ordinal numbers. Using the diamond principle, several examples were constructed that show the limits of further generalization. For example, a locally compact locally countable normal space with a continuous zero-selection, which is not a subspace of an ordered space was constructed. In [5-0101], a rotationally invariant function that is quasiconvex but not polyconvex was constructed. This gives an answer to a question posed in the monograph [X5-4]. The quasiconvex hulls of rotationally invariant functions were found. Further, the relaxation for a wide class of energies that describes non-matic elastomers was determined and the relations among semiconvex properties of rotationally invariant functions on spaces of matrices of various dimensions were described. Also, an explanation of pseudoelastic hysteresis based on the loss of 1-convexity was suggested. In connection with this, Kohn's proof of quasiconvexification was simplified. The classical results of Szekefalvi-Nagy and Foias about models of Hilbert space contractions were generalized to models for n-tuples of operators that use the multiplication operators by independent variables in spaces of holomorphic functions [5-010]. A complete analogy to the classical model was obtained for the case of bounded symmetrical domains using new results about the Pieri coefficients from the theory of representations of semisimple Lie groups [5-038]. The existence of the Taylor functional calculus is the basic result of the multivariable operator theory. The original proof [X5-14], [X5-15] was quite complicated and used deep results of complex analysis and cohomology theory. In spite of considerable effort the construction of the calculus has been simplified only in some particular cases, for example for operators on Hilbert spaces [X5-16], or for a narrower class of analytic functions [X5-7]. In [5-085], a new elementary construction of the calculus for general n-tuples of operators on a Banach space was presented. Moreover, the Taylor functional calculus is given by an explicit formula.

6. Department of Mathematical Logic, Numerical Algebra, and Graph Theory

6.1. Scientific research of mathematicians in the Department of Mathematical Logic, Numerical Algebra, and Graph Theory in the area of online algorithms deals with overloaded systems, where it is impossible to complete all the tasks before their deadlines; we give several new algorithms and lower bounds [6-020], [6-045]. Recently, this has become a very active research area worldwide, we are very pleased that our group has international level results and that, at the same time, the research involves active participation of students. Another recent result [6-046] gives a simplification and an improvement of a 25 year old algorithm of Gonzales and Sahni. To the important results in the area of online algorithms for scheduling, it is necessary to add chapters in the books [6-006], [X6-2].

6.2. More than 20 years ago Kusner conjectured that in the n-dimensional space with l_p-norm the maximal size of an equilateral set (a set in which every pair of points have the same distance) is $2n$ if $p = 1$, and $n + 1$ if $p > 1$. The paper [6-007] proves the strongest result concerning the case of p an odd positive integer. Namely for every such integer p there exists a constant c_p such that the size of every equilateral set is bounded by $c_p\ n\ \log n$.

6.3. The book Classical Mathematical Logic (in Czech, see [6-003]) is a publication in logic, which is more extensive than all Czech texts published before it. This book shows the present state of mathematical logic and simultaneously it tries to put it in the frame of the general development of deductive thinking. An intuitive view to every area of logic is put forward at first and this view is accessible to all readers, later precise mathematical text follows. The great results of mathematical logic as, e.g., Gödel's theorems of incompleteness, are described in detail and without assuming preliminary knowledge. Some parts appeared in Czech literature for the first time (e.g. saturation of ultrapower, unprovability of Goodstein's theorem in Peano arithmetic, and so on). The book obtained J., M., and Z. Hlávka's prize.

6.4. We succeeded to construct a complete infinite Boolean algebra that has no infinite complete subalgebra [6-025]. Previously, the only such example existed under the assumption of the axiom of constructibility; this was proved by R. Jensen in 1968.

7. Department of Didactics of Mathematics

7.1. In the field of mathematics education, members of Department of Didactics of Mathematics determined characteristic features of the process of grasping both "real" and "mathematical" situations by generalizing results gained during the study of specific cases. The structure of this process was described and possibilities of its cultivation were shown [7-027], [7-022]. Some ways of implementing research results in school practice were suggested [7-001].

7.2. The theoretical basis of the conception of investigating the semiotic approach in mathematics education was formulated. (a) Basic characteristics of the semiotic approach were determined, (b) methods for investigating semiotic representations in the teaching of geometry were developed which are based on the analysis of transformations of semiotic representations made during communication. The results are published in thesis [X7-1].

8. Branch in Brno

Differential Geometry

8.1. In the Brno Branch the research in the field of differential geometry was oriented towards a completely new area, namely the study of 3-forms (i.e. antisymmetric trilinear forms). The investigation was focused on the differentiable manifolds of dimensions 6 and 7. The most complete results were obtained in dimension 6 (see [8-083]). From the point of view of algebra, there exist three regular types and three singular types here. It was shown that the three regular types are very closely related with structures well known from the differential geometry, namely the product structures, the complex structures, and the tangent structures. With each of these forms a *G*-structure was associated. Necessary and sufficient conditions for the integrability of these *G*-structures were found, and necessary and sufficient conditions for the existence of special connections associated with these *G*-structures were described. Moreover, in dimension 6, the separate orbits (with respect to the action of the linear group $GL(6,R)$) were investigated. These results are closely related with results of N. Hitchin (Oxford) (see [X8-7], [X8-8]). There is also cooperation with T. Friedrich and his group (Berlin) (see [X8-1], [X8-4], [X8-5]). They study metric connections with antisymmetric torsion (i.e., the relevant torsion is a 3-form). It is appropriate to mention that forms of higher degree appear more and more often in theoretical physics (see [X8-10], [X8-11], [X8-12]).

Qualitative theory of ordinary and functional differential equations, dynamic systems, and difference equations

8.2. In the domain of theory of ordinary and functional differential equations, dynamic systems, and discrete equations, a new technique based on the methods of calculus was developed for the investigation of qualitative properties of such equations. By using this technique, a number of new results were obtained which generalize, extend, and complement many statements available in the literature. The results obtained are presented in a number of research papers and monographs [8-001], [8-004], and [8-005], and they are unimprovable in many cases.

8.3. In the papers [8-0121], [8-088] - [8-092], [8-094], [8-035], [8-037] fundamental results are presented concerning the oscillation theory for half-linear difference equations. The set of solutions of such equations is, in general, homogeneous but not additive. The results mentioned can be regarded either as discrete counterparts of the corresponding results for half-linear differential equations arising, e.g., in studies of radial solutions of elliptic equations with *p*-Laplacian, or as a generalization of the theory of linear difference equations. The main result is contained in the Roundabout Theorem allowing one to derive easily generalizations of the Sturm theorems and obtain efficient tools for the investigation of oscillatory properties such as the Riccati techniques or variational principle. These topics are also studied in Asia and America, and a number of researchers working there have shown interest in the results just mentioned.

8.4. The papers [8-012], [8-038], [8-095] [8-096], are devoted to (half-)linear dynamic equations on time scales. Investigation of dynamic equations on time scales makes possible to achieve results, which unify the theories of differential and difference equations as well as more general equations where the unknown function is defined on an arbitrary nonempty subset of the real axis. In this way, one can clarify the differences between the continuous and discrete cases, which is important, e.g., for the numerical approximation. The topics related to the above-mentioned equations are now actively investigated in the collaboration with leading experts in this field (USA), see [8-012], [8-038].

8.5. We have achieved even other results, which are not contained in the fields mentioned above. We have generalized Diliberto's theorem from planar ordinary differential equations to systems possessing invariant manifolds or first integrals ([8-100], [8-008], [8-007]). We have investigated the problem of existence of bounded solutions of strongly nonlinear systems by topological methods ([8-009]).

8.6. We achieved some results even in applied mathematics, namely we have studied qualitative and quantitative properties of some models of chemical kinetics of a low temperature plasma of an electrical arc. Our model was represented by a large system of nonlinear ordinary differential equations. We were able to successfully solve this problem from the formulation of rules for construction of such systems and discussion of their general asymptotic properties, to the numerical solution of concrete systems (which is quite difficult task as, from the point of view of numerical analysis, such systems are examples of stiff problems) ([8-099], [8-010]).

Global properties of dynamic systems

8.7. Global properties of n^{th} order differential equations were investigated in connection with algebraic and geometrical structures, which were induced by those equations and their transformations. In paper [8-078] there is derived the dependence of asymptotic behavior of solutions on their distribution of zeroes. Algebraic structures connected with global transformations of differential equations, ordinary and functional, were studied in papers [8-077], [8-079], [8-0115]. Some relations between functional equations and differential equations, ordinary or partial, generally non-linear, were described in papers [8-080] and [8-0114]. A general construction of all linear differential equations of the n^{th} order with prescribed properties of solutions was presented in [8-081]. Discrete representations of smooth dynamical systems are treated in articles [8-0116], [8-081], [8-0117], [8-0118], [8-0119].

Control theory of discrete and hybrid systems

8.8. Control theory of hybrid Petri nets has been studied using idempotent semiring (min,+). The class of hybrid Petri nets with (min,+)-linear input-output relation has been identified. We have proposed a new method for computation of transfer matrix between input and output. A formula for optimal control with respect to the "just in time" criterion has been derived together with its generalization to the case of variable maximal firing speeds in the continuous part of the Petri net ([8-039]). The dynamics of deterministic continuous and hybrid Petri nets has been described by a system of functional equations. These are functional equations of the fixed-point type with the operations minimum and infimum that can be viewed as integral equations in the sense of idempotent integration. We have characterized their relationship with systems of linear integral equations of Volterra type.

B4. International cooperation of the applicant/institution in research and development

B4.a. Participation of the applicant/institution in international research and development cooperation implemented on the basis of international contracts concluded by the Czech Republic with foreign entities

B4.b. Collective membership of the applicant/institution in non-governmental international scientific organisations

B4.c. Individual membership of applicant's employees in non-governmental international scientific organisations

CERME (European Society for Research in Mathematics Education): M. Tichá, F. Roubíček
GDM (Gesellschaft für Didaktik der Mathematik): M. Tichá
SFoCM (Society for the Foundations of Computational Mathematics): P. Přikryl
E-MRS (European Branch of Materials Research Society): P. Přikryl
AMS (American Mathematical Society): M. Fabian, J. Krajíček, M. Markl, V. Müller, P. Řehák, I.Straškraba, Š. Schwabik
Council of the Association for Symbolic Logic: J. Krajíček
EATCS (European Association for Theoretical Computer Science): J. Sgall
International Society of Difference Equations: P. Řehák
EMS: B. Balcar, A. Kufner, Š. Schwabik, J. Vanžura
International Linear Algebra Society: I. Saxl

B4.d. Contracts or joint projects of the applicant/institution with foreign organisations engaged in research and development

Contract on Cooperation with the Mississippi State University, U.S.A., 1994-2003

Contract on Cooperation with the Institut für Physikalische Hochtechnologie, Jena, Germany, 1996-2001

NATO grant No. CRG 970071: Function spaces and weighted inequalities, 1997-1999

NATO grant No. CRG 973982: Smoothness and separable reduction in nonlinear analysis, 1997-1999

Royal Society grant, United Kingdom: Weighted inequalities, integral operators and embeddings, 1997-1999

Common project ME 103 of Ministry of Education of the Czech Republic and NSF, U.S.A.: Mathematical logic, compexity theory, and their connections, 1997 - 2000

Common project of Ministry of Education of the Czech Republic and NSF, U.S.A.: Reliability problems in the finite element method, 1997-2001

Sokrates project – Comenius I: European mathematical development through exchange and education, European Union, 1997-2001

Common project ME 148 of Ministry of Education of the Czech Republic and NSF, U.S.A.: Reliability problems in computational mechanics, 1998-2000

Common project ME 333 of Ministry of Education of the Czech Republic and NSF, U.S.A.: Operads in algebra, geometry, and physics, 1998-2000

Grant of NSF No. DMS-9803435, U.S.A.: Applications of methods of algebraic topology to mathematical physics, 1999-2001

Contract on Cooperation with the Fakultät für Mathematik und Informatik der Fiedrich-Schiller-Universität, Jena, Germany, 1998-2003

Project CNRS-Academy of Sciences of the Czech Republic: Propriétés qualitatives d'equations de la dynamique des populations, 1999

Grant DFG, Germany, Optimale Einbettungen von Funktionräumen vom Besselpotential-Typ, Technische Universität Darmstadt, 1999

Slovak Academy of Sciences, grant of Vega Quantification of structure and of deformation processes in dispersion strengthened systems, 1999 repeated every year

Project Barrande (Czech Republic-France): Theoretical and numerical contributions to the study of compressible or incompressible viscoelastic fluids, 1999-2003

Common project of Ministry of Education of the Czech Republic and NSF, U.S.A.: Mathematical logic and computational complexity, 1999-2003

Grant NATO, Smoothness and separable reduction in nonlinear analysis, University of British Columbia, Vancouver, 2000-2001

Czech – Slovak Grant No. 11988198, jointly with the Mathematical Institute of the Slovak Academy of Sciences, Topological structures on spaces of partial functions and hyperspace, functional analysis of positive operators, and their applications, 2000-2002

Project of the Academy of Sciences of the Czech Republic, Russian Academy of Sciences, and the Institute of the Physics of Materials of the Academy of Sciences of the Czech Republic, Study of the influence of technological process and creep exposition on the development of microdefect in metals and composites with metallic matrix, St. Petersburg 2000-2004

GNFM, Continui di grado elevato e teoria delle distribuzioni, Universita di Roma III, 2001

Aktion – Kontakt: Stochastic evolution equations and their numerical approximations, Österreich, 2001-2002

Common project ME 476 Ministry of Education of the Czech Republic and NSF, U.S.A.: Randomized competitive algorithms for online problems, 2001-2003

NSF/NRC COBASE, Probabilistic competitive algorithms for online problems, 2001-2003

COCON (Coalgebra and Control), Project Grant NWO (the Netherlands Grant Agency), 2001-2003

Grant EU Socrates project: Understanding of mathematics classroom culture in different countries, European Union, 2002-2004

The Leverhulme Trust grant, United Kingdom: Function spaces, wieghted inequalities and approximation numbers for integral operators, 2001-2003

Grant CTESIN/2002/35, Generalitat Valenciana, 2002

Grant GA ČR č. 106/01/0648, Modification of semiconductors by puls lasers. Belarussian Academy of Sciences, 2002

Barrande Project Variational problems and their application to continuum mechanics, 2002-2003

Project Barrande Mathematical and munerical analysis of the development of a system with collision and friction, 2002-2003

Contract on Scientific Cooperation with Russian Academy of Sciences, Russian Federation, 2002-2003

Collaborative Linkage Grant, NAT0: Weighted inequalities, function spaces, interpolation, extrapolation, approximation, and entropy numbers, 2002-2003

Common project ME 603 Ministry of Education of the Czech Republic and NSF, U.S.A.: Homotopy invariant algebraic structures, 2002-2005

Grant Variational theory of microstructure, semiconvexity, phase transitions and complex materials, Univerzita v Pise, 2002-2005

HYKE – Program for research and exchange for doctoral and postdoctoral study, EU 2002-2006

NATO Cooperative Science &Technology Sub-Programme: Robin and Neumann problems in nonsmooth crecked domains, 2003

Slovenian – Czech Intergovernmental S&T Cooperation Programme: The theory of linear operators, 2003-2004

Slovak – Czech Intergovernmental S&T Cooperation Programme: Topological structures on function spaces and hyper-spaces, theory of positive operators, and their applications, 2003-2005

B4.e. Other forms of international cooperation

(i) List of long-term stays (6 months or more) of the members of the Mathematical Institute abroad:

Name	**Institution**	
Pavel Krejčí	Weierstrass Institute, Berlin, Germany	4 years 1997/2000
Jan Krajíček	University of Oxford, GB	2 years 1997/1999
Petr Hájek	Texas A&M University, Texas, USA	1 year 1998/1999
Eduard Feireisl	Université de Franche Comté, Besanson, France	6 months 1999
Šárka Nečasová	Instituto Superior Technico, Lisboa	6 months 1999
Jan Lang	University of Missouri, Columbia, USA	10 months 1999/2000
Pavel Řehák	University of Nebraska, Lincoln, USA	7 months 2001/2002
Jan Komenda	Center for Mathematics, Amsterdam, The Netherland	2 years 2001/2003
Miroslav Šilhavý	University Pisa, Italy	4 years 2002/2005
Bohdan Maslowski	University of New South Wales, Australia	10 months 2003/2004
Martin Panák	UNI, Dortmund, Germany	1 year 2003/2004

(ii) Lecture cycles of the members of the Mathematical abroad:

B. Balcar	Exhaustive structures on Boolean algebras	McMaster Univ., Canada	1999
E. Feireisl	Les équations de Navier Stokes compressibles	Univ. Besanson, France	1999
P. Hájek	Calculus I	College Station, Texas	1999
J. Krajíček	The P=PN? Problem	Univ. Oxford, GB	1999
E. Matoušková	Complex variable	J. Kepler, Univ., Linz, Austria	1999
	Calculus	J. Kepler, Univ., Linz, Austria	1999
V. Müller	Orbitas de operadores	Univ. Autonoma Metropolitanea, Mexico	1999
Š. Nečasová	Fluid mechanics	Ins. Superior Technico Coimbra, Spain	1999
E. Feireisl	Nonlinear differential equations	AV ČLR, Peking, China	2000
E. Feireisl	Differential equations and basic calculus	Ohaio Univ., Athens, Greece	2000
E. Matoušková	Ordinary differential equations	J. Kepler Univ. Linz, Austria	2000
	Calculus 2	J. Kepler Univ. Linz, Austria	2000
	Introduction to complex variable	J. Kepler Univ. Linz, Austria	2000
Š. Nečasová	Business calculus, Algebra calculus	Univ. of Pittsburgh, PA USA	2000
B. Maslowski	Stochastic analysis, basic calculus	Univ. of Kansas, USA	2000
J. Sgall	Optimization 4	Technical Univ. Eindhoven, The Netherland	2000
J. Sgall	Optimization and online algorithms	Univ. of Chicago ILL, USA	2000
M. Šilhavý	Phase transitions in solids	Univ. di Roma III, Italy	2000
	Basic thermodynamics	Univ. di Roma III, Italy	2000
	Phase transitions in solids	Univ. di Pisa, Italy	2000
E. Feireisl	Introduction aux problemes d´évolution	Univ. de Nancy, France	2001
E. Feireisl	Math. Theory of compressible fluids	Waseda Univ., Tokyo, Japan	2001
E. Matoušková	Ordinary differential equations	Univ. of South Carolina, USA	2001
E. Matoušková	Functions of complex variable	J. Kepler Univ., Linz, Austria	2001
I. Straškraba	Short courses on Navier-Stokes equations	Pacific Institute of Mathematik, Vancouver, Canada	2001
M. Šilhavý	Phase transitions and nonelliptic variational problems	Univ., Rio de Janeiro, Brazil	2001
P. Řehák	Differential equations	Univ. of Lincoln, USA	2001
M. Fabian	Optimization	Australian Math. Society, Australia	2002
M. Markl	Operads in Algebra, Topology and Physics	MU RAV, Romania	2002

E. Matoušková	Functional analysis in complex variable	J. Kepler Univ., Linz, Austria	2002
E. Matoušková	Ordinary differential equations	Univ., South Carolina, Columbia USA	2002
V. Müller	Mathematical Analysis	Andalucia, Spain	2002
M. Šilhavý	Energy minimization for isotropic nonlinear elastic bodies	CISM, Udine, Italy	2002
M. Šilhavý	Calculus 1	Univ. of Kentucky, USA	2002
J. Krajíček	Tutorial	Univ. of Athens, Greece	2002
H. Petzeltová	Ordinary diff. equations, Partial diff. eq.	Ohaio Univ., Athens, Greece	2002
B. Maslowski	Stochastic analysis	Univ. of Kansas, USA	2003
E. Feireisl	Basic calculus	Univ. de Nancy, France	2003
E. Feireisl	Dynamics of viscous compressible fluids	Univ. de Brescia, France	2003
P. Krejčí	Evolutionary quasivariational equation	Univ. de Pavia, Italy	2003

(iii) List of long-term stays of foreign guests in the Mathematical Institute

Name	**Country**	**Duration**
Mamoru Mimura	Okayama University, Japan	September 1998 – May 1999
Daria Apuchkinskaia	St. Petersburg State University, Russia	February 1999 – August 2000
Amiran Gogatishvili	Tbilisi State University, Georgia	October 1998 – August 2000
Florian Luca	Universitaet Bielefeld, Germany	September 1999 – August 2000
Takuya Sobukawa	Okayama University, Japan	April 2002 – December 2000
Alexander Zlotnik	Moscow Power Engineering Institute, Russia	September 2000 - January 2001
Nobuhiko Fujii	Tokai University, Japan	September 2001 – December 2001
Lasha Ephremidze	A. Razmadze Mathematical Institute, Georgia	September 2001 – August 2002
Camillo Constantini	Universita di Torino, Italy	October 2001 – September 2002
Calin Ambrozie	Romanian Academy, Romania	January 2002 – February 2003
Andrei Ronto	Institut of Math. NAS, Ukraine	August 2003 – January 2004
Sulkham Mukhigulashvili	Universita Tbilisi, Georgia	September 2003 – August 2004
Elisabeth Remm	Université de Mulhouse, France	November 2003 – January 2004

In the period 1999 –2003, 342 foreign mathematicians visited the Mathematical Institute through short-term scientific stays.

(iv) List of foreign prizes and awards

Michal Křížek
    2001: Hall of Fame of Science and Technology, Institute of Technology, San Diego, USA
Miroslav Engliš
    2001: ISAAC Award of the International Society for Analysis, its Applications and Computation, Berlin
Petr Přikryl
    2002: International Scientist of the Year 2002, International Biographical Centre of Cambridge, England

(v) The Mathematical Institute organized or co-organized the following international scientific meetings in the period 1999-2003 (the number of participants range between 30 and 300)

Winter School of Abstract Analysis, Lhota pod Rohanovem, January 1999.
19th Winter School Geometry and Physics, Srní, January 1999.
27th Winter School of Abstract Analyis, section Topology, Zahrádky u České Lípy, February 1999.
Partial differential equations and applications, Olomouc, December 1999.
Conference on the Ocassion of the 120th Birthday of Albert Einstein, Karolinum, Praha, March 1999.
Borůvka Mathematical Symposium, Brno-Valtice, May 1999.
Workshop on Algebraic Methods and Arithmetic Circuits, Rutgers University, New Brunswick, June 1999.
International Summer School IMAMM 99, Nečtiny, July 1999.
European Symposium on Algorithms, Praha, July 1999.
Workshop on functional Analysis and its Applications in Mathematical Physics and Optimal Control, Slovakia, September 1999.
Workshop on infinite dimensional stochastic analysis, Praha, September 2000.
15th IEEE Annual Conference on Computational Complexity, Florence, July 2000.
Summer school EVEQ, Praha, August 2000.
Winter School of Abstract Analysis, Křišťanovice, January 2000.

28th Winter School of Abstract Analysis, section Topology, Zahrádky u České Lípy, January/February 2000.
20th Winter School Geometry and Physics, January 2000.
Miniconference Banach space, Svatý Jan pod Skalou, November 2000.
Finite Element Methods, Javäskylä 2000.
Spring School Nonlinear Analysis, Paseky, April 2000.
External logic Seminar, Pec pod Sněžkou, September 2000.
Conference on Differential and Difference Equations, Brno, September 2000.
Seminar Programs and Algorithms on Numerical Analysis, Lázně Libverda 2000.
EQUADIFF 10, Praha, August 2001
Logic Colloquium, Vienna 2001.
Modelling, Plzeň, June 2001.
21st Winter School Geometry and Physics, Srní, January 2001.
9th Prague Topological Symposium, Praha, August 2001.
29th Winter School of Abstract Analysis, section Topology, Zahrádky u České Lípy, January 2001.
MFCS 2001 26th International Symposium on Mathematical Foundations of Computer Science, Mariánské Lázně, August 2001.
Fall Schooll of Logic Seminar, Pec pod Sněžkou, September 2001.
Winter School of Abstract Analysis, Lhota pod Rohanovem, January 2001.
22nd Winter School Geometry and Physics, Srní, January 2001.
30th Winter School of Abstract Analysis, section Topology, Litice, January/February 2001.
Czech-Austrian Seminar. Svatý Jan Pod Skalou, November 2001.
Workshop on Functional Analysis and its Applications in Mathematical Physics and Optimal Control, Slovakia, August 2001.
Circuit and proof complexity, Edinburgh, October 2001.
2nd Czech-French Conference on Mathematical Fluid Mechanics, Třešt, June, July 2002.
Seminar on the the Occasion of the 50th Anniversary of Mathematical Institute, Praha, December 2002.
Seminar Programs and Algorithms of Numerical Analysis 11, Dolní Maxov/Josefův Důl, June 2002.
Finite Element Methods: Fifty Years of Conjugate Gradients, Department of Mathematical Information Technology, University of Jyväskylä, 2002.
Finite Element Methods, Javäskylä, 2002.
International Seminar on the occasion of the 400th Birthday of P. de Fermat, Praha, 2002.
Computational Linear Algebra with Applications, Milovy, August 2002.
Conference and Differential and Difference Equations, Brno, September 2002.
Winter Scool of Abstract Analysis, Lhota pod Rohanovem, January 2002.
23th Winter School Geometry and Physics, Srní, January 2002.
31st Winter School of Abstract Analysis, section Topology, Zahrádky u České Lípy, January/February 2002.
Fall School of Logic Seminar, Pec pod Sněžkou, September 2002.
Spring School on Nonlinear Analysis, Function Spaces and Applications 7 (NAFSA 7), Praha, July 2002.
Workshop on Functional Analysis and its Applications in Mathematical Physics and Optimal Control, Slovakia, September 2003.
Fall School of Logic Seminar, Pec pod Sněžkou, September 2003.
Winter School of Abstract Analysis, Lhota pod Rohanovem, January 2003.
32nd Winter School of Abstract Analysis, section Topology, Zahrádky u České Lípy, February 2003.
24th Winter School Geometry and Physics, Srní, January 2003.
International Colloquium on Difference Equations and Applications, Brno, 2003.
International Summer School IMAMM, Roňov pod Radhoštěm 2003.

(vi) Membership in Editorial boards of International journals in the period 1999-2003

Name	**Journal**
Ondřej Došlý	Archivum Mathematicum, Brno
Miroslav Engliš	Czechoslovak Mathematical Journal
	Journal of Function Spaces and Applications
Miroslav Fiedler	Numerische Mathematik
	Linear Algebra And Its Applications
	Mathematica Slovaca
	Electronic Journal of Linear Algebra
	Czechoslovak Mathematical Journal
Eduard Feireisl	Mathematica Bohemica
	Czechoslovak Mathematical Journal
	Central European Journal of Mathematics

Ivan Hlaváček	Applications of Mathematics
Jan Chleboun	Applications of Mathematics
Tomáš Jech	Annals of Pure and Applied Logic
	Bulletin of Symbolic Logic
Kamil John	Tatra Mountains Mathematical Public
Jan Krajíček	Annals of Pure and Applied Logic
Josef Král	Czechoslovak Mathematical Journal
Pavel Krejčí	Applications of Mathematics
Michal Křížek	Applications of Mathematics
	Applicationes Mathematicae (Warsaw)
Alois Kufner	Journal of Inequalities and Applications (Singapore)
	Journal of Function Spaces and Applications (Indie)
	Journal of Differencial Equations and Applications (Indie)
	Journal of Analysis and Applications (Indie)
Jaroslav Kurzweil	Mathematica Bohemica
	Czechoslovak Mathematical Journal
Bohdan Maslowski	Central European Journal of Mathematics (Polsko)
	SIAM J. Control Optimization (USA)
Vladimír Müller	Mathematica Slovaca
František Neumann	Archivum Mathematicum
	Mathematica Bohemica
	Mathematica Slovaca
	Memoirs on Differential Equations and Mathematical Physics
Bohumír Opic	Mathematical Inequalities and Applications (Zagreb)
	Inequalities in Pure and Applied Math. (Melbourne)
Jan Pelant	Serdica
	Mathematica Slovaca
Pavel Pudlák	CALCOLO
	Matematica Bohemica
	Computational Complexity
Petr Přikryl	Applications of Mathematics
Jiří Rákosník	Czech Editorial Unit of Zentralblatt für Mathematics and MATH database
Ivan Saxl	Applications of Mathematics
Jiří Sgall	Operations Research Letters
	Discrete Mathematics and Theoretical Computer Science
	Journal of Scheduling
Štefan Schwabik	Mathematica Bohemica
	Archivum Mathematicum
	Mathematica Slovaca
Ivan Straškraba	Journal of Mathematical Fluid Mechanics
Milan Tvrdý	Memoirs on Differential Equations and Mathematical Physics (Tbilisi, Gruzie)
	Nonlinear Oscillations (Kyjev)
Jiří Vanžura	Mathematica Bohemica
Emil Vitásek	Applications of Mathematics
Václav Zizler	CMUC

B5. R&D budget of the applicant/ institution in the previous five years (in thousands of CZK)

Year	Institutional support from the state budget[6]	Targeted support from the state budget[7]	Other resources	Specification of other resources
1999	19 505	10 504	4 975	other off-budget income
2000	21 622	10 373	4 216	other off-budget income
2001	24 409	10 008	5 190	other off-budget income
2002	27 005	9 958	4 337	other of-budget income
2003	30 590	4 413	1 979	other off-budget income (at 30.9. 2003)

6 Total amount of funds the institution has received from the sources of the state budget of the Czech Republic as an institutional subsidy for its Institutional Research Plan.

7 Total amount of funds the institution has received from the sources of the state budget of the Czech Republic in the form of research grants, targeted research programs etc.

C. Description of Institutional Research Plan (IRP) for the period of 2005-2010

C1. Subject of the research activity implemented in the research plan

The subject of activities of the Institute will be basic research and further development of the knowledge system in real and functional analysis, in numerical and probabilistic analysis, in the theory of ordinary and partial differential equations, differential geometry, topology, mathematical logic, and complexity theory, and their applications.
Particular attention will be paid to complex development that is absolutely necessary for complete and general progress in mathematical knowledge. Cultivation of a single, individual branch of mathematics gives no guarantee for a harmonic development of mathematics as a field of science.
Some specific subjects of research are stimulated by progress of physics and technology and the respective mathematical results will be presented as application outputs.
Other subjects are focused to the inner needs of developing mathematics as an integral and complex branch of science.

C2. Present level of knowledge and status of ongoing research related to the subject of IRP, from both international and national viewpoints

Mathematics is today a very wide branch of science and top teams in its individual fields exist at a lot of universities and institutes all over the world. In some fields of mathematics, the Mathematical Institute belongs among these top institutions. In other fields, we belong at least to the best Czech institutions.
The present level of cognition achieved is best apparent from monographs some of which originated in the Mathematical Institute. The actual state of the research just being performed is best reflected in proceedings of international scientific meetings to which members of the Institute contribute.

1. Department of Real and Probabilistic Analysis

Beginnings of the generalized sum approach to integration and of the theory of generalized differential equations go back to the paper [X1-22] by J. Kurzweil from 1957. The integral introduced in this paper is quite simple: it is based on the Riemannian sums, only the corresponding partitions are ordered in a special way. Nevertheless, it led to a powerful non-absolutely convergent integral that is in the one-dimensional case equivalent to the Perron integral and covers the Lebesgue integral. Integrals of this type are nowadays called the Henstock-Kurzweil (HK) integrals. During the seventies, the theories of one-dimensional sum integration and of generalized differential equations have been completed in the Mathematical Institute. During the eighties and nineties, after an impulse by Mawhin [X1-28], a systematic study of the HK-integration on more-dimensional regions was realized. Enormous quantity of papers (see, e.g., Real Analysis Exchange) and books (Bartle [X1-1], Henstock [X1-15], [X1-16], Kurzweil [X1-24], Pfeffer [X1-34], Schwabik [1-004], Swartz [X1-41]) prove that this approach to integration remains a very important field part of the research in mathematical analysis. In the last decade, an attention is also paid to the topological structure of the space of primitives to the integrable functions, which is closely related to convergence theorems valid in the frames of the corresponding integration theory. Further topical problem is the extension of the sum approach to the integration of functions with values in a general Banach space. The study of the relationship between the sum integrals and the classical Bochner and Pettis integrals was initiated in [X1-24], and then followed by Fremlin [X1-9] and Gordon [X1-11]. The relationship between the weak McShane and Pettis integrals remains a difficult open problem, though attacked by leading specialists.

At present, the bibliography concerning nonlinear boundary value problems contains an enormous number of publications. For regular problems, a good account of the present state was given e.g. in Gaines & Mawhin [X1-10], DeCoster & Habets [X1-6], and Kiguradze [X1-20]. Proportionally to the progress in getting answers to the most important questions for regular problems an increasing attention is paid to problems with singularities and/or with impulses. For a general survey, see, e.g., Kiguradze [X1-19], [X1-21], Mawhin [X1-29], and O'Regan [X1-33]. Singular periodic problems for second order equations have been recently treated by several authors (e.g. Lazer & Solimini [X1-25], and [X1-7], [X1-14], [X1-43]). All of them restricted themselves to strong singularities, while the problems with weak repulsive singularities and the case that the eigenvalues of the related Dirichlet problem can be touched remained unsolved until lately. Problems with impulses have been considered by Hu & Lakshmikantham [X1-17], Liz & Nieto [X1-26], and others. Up to now, no result has been delivered for impulsive problems having only non-ordered pair of lower/upper functions.

A systematic treatment of stochastic partial differential equations is motivated by models from physics, biology, and control theory. Several approaches to SPDE’s have been developed rigorously, see e.g. the monographs by Da Prato and Zabczyk [X1-3] and [X1-4]. There are several actual topics of the theory of stochastic partial differential equations related to the research pursued in the Mathematical Institute. In particular, the “pathwise” properties of solutions (see, e.g., [X1-18], [X1-3], [X1-4], [X1-5]), large time dynamics of Markov processes (see e.g. [X1-4], [X1-2]), the Feller property (see e.g. [X1-27], [X1-8]) and stochastic partial differential equations driven by a fractional Brownian motion are the examples. As concerns the last topic, the research is still in a very early stage. However, some results on existence, uniqueness, and pathwise regularity have been proved in [1-016], [X1-13], and [1-030].

The importance of spatial tessellations as models of space filing partitions is demonstrated by many examples in the monograph [X1-31]. With very few exceptions their practical applications are based on the results obtained by stochastic simulations. A crucial problem is a unified classification of spatial tessellations.

2. Department of Evolution Differential Equations

Mathematics is an open system, where each new discovery creates new space for further questions, which might have been meaningless before. Solving a problem gives rise to new even more complex problems. A competitive research team is characterized by the ability of asking relevant questions, giving adequate answers, and receiving an appropriate attention and recognition in the international scientific community. Members of the research group Evolution Differential Equations are successful in this respect. Their results in the qualitative theory of evolution equations have a durable non-negligible impact among specialists in their research field. They produce a top quality research in the development and subsequent analysis of mathematical models for systems arising in continuum mechanics and thermodynamics. The fact that two of them participate actively as authors and/or editors in the project of a modern Handbook of Differential Equations – Evolutionary Partial Differential Equations (item [2-004] in the publication list is part of the series) is a convincing evidence for this statement.

3. Department of Qualitative Methods of Mathematical Analysis

The first essential results on bifurcations of solutions to variational inequalities appeared in the 1980’s, some of them in the Mathematical Institute (M. Kučera). Since then the German and Italian schools have developed a theory of potential problems, whereas in the Mathematical Institute results on existence and distribution of bifurcation points of non-potential variational inequalities have been obtained.

Necessary and sufficient conditions for the continuity up to the closure of a given domain of a solution to the Dirichlet problem for the Laplace equation are known since several decades ago. On the other hand, necessary and sufficient conditions for the Neumann problem for the Laplace equation have not been known. The method of integral equations for solutions to boundary value problems has been used for one hundred years and last forty years includes also the study of boundary value problems on non-smooth domains. Recently it is also used for study of boundary value problems on planary domains with smooth boundary and a crack. (See, e.g. [X3-6].)

In the last ten years members of the function spaces group together with foreign colleagues have proved a series of results on optimality of imbeddings of Sobolev type spaces (see, e.g., [X3-2], [3-013], [3-055], [3-051], [3-041], [3-042], [X3-3]). They have made use of techniques from weighted inequalities, interpolation and extrapolation theory, and also Fourier analysis. Further, they have developed methods of limiting real interpolation ([3-026], [3-027], [X3-4]) and essentially contributed to the development of extrapolation methods ([3-

014], [3-042], [3-029], [3-034]). Also the results achieved in the theory of weighted inequalities ([3-033], [3-035], [3-070], [3-001]) enjoy international reputation.

4. Department of Constructive Methods of Mathematical Analysis

All the suggested subjects of research continue top world research.

The finite element method (FEM) has been pursued at hundreds of universities and goal-oriented institutions. The FEM has diversified into tens of fairly different variants; see [X4-1], [X4-5], for example. It has also become necessary to investigate closely related subjects as mesh generation or solving systems of algebraic equations. Due to the extensiveness of the FEM, research groups specialize in particular subjects. We accomplish international standards both in the study of particular features of the FEM and in the a posteriori error estimation.

The methods for solving problems with uncertain input data have gained increasing attention in the last decade [X4-2]. Owing to the enormous number of applications, the research is still in its infancy as yet rigorous mathematical treatment is scarce; this applies especially to sophisticated state problems. In this respect, we are pioneers in the Czech Republic at least.

The problems of phase changes belong to moving boundary problems [X4-7]. The models of turbulent melt flow studied in the framework of the computational modeling of crystal growth and surface modification of semiconducting materials are uncommon and individual on the European scale at least. Moreover, the models of pulsed laser-induced phase changes in semiconductor thin films developed at the Institute are up to international standard as well.

The study of properties of solutions of Einstein's equations is also performed at the Faculty of Mathematics and Physics of Charles University, Prague, and at many universities abroad [X4-6]. The results published by researchers from the Institute are considered important and their authors were invited for a visit and collaboration with mathematicians from Dalhousie University, Canada.

The extent of investigation of Fermat numbers is exceptional in the Czech Republic, and even quite rare abroad. The wide treatment of the subject is a result of a close cooperation with foreign researchers. The number theory emerged centuries ago and is still flourishing [X4-4].

5. Department of Topology and Functional Analysis

The central open problem in operator theory is the invariant subspace problem, i.e., the question whether each bounded linear operator on a Hilbert space has a nontrivial invariant subspace. There are some partial results both positive and negative. The most important negative results are counterexamples in Banach spaces. The main positive results in the recent years were obtained by means of the Scott Brown technique, for example, that each Hilbert space contraction whose spectrum contains the unit circle has a nontrivial invariant subspace.

In the field of geometry of Banach spaces a series of questions concerning the existence of equivalent norms remain open. Also, there is an open question to find an inner geometrical characterization for various classes of Banach spaces. Various results are known for separable Banach spaces, but for non-separable Banach spaces. The analogous results are not known. These questions are particularly interesting for weakly compactly generated spaces and related classes of Banach spaces.

In the field of function theory and its interplay with operator theory, many results are known for basic classical domains, like the disk, polydisk or the Euclidean ball. It is interesting to study similar questions for operators in other symmetrical domains.

6. Department of Mathematical Logic, Numerical Algebra, and Graph Theory

In the foundation of mathematics (especially in set theory), Czech mathematics has belonged to the distinguished centers of progress since the sixties. The subject of the foundation of mathematics changed successively in the whole world from the set theory to the investigation of weak arithmetic and to the estimation of complexity of proofs. During this change Czech mathematics did not loose contact with the important centers of the world and results obtained by Czech mathematicians are very appreciated.

The theory of computational complexity originated in the seventies of the last century. In that time the main problems as the well-known problem whether P=PN were formulated. Solution of these problems by combinatorial methods would be possible if one could find exponential lower bounds on the complexity of Boolean circuits. After initial success (monotonic circuits, circuit with bounded depth), stagnation came. Thus the following investigation is concentrated on the following two directions:

1. Investigation of the use of random generators in algorithms, and the related questions about pseudo-random generators and one-way functions.

2. Investigation of logical aspects of complexity, such as the complexity of propositional proofs and provability in relatively weak theories. This field is now called proof complexity. The main source in this field is Krajíček's monograph [X6-1].

There was great progress during last ten years in both areas. Our group, with respect to the tradition of mathematical logic, successfully joined mainly in the second direction and essentially contributed to its development. The main results in this area concern exponential lower bounds on the complexity of proofs in different proof systems.

7. Department of Didactics of Mathematics

The aims of our research correspond to the main directions of the didactical research carried out in distinguished didactical centers. We succeeded in detecting and following the main streams in research in mathematics education aimed at the problem of (a) representations, (b) students' problem posing.
Our results have also been positively evaluated abroad (see C4).

8. Branch in Brno

The investigation of existence of geometric structures on differentiable manifolds is a classical topic of algebraic topology. The problems of this kind are very difficult and, taking a sceptical view, we can say that only few results are available. (Satisfactory results are available either on low dimensional manifolds or without dimension restriction only for some particular structures. We are able to decide whether on a manifold there is a nowhere vanishing vector field, but when looking for 5 linearly independent fields we do not find a satisfactory answer.) From this point of view new results are always desirable.

The investigation of the qualitative properties of solutions of functional differential equations is exceedingly complicated in view of the nonlocal character of these equations. For this reason, it is difficult to apply to such equations the calculus techniques typical for the ordinary differential equations. Although the fundamentals of the theory of functional differential equations were developed in the 1970's, a deeper knowledge of the qualitative properties of solutions (in particular, efficient conditions guaranteeing the existence and uniqueness of a solution possessing given properties) is still desirable. It is not surprising that, in the well-known large monographs of J. Hale [X8-6], V. B. Kolmanovskii and A. D. Myshkis [X8-9], and N. V. Azbelev et al. [X8-2], one cannot find any detailed information on the solvability of initial value and boundary value problems.

Recently, the Brno research team has developed new techniques for the investigation of functional differential equations which made possible to obtain a number of sharp results for boundary value problems for the scalar first and second order functional differential equations and for general boundary problems for some classes of systems of functional differential equations. The nonnegativeness (nonpositiveness) of solutions and the well-posedness of the general boundary value problems for functional differential equations were also studied. In particular, the well-known Kamke type results on the nonnegativeness of solutions, and the Kurzweil-Vorel and Opial theorems on the well-posedness were generalized for functional differential equations. Functional differential equations on unbounded intervals were also studied.

Geometry has always devoted a lot of attention to the study of bilinear forms on differentiable manifolds. These forms have been either symmetric (Riemannian and pseudo-Riemannian geometry) or antisymmetric (symplectic geometry). Only in the last years systematic geometrical investigations of forms of higher degrees appear. Naturally, in the first place we meet the trilinear forms. The limitation to these forms is also influenced by the level of knowledge of these forms from the point of view of algebra. (The information about biquadratic forms is by far not so good as the information about the trilinear forms.) Then, from the point of view of differential geometry and physical applications, the antisymmetric trilinear forms (3-forms) became a subject of interest. They are in the center of interest only in the last decade. N. Hitchin (Oxford) studies systematically stable regular 3-forms on manifolds of dimension 7 (see [X8-7], [X8-8]). T. Friedrich (Berlin), S. Ivanov (Sofia) et al. study 3-forms related to metric connections with antisymmetric torsion (see [X8-1], [X8-4] [X8-5]). (We could say these are geometric applications of 3-forms.) J. E. Marsden (U.S.A.) is interested in applications of the forms of higher degree to the calculus of variations and to mechanics (see [X8-10], [X8-11]). (This is the question of generalization of the symplectic formalism to the multisymplectic one.) J. Bureš and J. Vanžura [8-021] described the structure of all regular 3-forms on manifolds of dimension 7. Generally, we can say that the investigation of geometry and topology of 3-forms is very promising and the variety of structures described by 3-forms is substantially larger than the variety of structures described by 2-forms (i. e. symplectic structures).

C3. Relationship between the proposed IRP and the current research focus of the applicant/institution and its impact on the long-term perspective of research and development of the applicant/institution

The subject of the institutional research plan represents, at the same time, the principal orientation of research activities of the Mathematical Institute.

In general, the research plan will contribute to improvement of the level of cognition in mathematics and raise of education level, in particular also to the application of mathematical knowledge in practice. This is a branch of scientific activities that contributes significantly to the enrichment of Czech as well as world's both scientific and cultural legacy.

The subject of the institutional research plan will also contribute to the long-term perspective of research development in the Mathematical Institute. Mathematical knowledge is built up gradually, its foundations were laid out in ancient history, and its future development will undoubtedly be influenced by the results obtained in the work on the research plan.

Research orientation of the applicant fully conforms the subject of the research plan as is proved in part C1 of the proposal. The research plan also exactly follows the long-term perspective of research and development of the applicant, i.e., according to part B, the complex development of theoretical knowledge in all mathematical disciplines and its applications.

9. Department of Real and Probabilistic Analysis

In the period 1999-2003, the Department of Real and Probabilistic Analysis solved problems from the theory of integration, ordinary and generalized differential equations, stochastic analysis, stochastic geometry, and mathematical statistics. All these research fields belong to the institutional research plan of the Mathematical Institute. The permanent relevance of these fields in the context of the world progress in mathematics is obvious, the team of the department has been up to now very successful and its members are well respected. The assumption is that also in the next period the research will continue in the same lines. Possible changes in the aims can be caused by unpredictable changes of the actual state of the discipline in the world context or may be related to the age constitution of the team. Due to the death of Z. Šidák the research in the classical mathematical statistics is not supposed to continue. However, the co-operation with the applied research based on the methods of mathematical statistics or stochastic analysis or stochastic geometry is supposed to continue. Apparently, it can be expected the research in stochastic analysis will gain more attention. The personal situation in this field seems to be optimal: in addition to B. Maslowski and J. Seidler, who are matured and well-respected specialists, new young gifted members (M. Ondreját, M. Vyoral) are involved. As concerns the theory of integration, the main attention will be paid to the integration in abstract spaces. In this connection a long-time or even permanent stay of prof. Ye Guoju (University of Lanzhou, China) is desirable. For the research in ordinary differential equations, the main subjects will be singular and/or impulsive boundary value problems and generalized differential equations. Successful co-operation with the Faculty of Sciences of Palacký University in Olomouc is supposed to continue. This year, a gifted mathematician oriented to this subject started his graduate study in the frame of this co-operation. An increasing attention should be paid to the education of young gifted mathematicians or perspective matured specialists from abroad (e.g. from Ukraine or China) interested in the subjects studied in the department.

10. Department of Evolution Differential Equations

It is to be expected that the theory of evolution differential equations will remain an active research discipline in the period 2005-10 on both the national and the international level. The development of computers and computer science has opened the way to industrial applications for numerical as well as analytical methods of solving complicated spatially structured evolutionary systems. Both institutional and financial support from public sources independent of the education system (mainly within the Academy of Sciences) for research teams working on the interface between theory and application can further be expected, since their specialization usually exceeds university teaching standards, and Czech private industrial investments could hardly make efficient use of their full research capacity. For the research group Evolution Differential Equations, this means in particular to pursue its research activities in the direction of the highest competence of their members, that is, qualitative theory of complicated dynamical models in physics and other applied sciences, with objectives motivated mainly by technical problems in continuum mechanics and thermodynamics. Growing attention will certainly be paid to the cooperation with applied research institutions and to the education of new gifted young researchers.

11. Department of Qualitative Methods of Mathematical Analysis

The research plan is a continuation and a further development of the work having been carried out in the Mathematical Institute. The problems studied are an important part of mathematical analysis, especially important from the point of view of the theory of partial differential equations, integral operators, function spaces, weighted inequalities, real interpolation, and extrapolation. We shall make use of methods developed mostly in the last decade, with significant contributions of our researchers. They have published many important results from these areas in highly recognized mathematical journals (see the list of literature).

At present, researchers in the Mathematical Institute (in collaboration with L. Recke from Berlin) have proved smoothness of bifurcation branches for variational inequalities. It concerns special cases and a complete abstract theory with applications should be established in the framework of the research plan.

The theory of weighted inequalities has a long year tradition in the Mathematical Institute and its researchers have gained international reputation. We intend to continue our work in these areas (see part C5). We shall also pay attention to applications of results obtained.

The same can be stated about the integral equations method and its applications to solutions of boundary value problems. In this area, D. Medková continues the work of J. Král.

12. Department of Constructive Methods of Mathematical Analysis

All the fields of research characterized in Chapter B3 blend with the Institute's research orientation. Apart of other things, it includes theoretical and practical aspects of mathematical and computer modeling. In detail, a theoretical analysis of a model, an approximation of a model, a numerical method, computational mathematics, computer code, and numerical experiments.

The proposed research project is based on the Institute's long-term R&D prospect, which continues in theoretical and practical aspects of mathematical modeling. The members of the department have successfully specialized in certain fields and also acquired internationally recognized results.

The research will concentrate on the finite element method with the accent on the maximum principle and on computationally advantageous partitions of domains; on a posteriori error estimation of errors arising in approximate solutions of differential equations, and on adaptive methods for solving differential equations; on the formulation and analysis of methods for solving problems with uncertain data; on computer modeling of preparation and surface modification of semiconductors inclusive of phase changes; on the study of spacetimes models used in general theory of relativity; and on further investigation of selected topics in number theory.

13. Department of Topology and Functional Analysis

The proposed circles of questions of the research project are closely related to the scientific orientation of the members of the department. Number of publication in top international journals and several monographs that have been published in recent years prove their high experience in the field.

Let us mention, for example, results concerning equivalent renormations of Banach spaces, spectral theory of operators, the classification of non-separable Banach spaces, theory of strongly homotopic algebras or theory of symmetrical domains in C^n.

14. Department of Mathematical Logic, Numerical Algebra, and Graph Theory

The subject of mathematical logic and computer science included in this proposal is a continuation of a traditional scientific activity of the Mathematical Institute. This subject is very perspective from the point of view of future development of mathematics and thus it is quite necessary to consider this area quite seriously.

15. Department of Didactics of Mathematics

The scientific aim in the field of mathematics education follows and deepens research done so far. It is oriented to areas studied previously (the development of cognitive abilities and concept creation processes, such as those of fractions; problem posing and problem solving; different modes of representation; research methodology), and to further areas of investigation, which stemmed from results of our research (the relationship of theory and practice in mathematics education; possibilities of using team reflection).

16. Branch in Brno

Discrete-event systems are dynamic systems where the state changes only when an event takes place. Their dynamics is not usually described by systems of difference (or differential) equations, but using discrete models as finite automata, Petri nets and various extensions. This type of systems can be frequently encountered in technological systems (telecommunications, computer networks, manufacturing systems, etc.). In the next period, control theory of weighted and timed automata will be studied.

The investigation of the antisymmetric 3-linear forms is at its very beginning and seems to be very promising. These forms can be considered as an extension of symplectic forms. The extent, depth and the contemporary intensity of development of the symplectic geometry are well known. At the same time it is obvious that the theory of the antisymmetric 3-linear forms will be even more extensive. Naturally, analogies with the symplectic geometry appeared, but first of all we find here phenomena not known from the symplectic geometry. Results of the study of 3-forms were so far applied to theoretical mechanics and theory of partial differential equations (e. g., the Monge-Ampère equation) (see [X8-3], [X8-10], [X8-11]).

C4. The applicant's/institution's role or significance in the overall research effort going on within the field of IRP on both the national and international scales

The applicant pursues the subject of the research plan in the national as well as international context. Both the monographs, and journal and proceedings papers that appeared in the recent period and whose authors or coauthors are members of the Institute significantly contributed to further development of the subject of the institutional research plan.

17. Department of Real and Probabilistic Analysis

The contribution of the Department of Real and Probabilistic Analysis are focused mainly on the generalized sum integration, generalized differential equations, boundary value problems, stochastic analysis, and stochastic geometry. The most important results achieved in the period 1999-2003 were described in Part B3.

As concerns the generalized sum integration, the Mathematical Institute has the world priority due to J. Kurzweil and his paper [X1-22] mentioned in Part C2. Nowadays, integrals of the type introduced in that paper are generally called the Henstock-Kurzweil (HK) integrals (R. Henstock rediscovered an equivalent notion in 1960.) Kurzweil integration theory turned out to be a powerful tool for investigating differential and integral equations. In [X1-22], certain difficult convergence effects in ordinary differential equations were explained. Further, in the seventies, a complete theory of generalized differential and integro-differential equations was established by Schwabik, Tvrdý, and Vejvoda, see [X1-40] (see also [X1-39]). The first stage of the theory of the HK-integral was resumed by Kurzweil in [X1-23] and [KX1-24]. Further, in the eighties, Jarník, Schwabik, and Kurzweil introduced the PU-integral (based on the concept of "partition of unity") for which they succeeded to formulate and prove the Stokes theorem also for fields with singularities. A general principle of the interchange of limit and integral based on the equi-integrability was included in [X1-24]. In connection with the convergence principle, a question arises whether the natural integral of step functions can be extended to the integral of more complicated functions when integrating over more dimensional intervals. Jarník and Kurzweil presented some answers during the period 1997-1999. Related problems of the topological structure of the spaces of primitives with respect to various HK-integrations are the subject of the monographs [1-002] and [1-003]. Recently, the interest in the integration of Banach space valued functions increased. In particular, Schwabik and Ye Guoju introduced new notions of the strong and weak McShane integrals (this integral belongs to the family of HK-integrals and in the finite-dimensional case is equivalent to the Lebesgue integral) and presented their comparison to the Bochner and Pettis integration, see [1-057]-[1-059].

Using the upper/lower functions method, in the papers [1-042], [1-043], [1-047] and [1-048], Rachůnková, Tvrdý, and Vrkoč proved the existence of nonnegative solutions to certain boundary value problems, including hitherto unsolved problems with weak repulsive singularities and the case when the first eigenvalue of the related Dirichlet problem is touched. The same authors extended the method of upper-lower functions also to the impulsive problems, weakened usual monotonicity assumptions, and obtained first partial results for the non-ordered case, see [1-045] and [1-046].

Important results on the ergodicity of solutions of various types of stochastic partial differential equations (including the Navier-Stokes one) have been obtained by Maslowski and Manthey ([X1-27], [1-029]), Flandoli and Maslowski [X1-8], Seidler [X1-38], Maslowski and Seidler [1-032], Goldys and Maslowski [1-021]. Results on qualitative properties of paths of stochastic evolution equations including regularity and Lyapunov stability have been obtained by Seidler [X1-37], Dozzi and Maslowski [1-014], and Ondreját [X1-32]. Particular attention is now paid to the stochastic partial differential equations driven by fractional Brownian motion where the Mathematical Institute has a remarkable priority thanks to the papers [1-016] and [1-030].

I. Saxl with co-authors thoroughly studied the properties of randomly simulated spatial Voronoi tessellations, see, e.g., [X1-35], [X1-36], [1-040], [1-097]. It is worth mentioning that the tessellations generated by Bernoulli cluster fields, developed and studied in [1-039], have important applications, e.g., in theory of materials.

18. Department of Evolution Differential Equations

Members of the research group Evolution Differential Equations published during the period under consideration substantial contributions in several research areas. The most significant ones (represented mainly by items [2-012], [2-035], and [2-079] in the reference list) consist in giving a new characterization of the global long-time behavior of solutions to the equations of motion of compressible fluid. The one-dimensional system describing the expansion of a strongly nonlinear gas was solved in [2-073]. The important work [2-040] on methods of solving evolution equations with a non-convex potential becomes a starting point for further research in this direction. The paper [2-055] solves the reliability problem in a model for oscillations of an elastoplastic beam under uncertain data. The analysis is based on the worst scenario principle.

19. Department of Qualitative Methods of Mathematical Analysis

The established results represent a significant contribution in international scale (which can be supported by a series of publications in recognized international journals). Some of them bring brand new methods and approach to unsolved problems.

The publication [X3-5] is the first paper on conical differentiability of systems controlled by a unilateral parabolic problem on an infinite time interval (works published up to now deal only with contact elliptic problems).

A new problem area has been opened concerning stabilization and destabilization influence of non-standard boundary conditions on bifurcations in reaction-diffusion systems (see [3-023]). In particular, more detailed information about bifurcations of spatial patterns (i.e. of stationary solutions which are non-homogeneous in the space) have been obtained. For a certain class of variational inequalities with parameter, the smooth dependence of the solution on parameter has been proved (see [3-024]) as well as the existence of smooth branches of simple eigenvalues and the existence of smooth branches of non-trivial solutions bifurcating from eigenvalues of a linearized inequality satisfying a certain condition of simplicity (see [3-025]). The result has been applied to a unilaterally supported beam compressed by axial force, to non-linear elliptic equations, and their systems with unilateral integral conditions.

20. Department of Constructive Methods of Mathematical Analysis

The finite element method has developed into an enormously extensive subject, which is investigated in virtually all developed countries inclusive of the Czech Republic. The "Czech School" has gained greater international recognition than one would infer from the relatively small number of the scientists in this field. The Institute contributed two monographs in the nineties, monograph [4-004], and tens of papers in prestigious foreign scientific journals.

Many groups abroad investigate a posteriori estimates, especially in the USA. Theoretical works are rather rare in the Czech Republic. The monograph [4-004] published abroad and the papers [4-084], [4-085], [4-088] indicate results recognized in the national as well as international context.

Various problems with uncertain data have been solved in foreign and, to a small extent, in domestic institutions mostly by engineering methods based on computational power. (In medicine, specifically, the examination of the impact of uncertain data is often reduced to statistical and probabilistic analysis, and other aspects are neglected). Both the analysis of the impact of uncertain input data on the solution of differential equations or inequalities, and the mathematical rigor of the analysis within the framework of the worst scenario method are unique on the national level. Not even abroad a parallel is known.

The modeling of phase changes, as done in our institute, is unique in the national context. However, it cannot manage without cooperation with experimentally oriented institutions (in particular, the Institute of Physics AS CR and the Institute of Physics of Charles University up to now).

Two topics should be distinguished in the international context.

(i) Models of the Bridgman growth, i.e. the growth of the crystal from the melt, are the subject of interest in Germany and the U.S.A. The Czech laminar model tries to compete with the laminar model developed at the university in Freiburg, Germany. The Czech model of turbulence in the process of crystal growth seems to be unique at this moment and it brings a brand-new view of the problem.

(ii) The models of laser irradiation employ the theoretical results from physics obtained in the U.S.A. above all, the modeling in the style used here is done rather scarcely elsewhere again. The Czech models and their possible exploitation are the subject of international interest (Germany, Belarus).

In the Czech Republic, selected parts of relativistic physics are pursued by an internationally renowned group at Charles University. Two young researchers from the department collaborate with this group but also carry on their own research. The number of their publications as well as the fact that they were invited to collaborate with Canadian mathematicians indicate high quality of their results.

Number theory is a matter of individuals not only in the Czech Republic but also abroad. A successful cooperation with foreign scholars (USA, Mexico) lasts several years and resulted in [4-002] and other works. It indicates that the Institute has acquired internationally recognized results.

21. Department of Topology and Functional Analysis

Many of results obtained in the department are of top international quality and form borders of present knowledge. Such results are for example, the characterization of Banach spaces with equivalent uniformly Gateaux norm, the existence of invariant subspaces for polynomially bounded operators, or the theory of strongly homotopic algebras. These and other results were described in detail in part B3.

22. Department of Mathematical Logic, Numerical Algebra, and Graph Theory

In the foundations of mathematics (especially in the set theory) Czech mathematics has belonged to the distinguished centers of progress since the sixties. The subject of the foundamentals of mathematics changed successively in the whole world from the set theory to the investigation of weak arithmetic and to the estimation of complexity of proofs. During this change, Czech mathematics did not loose contact with the most important centers of the world and results obtained by Czech mathematicians are very appreciated.

We obtained new results in the area of approximation algorithms for scheduling and “load balancing” [X6-040], [X6-042], [X6-010], [X6-011].

The following two results apply techniques on the borderline of online algorithms and communication complexity: the first application is to cryptography, the second one to the cake-cuttings, which is a widely studied area of concrete complexity.

An improvement of the important result of extreme combinatoric, the Frankl-Rödl theorem concerning set systems with prohibited intersections.

New results concerning the complexity of resolution, its connection with bounded arithmetic, and connection between provability of weak Pigeonhole Principle and the cryptographic hypotheses have been proved [X6-029].

New results concerning non-conservativity in bounded arithmetic were proved [X6-022].

We succeeded to find a new characterization of structures with Schanuel's dimension or with abstract Euler's characteristic using combinatorial properties of definable sets [X6-031].

We found new reductions between disjoint pairs of NP-sets and connections with propositional proof systems [6-033].

23. Department of Didactics of Mathematics

The orientation of our research is beneficial not only for the Czech Republic but also from the international point of view. It can be seen best from numerous invitations to give lectures at international conferences and at universities in both the Czech Republic and abroad, and from requests for the publication of our results in journals and monographs [7-010], [7-027], [7-001], [7-032].

24. Branch in Brno

In the qualitative investigation of solutions of ordinary and functional differential equations, a number of powerful results have been obtained which gained the world recognition. In particular, the theory of oscillation for linear and half-linear second order equations was, in a sense, completed. A general theory of boundary value problems for functional differential equations and their systems was constructed, in which framework the most general, in a natural sense, versions of the classical statements were obtained and new results were got for concrete cases. In studies of two-point boundary value problems for singular second order differential equations, rather sophisticated results were obtained. A detailed study of the scalar functional differential equation with a two-point boundary condition was carried out.

In the field of control theory of discrete-event systems interesting results have been achieved for systems modeled by Petri nets [8-039] and some conference publications) as well as for systems modeled by finite automata [8-070] where some other results have been submitted for publication in control theory journals.

In the process of investigation of 3-forms on differentiable manifolds of dimensions 6 and 7, results were obtained providing us with basic geometrical information about all types of forms appearing in these dimensions. In dimension 6 connections with classical geometrical structures were discovered which have very substantially contributed to the understanding of 3-forms on manifolds of this dimension. The results are partially published, some of them will appear. They were presented at several international conferences where they aroused quite a lot of interest. Consequently we were able to establish international cooperation (Berlin, Wroclaw).

C5. Objectives of IRP

Particular aims of the institutional research plan in the individual research fields are characterized in the following text. In general, the principal goal is to develop theoretical knowledge in the key branches of mathematics and to apply these results in practice.

25. Department of Real and Probabilistic Analysis

The priorities of the Department of Real and Probabilistic Analysis in the future will be the following: (a) theories of generalized sum integrations, (b) boundary value problems, (c) stochastic evolution equations, and (d) stochastic geometry. The primary general aim consists in the effort of the group to continue the research in the direction described above (see B3 and C2) since it has the priority and a considerable experience in the given domain. The particular aims are the following:

(a) Generalized sum integration:
To concentrate on the problem "*For which integration bases the set of step functions is sequentially dense in the set of integrable functions*?"

To find the relations between the convergence theorems based on the concept of equi-integrability for the McShane integral and the known convergence theorems for the Lebesgue integral.

To study the properties of generalized summation integrals of the Henstock-Kurzweil and McShane types with respect to the integration of functions with values in a Banach space and compare them with the known integrals (Bochner, Pettis, Dunford, etc.). A book devoted to Banach space integration will be one of the outputs.

To establish new foundations for the generalized differential equations with respect to new foundations of the theory of integration. To investigate systematically evolution problems in the space of regulated functions.

(b) Boundary value problems:
To focus on the existence and properties of solutions to nonlinear boundary value problems with singularities and/or with impulses. In particular, to prove existence results for impulsive problems having lower and upper functions which need not be well ordered.

(c) Stochastic evolution equations:
To study the basic qualitative properties of stochastic evolution equations, including equations in 2-smooth Banach spaces.

To study asymptotic behavior of solutions to stochastic evolution equations by means of the theory of Markov processes with special attention paid to stochastic partial differential equations. Priority will be given to the investigation of non-autonomous systems and to well physically motivated equations.

To study problems of stochastic optimal control for infinite dimensional equations, in particular, for stochastic partial differential equations and their relation to semilinear parabolic equations on Hilbert and Banach spaces.

To investigate equations where the random perturbation is instead of the Wiener process modeled by the Poisson random measure, Levy process or fractional Brownian motion. The emphasis will be put on large time behavior and development of new methods in cases when the solutions are not Markovian.

To study the existence and uniqueness of solutions of stochastic hyperbolic equations and their stability.

(d) Stochastic geometry:
New highly anisotropic models will be included into the existing Internet database of spatial Voronoi tessellations. Simultaneously, the estimation of the properties of such original tessellations from their induced tessellations will be considered. An analogous database of planar tessellations will be built up. Furthermore, the classification of point processes based on the characteristics of Voronoi tessellations (polygonal and polyhedral method of point pattern recognition) will be further examined. Applications can be expected, e.g., in metallography, ecology, economic spatial competition, and servicing.

26. Department of Evolution Differential Equations

Science in its complexity is very variable. New research directions arise more and more often. Some fashionable trends are exhausted very soon, some other give rise to an important compact theory. It makes little sense to try to fix rigid long-term research objectives in such a flexible discipline as applied mathematics. The research group Evolution Differential Equations is, nevertheless, personally and professionally stabilized, its members are able to react in an adequate way to the changing situation in science as well as to demands of cooperating applied research institutions, and solve new problems within their competence domain. For the next period, emphasis will be put on a more detailed investigation of the solvability of equations describing collisions of moving rigid bodies in fluid and equations for phase transitions in materials with non-local particle interaction, modelling of microstructures occurring in oscillating systems with a non-convex energy functional, and development of models for discontinuous processes and systems with one-sided constraints with applications, e.g., to mechanics of elastoplastic materials exhibiting fatigue.

27. Department of Qualitative Methods of Mathematical Analysis

Continuation of the study of weighted inequalities for ρ-quasiconcave integral operators with the help of the discretization and anti-discretization method. Applications of results in the interpolation and function spaces theory. To continue study of the optimality of imbeddings of function spaces.

Further development of extrapolation methods aimed at establishing a theory of more complicated spaces from basic spaces. Further development of the theory of differentiable vector-valued functions feedbacked by needs of applications – especially spaces with dominating mixed derivatives on domains.

Continuation of collaboration with mathematicians working in the elasticity theory.

We shall continue studying non-standard applications of the implicit functions theorem to variational inequalities. The objective is a general theory applicable in situations when the classical methods fail. We shall tackle applications to partial differential equations with unilateral boundary conditions, describing, e.g., unilateral membranes or a certain control. In particular, applications to a description of smooth bifurcations of spatial patterns in reaction-diffusion systems connected with biological and ecological models will be dealt with.

Also we intend to further develop the method of integral equations. Especially we shall study properties of solutions of boundary value problems and problems describing cracks.

Continuation of the research for more general (for instance, orthotropic) materials, seeking solutions to contact problems for non-linear plates, problems of the non-uniqueness of solutions, models of a dynamic contact of two deformable bodies (including the slip effect), study of optimization of systems described by variational problems.

28. Department of Constructive Methods of Mathematical Analysis

The maximum principle is an important feature of solutions to elliptic and parabolic differential equations and so it should be preserved by a numerical solution too. We aspire to generalize the discrete maximum principle to simplicial elements in the *n*-dimensional space.

We will strive after new error indicators and error estimators usable in solving nonlinear parabolic differential equations with various sorts of nonlinearity. The next goal comprises the design and analysis of efficient adaptive method for time-dependent problems with two spatial variables.

Several subjects will be pursued in problems with uncertain input data:

(a) Further elaboration of the worst scenario method combined with fuzzy set theory; especially fuzzy sets of parameters of differential equations will be considered.

(b) The behavior of models with uncertain data in geophysics: ground water flow and mechanical stress in rocks (in cooperation with the Department of Mechatronics, Technical University in Liberec, and the Institute of Geonics, Academy of Sciences, Ostrava).

(c) Appraisal of the impact of uncertainties in certain medical diagnostic methods. It is a continuation of an informal cooperation with the Institute of Clinical Biochemistry (1st Faculty of Medicine, Charles University, Prague) in the reliability analysis of pancreas oriented ^{13}C -breath tests.

(d) The analysis of nonlinear parabolic problems with uncertain input data. A continuation of the preceding research focused on linear parabolic problems [4-034].

In mathematical modeling of phase change processes, we intend to concentrate on:

(1) The development of conservative schemes for solving moving boundary problems that would be based on the method of lines and would exploit the existing mathematical software for solving initial-value problems for systems of ordinary differential equations.

(2) A theoretical analysis of numerical methods for solving moving boundary problems based on the combination of Rothe's method of lines and the method of the transfer of boundary conditions.

(3) The development of new algorithms based on the methods from (2) and intended for new areas of application, e.g., problems with the kinetic conditions at the moving interface, problems with multiple moving boundaries.

Moreover, we intend to study the models of heat and mass transfer in porous materials (in cooperation with the Faculty of Civil Engineering, CTU Prague). We also assume cooperation with (i) Institute of Electronics, National Academy of Sciences of Belarus, and Hahn-Meitner-Institut Berlin in the field of the computational modeling of changes in semiconductor surfaces due to pulsed laser irradiation; (ii) Institute of Physics, Charles University Prague, in the field of the development and application of a method of complex mapping of CdTe and CdZnTe crystals grown from the melt – the evaluation of real growth conditions enabled by correlating the model and the technological experiment will enable fabrication of crystals with pre-defined physical conditions (important for the production of infrared detectors, gamma detectors etc.).

Together with Canadian mathematicians, we will work on a generalization of the theorem on four-dimensional Lorentzian manifolds with vanishing curvature invariants to all dimensions. For this purpose, it will be necessary to generalize known results and methods (e.g. Newman-Penrose formalism, Petrov classification etc.), which are currently used in four-dimensional calculations, to an arbitrary dimension.

The investigation of Fermat numbers will continue. Attention will also be paid to Sophie Germain primes.

29. Department of Topology and Functional Analysis

Consequences of the theory of strongly homotopic algebras for transfers of algebraic structures, especially with respect to applications to mathematical physics, will be studied.

A related problem is the construction of a cofibrant operad based on the cellular decomposition of compactification of the configuration space of fermions in the plane. This construction will be connected with one of the oldest problems of topology – characterization of the homotopic type of spaces.

In general topology the research will be concentrated on the theory of selections and of hyperspaces. For example, the characterization of spaces having a continuous selector will be studied. Another circle of problems is the behavior of graphs of continuous functions in the Vietoris topology. A number of problems are motivated by relations between general topology and functional analysis.

In function theory and its applications to operator theory, the research will be concentrated on the following circles of questions:

Investigation of the theory of functions and operators on bounded symmetric domains, especially generalizations of Bloch, Q_p, etc. spaces, descriptions of holomorphic retractions onto boundary domains, properties of eigenvalues of invariant differential operators and their connection with representations of Lie group.

Investigation of operator models on the spaces of analytic functions, generalization of Arveson's curvature.

Investigation of the Bergman kernel of spaces of non-holomorphic functions (for example harmonic, caloric, etc.) and the Sobolev analogues of these spaces, connections of these objects with differential geometry, and their applications in quantification.

Study of various "canonical" classes of operators on function spaces, e.g., Toeplitz, Hankel, or symbolic calculi of Arazy and Upmeier. Further, the questions concerning the existence of subspaces of holomorphic functions in various weighted L^∞ spaces and their locally convex generalizations.

The questions concerning the complementarity of the subspace of compact operators and of subspaces of holomorphic functions will be studied.

In operator theory, the attention will be concentrated to questions concerning the invariant subspace/subset problem. These problems can be equivalently formulated by means of the notions of cyclic, supercyclic, and hypercyclic vectors.

The attention will be concentrated on the following circles of questions:

Construction of orbits of operators with given properties and their use for construction of nontrivial invariant subspaces and subsets.

Study of the role of reflexivity of Banach spaces in the invariant subspace/subset problem.

Construction of an invariant closed homogeneous subset for power bounded operators.

The following questions will be also studied.

One of the basic classical open problems is the question whether each complemented subspace of $C[0,1]$ is isomorphic to some $C(K)$ space. There are many deep results and partial solutions in this field but the problem in its generality is still open. An interesting related problem is whether the quotient spaces of $C(K)$, where K is a countable compact, are saturated by c_0.

Another important problem is whether the characterization of reflexive spaces by means of 2-rotundity is true also for non-separable spaces. The problem has a positive solution if the condition of 2-rotundity is replaced by the weak 2-rotundity.

30. Department of Mathematical Logic, Numerical Algebra, and Graph Theory

(1) Mathematical logic. Complexity theory and finite combinatorics
The main subject of our logic group is proof complexity. This is an area of logic that studies questions similar to those in computational complexity theory using the concept of logical calculus instead of the Turing machine. Problems about the relation between complexity classes have their counterparts in problems about the relation of theories and proof systems for propositional logic. Proving separations of theories and exponential lower bounds on the length of propositional proofs seems as difficult as proving separation of complexity classes and proving exponential lower bounds on the size of Boolean circuits.

However, studying the problems from a different angle may bring progress to the whole area of complexity.

The main problems that we want to concentrate on are: conservativity between fragments S^1_2, finding new constructions of models of bounded arithmetic, formalization of randomized computations and cryptographic concepts in bounded arithmetic, and provability of versions of the Pigeonhole Principle in propositional proof systems. In computational complexity we plan to work on lower bounds for the size of algebraic circuits.

In combinatorics we will work on explicit constructions of Ramsey graphs.

(2) Online and approximation algorithms, scheduling algorithms
These topics are a very active area of the theory of algorithms and our group has been quite successful at the international level. The main goal is a design and analysis of online and approximation algorithms for problems including scheduling *k*-server problem, and their variants. Currently we focus on the scheduling with the goal to maximize the number of jobs completed before their deadline.

Despite recent effort of many researches and some partial results (including ours), many basic problems remain open - we hope that we can significantly contribute to their study. In this research, we use standard tools of algorithm design, with focus on randomized algorithms and combinatorial methods.

(3) Matrices and graphs
Mutual relationship between matrix theory and graph theory will be used to obtain results in Laplacian eigenvalue problems for graphs and in combinatorial matrix theory.

31. Department of Didactics of Mathematics

In future, we intend to continue with the study of mutual relationships between processes: “grasping of situation - problem posing - grasping of problem - problem solving” and while doing so, to deepen the study of representations and problem posing. We will extend our research by the study of possibilities of using the ability to pose the problems as (a) the aim and means of mathematics education, and (b) a diagnostic tool that enables us to study the level of knowledge as well as the causes of misunderstandings.

We will summarize the evidence and classification of phenomena enabling us in both research and school practice to determine (a) the level of understanding the concept of fraction, (b) the ability to solve problems, and (c) the causes of mistakes and misunderstanding.

We will connect and enrich the existing areas of our research. One of suitable unifying views seems to be the study of possibilities of investigating the level of students’ knowledge by analysing problems, which the students created and later solved.

Our work on Socrates-Comenius Project will go on until 2004. We will prepare courses for practising teachers both from the Czech Republic and abroad. We intend to go on with the collaboration with our colleagues from Italy and Germany.

We will amplify our analyses of semiotic representations (by comparing various approaches). We will characterize communicative and cognitive processes in the teaching of geometry from the point of view of the choice of a semiotic system of representation.

We intend to elaborate methods for diagnosing the level of understanding of mathematical concepts, which will be applicable both in research and school practice.

32. Branch in Brno

We will continue in the study of the qualitative properties of solutions of ordinary and functional differential equations. More precisely, the following topics will be investigated:

a) various questions from the qualitative theory of boundary value problems for ordinary and functional differential equations and their systems,

b) asymptotic properties of solutions of ordinary and functional differential equations, namely, boundedness, oscillatory behavior, monotonicity, etc.,

c) boundary value problems and the asymptotic theory of differential equations in the Banach space,

d) asymptotic theory of higher order ordinary differential equations including the half-linear equations,

e) singular boundary value problems for ordinary and functional differential equations and their systems.

The research methods will use our techniques developed earlier. The techniques will be modified and extended in order to cover new cases.

In the field of differential geometry, we shall continue the research of antisymmetric 3-linear forms. The largest number of results is available in dimension 6. Here we shall try to classify 6-dimensional manifolds on which 3-forms of a given type exist. In dimension 7 it will be necessary to find further information about the geometry of G-structures associated with particular types of 3-forms. The research in dimension 8 will start practically from the beginning, because only very little is known here. The investigation of the associated G-structures will have to be performed with the help of computers. (Every basic calculation requires here already three days of work if we compute by hand. Moreover, the risk of making a mistake is high.) Here the system Mathematica has proved to be very convenient. We also intend to investigate systematically the spaces (orbits) of 3-forms of each type. Let us mention that starting from dimension 9 the situation changes substantially, and this is the reason why we pay so much attention to dimensions 6, 7, and 8. There will be a parallel research of 3-forms in a general setting (i.e. without restriction to a particular dimension). The goal will be to discover constructions and structures (e.g., Poisson type structures) which are associated with a given 3-form. We intend to cooperate with the group concentrated around T. Friedrich (Berlin), which is interested in metric connections with antisymmetric torsion (i.e., the torsion is a 3-form).

C6. Strategies and methods to be applied to carry out IRP

Strategy and methods of carrying out the institutional research plan consist in standard means of basic research in mathematics.
All research relies on a good access to scientific books and journals. In mathematics, this is an absolutely necessary condition for successful scientific research in general and for solving the Institutional Research Plan in particular.
Therefore, the Mathematical Institute pays maximum attention to, and spends much money for obtaining books and journals for its Center of Scientific Information. This is the biggest public specialized mathematical library in the Czech Republic of the nation-wide range. Beside the paper versions, we also try to get access to the Internet versions to the greatest extent possible.
Present total costs of the regular updating of the Library book and journal funds are 2 to 3 million crowns per year. However, the prices on the international market of scientific publications continually grow.
An integral part of the activities of the Mathematical Institute is editing and publishing mathematical journals. The Institute publishes three international scientific journals that present original mathematical papers. They are: Czechoslovak Mathematical Journal and Mathematica Bohemica (4 issues per year, they are successors of Časopis pro pěstování mathematiky a fysiky established in 1872), and Applications of Mathematics (6 issues per year, established in 1956). The journals mentioned are (subject to some copyright conditions) also available on the Internet.
In the framework of a joint project of the European Mathematical Society and the bibliographic journal Zentralblatt für Mathematik, the Mathematical Institute maintains the Czech editing unit of the journal since 1997. Its aim is to provide reviews of mathematical publications and prepare input text for the Zentralblatt für Mathematik and the MATH database.
National and international contacts are the method of scientific work that enables immediate exchange of information. Therefore, a significant strategy is also the participation at national and international scientific meetings, broad contacts with other mathematical institutions in the Czech Republic as well as abroad, and mutual scientific visits both of the members of the Institute at foreign institutions and of foreign researchers at the Mathematical Institute. The Institute offers to foreign mathematicians two positions for long-term scientific stays (usually for 1 year) every academic year. Short-term stays are the standard method of solving the IRP (see Part B4).
Grant funds are also very significant means to national as well as international contacts (see the list of grant and programme projects).
Very efficient computers are necessary in some branches of mathematical research for verifying and comparison of numerical methods and algorithms that were established as a result of theoretical research.
It is assumed that MS as well as PhD students will be integrated in all the branches of research at the Institute. It is absolutely necessary for the success of the research plan and the development of the Mathematical Institute as a whole that the members of the Institute are tutors of MS diploma works at universities, that they attract students for graduate study at the Institute, and that finished doctorands become members of the Institute. This is the only way to perspectively solve the problem of the average age of the members of the Institute. We believe we have started the progress in this way successfully.
The Institute is deeply concerned with the problem of young scientists and their salary situation. The PhD students mentored at the Institute who have outstanding study and in particular scientific results are offered a part-time job. This way initiates their closer contact

with the Institute that can finish as a standard job of a young scientist at the Institute after completing his/her PhD study. Another way of improving salary situation of top young researches is the Otto Wichterle Premium for Young Scientists of the Academy of Sciences that is connected with a three year financial support of the winner. The Mathematical Institute exploits this opportunity and regularly nominates its young researchers. During 2 years of providing this Premium, 5 members of the Institute have been honored.

C7. Time schedule of IRP

To fix a detailed time schedule of research in mathematics is extremely hard and, as far as new basic research results are concerned, impossible. These pioneering results in mathematics usually cannot be predicted. Applications of the research results obtained can often be scheduled in time. However, mathematical results are usually applied to practice via physical or technical research. Then mathematicians can influence the time schedule only partially. The expected time schedule in the individual branches of mathematical research is briefly outlined in the following.

33. Department of Real and Probabilistic Analysis

The time schedule can be divided into 2 stages. Preliminarily it can be expected that the progress in particular fields will continue as follows.

(a) Generalized sum integration:
The first stage will be devoted to the study of convergence principles and of topological properties of various kinds of sum integrals in finite-dimensional spaces. The first part of monograph on integration in abstract spaces will be prepared. In the second stage, the previous results will be further completed and more attention will be paid to their application to the investigation of the properties of generalized differential equations.

(b) Boundary value problems:
First, basic existence principles for nonlinear impulsive problems will be completed and effective methods for constructing the upper and lower function will be sought. Second, further extensions to singular problems will be considered.

(c) Stochastic analysis:
Throughout the whole period, basic properties of stochastic evolution equations including equations perturbed by fractional Brownian motion will be concerned.
In the first stage, the study of the existence and uniqueness of solutions to stochastic hyperbolic equations and of their stability will be carried out. Attention will be paid to the limit behaviour of some important equations with applications in physics and to optimal control problems governed by stochastic partial differential equations including the Hamilton-Jacobi ones.
In the second stage, the results achieved during the first stage will be generalized to more general equations. In particular, the aim is to consider equations with stochastic perturbation modeled by process, which is not the Wiener one.

(d) Stochastic geometry:
First, theoretical research will continue and the database of planar tessellations will be built up and made openly accessible. Second, anisotropic models will be included into the spatial database.

34. Department of Evolution Differential Equations

The first stage of the research activities will concentrate on the derivation of admissible mathematical contact conditions for bodies in collision in a fluid. This will lead to the possibility to correctly state the problem and prove the well-posedness of the corresponding system of equations of motion. For non-local phase transition models and systems with non-convex potentials, attention will be paid to questions of existence and uniqueness of solutions in appropriate classes of functions. A general framework for a consistent mathematical description of time-discontinuous structural changes will be searched for as an extension of known properties of classical physical models for discontinuous processes. As second step, qualitative properties of the derived systems of equations will be investigated, in particular their stability, long-time behaviour, and characterization of a possible steady state.

35. Department of Qualitative Methods of Mathematical Analysis

In the first phase we shall especially deal with the following problems:
a1) The integral equations method will be used for solutions of boundary value problems on domains with cracks.
a2) Discretization and anti-discretization of weighted norms of ρ-quasiconcave integral operators and characterization of weighted inequalities for these operators in the class of all non-negative measurable functions.
a3) Characterization of optimal imbeddings of function spaces.
a4) Study aimed at obtaining new results of extrapolation properties of basic spaces of integrable functions, whose further objective is an extrapolation description of more general spaces, particularly, of Orlicz spaces.
a5) Studying bounds for the coefficient of friction for more general materials (for instance the orthotropic ones).
a6) Contact problems for non-linear plates, optimization of systems described by variational problems (extending results on the conical differentiability).
a7) Establishing a general theory, employing the implicit functions theorem in a non-standard way for study of bifurcations for variational inequalities.
a8) Study of spaces whose norm contains the difference of the maximal function of the non-increasing rearrangement and the non-increasing rearrangement.

In the second phase we shall concentrate on:
1) Employing the integral equations method for the study of properties of solutions to boundary value problems.
2) Characterization of validity of weighted inequalities for the ρ-concave integral operators on the class of all non-negative and monotone functions.
3) Employing results from a2) and 2) in the interpolation and function spaces theory.
4) Development of spaces of differentiable vector-valued functions on domains feedbacked by current needs in applications (continuation of the collaboration with mathematicians working in the elasticity theory).
5) Questions about the non-uniqueness of solutions to contact problems for non-linear plates and models of dynamic contact of two deformable bodies (including the slip effect).
6) Applications of results from a7) to boundary value problems for partial differential equations with unilateral boundary conditions
7) Weighted inequalities for general maximal functions on metric spaces with measure.

36. Department of Constructive Methods of Mathematical Analysis

Research schedule depends on relations between particular research subjects and already finished phases of the research. In general, theoretical aspects of the suggested problems will be investigated in 2005-2007. Also in this period, the present scientific knowledge will be applied to specific problems. At a later time, acquired knowledge will be incorporated into methods for solving practical problems.

37. Department of Topology and Functional Analysis

The character of the proposed questions does not make it possible to give a precise schedule of their solution. It is possible to expect, however, that new important results will be obtained in great part of the proposed problems. It is also possible that the obtained results will open new circles of questions. However, it is difficult to speculate about it at present.

38. Department of Mathematical Logic, Numerical Algebra, and Graph Theory

In mathematical logic at the beginning we shall concentrate on the problem of connections among different systems of bounded arithmetic (the so called problem of conservativity), connection between Pigeonhole principles and pseudo-random generators. Later we shall deal with questions more connected with foundations, such as statements of consistency and quantum logic.
In complexity theory and combinatoric our first aim is to investigate circuits with linear gate and to construct Ramsey graphs. We also plan to deal with lower bounds on complexity of boolean circuits and to follow new trends in this area.
In graph theory a new definition of a generalized weighted graph is being prepared. The properties of such graphs as well as relationship with Laplacian will be discussed.
In set theory we shall continue in investigation of stationary sets in relation with large cardinals. The current stage into stationary sets is described in some detail in the chapter that was written for the forthcoming Handbook of Set Theory [6-004]. In the theory of Boolean algebras we are going to investigate various properties of complete Boolean algebras related to the theory of forcing. It is investigated long standing open problem of von Neumann and Maharam, on Boolean algebras that carry a measure. We also want to continue in research of nonstandard methods. In the future it would be suitable to formalize and later to study the attempt of dynamic set theory as was informally described during investigation of alternative set theory.

39. Department of Didactics of Mathematics

Experiments (from C5) will be suggested and carried out and studies elaborated during the year.

40. Branch in Brno

Algebraic topology and differential geometry:
First year will be devoted to the geometry of 3-forms in dimension 7.
Second year will be concentrated on the topology of 3-forms in dimension 7 and on the computer processing of 3-forms in dimension 7.
Third and fourth year will be devoted to the differential geometry of 3-forms in dimension 8. We shall also start their topological investigation.
In the fifth and sixth year we shall study the topology of 3-forms and applications of 3-forms.

Control theory of discrete-event systems and hybrid systems:
First two years: decentralized and modular supervisory control of logical automata
Next two years: supervisory control of weighted and timed automata
Last two years: Testing of new control methods in applications and conclusions

C8. Anticipated results of IRP (including their characterization, and estimated time frame of their implementation)

The outputs in basic research and in mathematics in particular are mostly represented by scientific publications, specialized monographs, papers in recognized international journals, contributions to international scientific meetings, and papers in the proceedings of these conferences.

The application of theoretical mathematical results to practice usually cannot be planned, neither in time, nor in the way of application.

There are mathematical results that were applied tens or hundreds of years after their disclosure. For example, the classical theory of numbers is now intensively used in cryptography. Another significant example of such an application of theoretical mathematical results almost one hundred years after the publication in a mathematical scientific journal is the use of the Radon integral transform in computerized tomography. Only the wide development of computer hardware and software made possible the practical application of long time known theoretical results.

We expect that a lot of scientific publications including several monographs will appear during the treatment of the institutional research plan. This concerns all the branches of research that are the subject of the research plan. The standard frame of a mathematical publication, i.e. definition - theorem - proof, will be respected. Most works structured in this way will be complemented with practical examples and an outline of possible applications. The works will stem from the results having been published and will generalize them. On the other hand, it is expected that results qualitatively and completely new in the world scale will also arise.

Algorithms and computer codes will also belong among important results, especially from the point of view of possible applications.

As international contacts are absolutely necessary for the research in mathematics a form of results will be also lectures and talks at international scientific meetings and contributions to their proceedings, and, moreover, invited lectures of the members of the Mathematical Institute at Czech as well as foreign institutions.

An important result will also consist in the education of both MS and PhD students and tutoring their diploma and dissertation theses, and in the preparation of university texts and textbooks.

D Personnel

D1. Key personnel: List of leading researchers, the applicant's/institution's employees, who may substantially and creatively contribute to the fulfilment of research plan objectives, along with their personal data, envisaged major activities and allocated capacity (expressed as a working load in per cent)

Surname	Name	Titles, scientific degree	Year of birth	Principal activity	Working load in %
Balcar	Bohuslav	RNDr., DrSc.	1943	Boolean algebras, topology and functional analysis	100
Eisner	Jan	Mgr., PhD.	1967	Qualitative study of differential equations and variational inequalities	100
Engliš	Miroslav	RNDr., DrSc.	1964	Functional analysis-operator theory	100
Fabian	Marián	Doc. RNDr., DrSc.	1949	Boolean algebras, topology and functional analysis	100
Feireisl	Eduard	RNDr., DrSc.	1957	Evolution equations	100
Gogatishvili	Amiran	PhD.	1961	Function spaces	100
Hájek	Petr	Mgr., DrSc.	1968	Boolean algebras, topology and functional analysis	100
Hakl	Robert	Mgr., PhD.	1973	Ordinary differential and difference equations	100
Chleboun	Jan	RNDr., DrSc.	1960	Finite element analysis of non-linear problems	100
Jarušek	Jiří	RNDr., DrSc.	1951	Qualitative study of differential equations and variational inequalities	100
Jech	Tomáš	Prof., RNDr.	1944	Mathematical logic	100
John	Kamil	RNDr., DrSc.	1942	Boolean algebras, topology and functional analysis	100
Komenda	Jan	Mgr., PhD.	1971	Ordinary differential and difference equations	100
Krajíček	Jan	Doc. RNDr., DrSc.	1960	Mathematical logic	100
Krbec	Miroslav	RNDr., CSc.	1950	Function spaces	100
Krejčí	Pavel	RNDr., CSc.	1954	Evolution equations	100
Křížek	Michal	Prof. RNDr., DrSc.	1952	Finite element analysis of non-linear problems	100
Kučera	Milan	Prof. RNDr., DrSc.	1946	Qualitative study of differential equations and variational inequalities	100
Markl	Martin	RNDr., DrSc.	1960	Algebraic topology, differential geometry, homological algebra	100
Maslowski	Bohdan	RNDr., DrSc.	1957	Theory of stochastic evolution equations	100
Matoušková	Eva	Doc. RNDr., PhD.	1967	Boolean algebras, topology and functional analysis	100
Medková	Dagmar	RNDr., CSc.	1957	Qualitative study of differential equations and variational inequalities	100
Müller	Vladimír	RNDr., DrSc.	1950	Functional analysis-operator theory	100
Nečasová	Šárka	RNDr., CSc.	1965	Evolution equations	100
Ondreját	Martin	Mgr., PhD.	1976	Theory of stochastic evolution equations	100
Opic	Bohumír	RNDr., DrSc.	1948	Function spaces	100
Panák	Martin	Mgr., PhD.	1973	Algebraic topology, differential geometry, homological algebra	100
Pelant	Jan	RNDr., DrSc.	1950	Boolean algebras, topology and functional analysis	100
Petzeltová	Hana	RNDr., CSc.	1945	Evolution equations	100
Pravda	Vojtěch	Mgr., PhD.	1971	Numerical and analytical methods in the theory of relativity and celestial mechanics	100

Surname	Name	Titles, scientific degree	Year of birth	Principal activity	Working load in %
Pravdová	Alena	Mgr., PhD.	1971	Numerical and analytical methods in the theory of relativity and celestial mechanics	100
Přikryl	Petr	Doc. RNDr., CSc.	1942	Efficient approximation schemes to the solution of elliptic and parabolic problems	100
Pudlák	Pavel	RNDr., DrSc.	1952	Mathematical logic	100
Roubíček	Filip	Mgr., PhD.	1974	Didactics of mathematics	100
Řehák	Pavel	Mgr, PhD.	1972	Ordinary differential and difference equations	100
Segeth	Karel	Doc. RNDr., CSc.	1943	Finite element analysis of non-linear problems	100
Seidler	Jan	CSc.	1960	Theory of stochastic evolution equations	100
Sgall	Jiří	Doc. RNDr., DrSc.	1965	Mathematical logic	100
Schwabik	Štefan	Prof.RNDr., DrSc.	1941	Differential equations and integration theory	100
Sochor	Antonín	RNDr., DrSc.	1942	Mathematical logic	100
Straškraba	Ivan	CSc.	1947	Evolution equations	100
Šilhavý	Miroslav	RNDr., DrSc.	1949	Math. methods in continuum mechanics	100
Šremr	Jiří	Ing. PhD.	1976	Ordinary differential and difference equations	100
Tichá	Marie	Mgr., CSc.	1947	Didactics of mathematics	100
Tvrdý	Milan	Doc. RNDr., CSc.	1944	Differential equations and integration theory	100
Vanžura	Jiří	Doc. RNDr., CSc.	1943	Algebraic topology, differential geometry, homological algebra	100

D2. **Staff:** Qualification and professional specialization of additional research team members, along with their major activities and summarized work capacities (in hours per year)

Qualification/ professional group	Number of persons	Major activities	Total capacity
PhD students	10	research work in the frame of doctoral study	6 600
part-time jobs	15	scientific research, consultations	11 440
visiting professor	2	scientific activities	4 400

D3. **Auxiliary personnel:** Estimated working capacity (in hours per year) of supporting personnel providing subsidiary and infrastructure support for IRP

Characteristic of the supporting activity	Working capacity
Library	7920
Computing Center	9 020
Editorial Boards	7 700
Economic Administration	25 410
Secretaries	5500

D4. List of major implemented R&D results related to the subject of IRP achieved by the members of research team, within the period of 1999-2003

1. Reálná a pravděpodobnostní analýza
1. Real and Probabilistic Analysis

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E Facilities, material and technical resources

E1. Description of present facilities, spatial conditions, and material and technical resources in the operating site of applicant/institution that can be used to carry out IRP

The Mathematical Institute is located in the building at 25 Žitná Street, Praha 1, and it has the right of use to this real property. As, despite all its efforts, the Institute is not able to acquire a great number of young scientific workers the space conditions are acceptable. The building certainly needs regular maintenance.
The Brno Branch of the Institute is located in the building of the Institute of Physics of Materials of the Academy of Sciences at 22 Žižkova Street.

E2. Infrastructure, instrumentation and major technical equipment which is necessary to procure in order to realize the research plan objectives

Service departments of the Mathematical Institute take care of good working conditions for the members of the Institute. First, it is necessary to mention the Scientific Information Center that operates also as a public library. This is the biggest specialized mathematical library in the country. It is more and more expensive to buy new volumes of journals (including Internet journals) and new books. At present, the sources of new books are practically only grants of the members of the Institute.
It is still true for most mathematical branches (except for numerical analysis and some further fields) that research in mathematics requires only a pencil and paper. Naturally, it is necessary for each employee of the Institute (not only a scientific member) to have a computer available as a means of communication. This is the reason for gradual and sometimes expensive upgrading the computers, printers, and net servers.

F Financial resources needed to carry out IRP

F1. Breakdown of allowable costs (in thousands of CZK)

Year 2005	Total		Out of which institutional support	
Wages and salaries	B1	25000	B2	25000
Contractual agreements	B3	545	B4	545
Compulsory statutory taxes	B7	8868	B8	8868
Allocation into the Fund of Social and Cultural Needs	B9	507	B10	507
Property acquisition (major equipment)	B11	1305	B12	1305
Depreciation, maintenance and repairs of the property	B13	0	B14	0
Materials, small inventory and consumables	B15	6125	B16	6125
Purchase of services	B17	1700	B18	1700
Travel expenses	B19	3100	B20	3100
International cooperation	B21	400	B22	400
Publication of results and protection of intellectual rights	B23	400	B24	400
Supplementary (overhead) expenses	B25	4650	B26	4650
Total	E15	52600	E16	52600

Year 2006	Total		Out of which institutional support	
Personal expenses	E19	39400	E20	39400
Property acquisition costs	E21	2850	E22	2850
Operational costs	E23	8000	E24	8000
Travel expenses	E25	3150	E26	3150
International cooperation	E27	450	E28	450
Publication of results and intellectual rights protection	E29	400	E30	400
Supplementary (overhead) costs	E31	4650	E32	4650
Total	E33	58900	E34	58900

Year 2007	Total		Out of which institutional support	
Personal expenses	E37	45000	E38	45000
Property acquisition costs	E39	2600	E40	2600
Cost of operation	E41	8500	E42	8500
Travel expenses	E43	3500	E44	3500
Costs of international cooperation	E45	700	E46	700
Costs of the publication of results and rights to the results	E47	600	E48	600
Supplementary (overhead) expenses	E49	5000	E50	5000
Total	E51	65900	E52	65900

Year 2008	Total		Out of which institutional support	
Personal expenses	E55	53000	E56	53000
Property acquisition costs	E57	2660	E58	2660
Cost of operation	E59	8500	E60	8500
Travel expenses	E61	3400	E62	3400
Costs of international cooperation	E63	700	E64	700
Costs of the publication of results and rights to the results	E65	600	E66	600
Supplementary (overhead) expenses	E67	5100	E68	5100
Total	E69	73960	E70	73960

Year 2009	Total		Out of which institutional support	
Personal expenses	E73	61000	E74	61000
Property acquisition costs	E75	2775	E76	2775
Cost of operation	E77	8500	E78	8500
Travel expenses	E79	3400	E80	3400
Costs of international cooperation	E81	600	E82	600
Costs of the publication of results and rights to the results	E83	600	E84	600
Supplementary (overhead) expenses	E85	5200	E86	5200
Total	E87	82075	E88	82075

Year 2010	Total		Out of which institutional support	
Personal expenses	E91	71000	E92	71000
Property acquisition costs	E93	2450	E94	2450
Cost of operation	E95	8600	E96	8600
Travel expenses	E97	3500	E98	3500
Costs of international cooperation	E99	800	E100	800
Costs of the publication of results and rights to the results	E101	600	E102	600
Supplementary (overhead) expenses	E103	5600	E104	5600
Total	E105	92550	E106	92550

F2. Justification of items and allowable expenses, specification of financial resources

Institutional support will be the principal financial resource for the Mathematical Institute. Possible further resources in the form of contributions obtained for individual projects from grant agencies (Grant Agency of the Czech Republic, Grant Agency of the Academy of Sciences, etc.) cannot be planned for long time horizon. The plan of financial support assumes a year-to-year increase of about 12 per cent.

Comments to the individual items planned for 2005

The wages and salaries planned stem from the actual structure of the key personnel contributing to the IRP and their classification in the system of qualiftication degrees and classes. These wages and salaries represent the minimal funds that the Mathematical Institute absolutely necessarily needs to keep its today's top specialists and to attract as many young gifted mathematicians as possible who will be able to continue the trend started.

The proposal of Property acquisition costs is based on the expected needs for maintaining hardware and software in the Mathematical Institute in 2005-2010 and on the assessed state of the equipment the beginning of this period. It statistically considers, moral as well as technical, mortality of the individual components (e.g. active LAN elements), no-breakdown lifetime (servers) and function lifetime (PC's of employees, printers, etc.). The estimated number of the individual devices necessary is based on these facts. The price of the devices is specified according to actual official price lists of possible suppliers. If a particular type of a device is presented it gives only a rough information. In the perspective of several years, it is completely impossible to predict even expected future costs.

The item Materials, small inventory, and consumables contains, in accord with the accounting system prescribed in the Institute, in addition to costs of current material (e.g. paper, toners, storage media, gasoline, long-term small material of physical as well as non-physical nature, etc.), mainly costs of scientific literature that is indispensable for the existence of the Mathematical Institute. It is important to keep in mind that the Library of the Institute is a public library of nation-wide range. The actual costs are almost 3 milion crowns a year and the year-to-year increase of prices is about 15 to 25 per cent. The choice of journals is very restricted now for this reason and any further restriction would expose to danger the sole existence of the Mathematical Institute.

The item Purchased services used in direct connection with the treatment of the IRP includes, in principle, costs of cooperation with other institutions, conference fees, Internet access, purchase and innovation of necessary software, communication services, etc.

The Travel expenses item planned assumes that the range of our foreign presentation (conferences, lecture circles, study stays) will be at the same level as now.

The item International cooperation includes costs of stays of foreign guest, mainly of visiting professors whose participation in the IRP is expected.

We do not expect significant publication costs. The amounts planned represent the costs of obtaining final printed versions, innovation of necessary software that allows Internet communication with authors, costs of mail services, etc.

The planned item Overhead expenses (electricity, gas, water, cleaning, maintenance of movables as well as immovables) is based on the present state and takes permanent (also further expected) increase of prices into account.