CHARLES UNIVERSITY: RESEARCH EVALUATION 2014-2018
SELF-EVALUATION REPORT

UNIT	**Faculty of Mathematics and Physics**

1. MISSION, PROFILE, VISION

The Faculty of Mathematics and Physics is a leading Czech institution both in research and education in the areas of computer science, mathematics, and physics. **Our focus is on supporting excellent research connected with education of talented students**; all graduate students have individual study plans and are strongly encouraged to spend at least a part of their studies at the relevant academic institutions abroad.

Although the Faculty is large, and according to various scientometric evaluations, it produced approximately 25% of all research outputs of Charles University (henceforth **CU**) in 2014-2018, our focus was not on overall coverage of most areas of computer science, mathematics, and physics, but rather on keeping high standards in the areas where the Faculty had already been the leader, and opening new areas of research and education by exploiting connections of the new areas to the ones already strong at the Faculty. This, somewhat conservative, approach was necessitated by the general lack of space in the Faculty premises as well as the lack of substantial financial means for a more extensive development. The situation changed in part in 2017, when CU started the new Primus program supporting young scientists coming or returning from abroad and bringing new topics and ideas to the Faculty. Space limitations, however, remain a major problem; for example, the School of Mathematics had to start renting working space in a nearby office building owned by a private company. Therefore, during all the evaluated period, the Faculty was strongly supporting the construction of a new multipurpose building in the Troja mini-campus (to be finished in 2020), with the total budget of over 10 million euros.

The **School of Computer Science** is the one that faces the toughest competition in the Czech Republic, the main schools competing for students being several Faculties of the Czech Technical University in Prague and of the Masaryk University in Brno. Computer science and information systems at CU ranked 251-300 in the QS World University Rankings by Subject in the evaluated period, i.e., in the *QS World University Rankings by Subject 2019* (henceforth **QS2019**). The two strongest research groups of the School, supported by several ERC grants, dealt with theoretical computer science and discrete mathematics (in fact, their research contributed in part to an even better QS2019 ranking of CU in Mathematics - see below). Four research groups from the School focus on applied computer science: artificial intelligence, machine learning, modeling and formalizing of algorithms, data structures as well as state-of-the-art methods for visual computing. A number of applied computer science projects developed in collaboration with, or as contract work for, companies such as Deutsche Telecom, IBM, and Oracle were running at the School in the evaluated period. There is also a very active group in mathematical linguistics with remarkable applied projects and outreach, such as the LINDAT/CLARIN project contributing to quality translations between Czech and English both in the academic and non-academic circles, and the unique MALACH visual history archive of testimonies of Holocaust survivors, and survivors of other genocides, hosted by the Faculty in collaboration with the Shoah Foundation. Linguistics at CU ranked 101-150 in QS2019.

The **School of Mathematics** consists of several pure and applied mathematics groups and a group of probability and statistics. Both mathematics, and statistics and operational research at CU ranked 151-200 in QS2019. In 2017 the first ERC Consolidator grant was awarded to a member of the School in universal algebra. Prior to that, two ERC.CZ grants had been awarded in analysis and mathematical modeling (these Czech grants were awarded to individuals who had received an A-grade in the second round of an ERC competition, but whose projects were eventually not funded by the ERC). A number of academic staff were involved in activities of projects of excellence in basic research supported by the Grant Agency of the Czech Republic (henceforth **GAČR**). There were also applied projects running in collaboration with, or as contract work for, various companies and centers, notably the ČSOB Bank (financial mathematics) and the FH Cancer Research Center (medical statistics). Since its establishment in mid 2013 as a joint venture of the Faculty and several institutes of the Czech Acad. Sci. , the Nečas Center for Mathematical Modeling aims at serving as a platform coordinating activities of several Czech Republic based teams focusing on theoretical and applied mathematics, notably on continuum mechanics.

The **School of Physics** is the largest School of the Faculty, with the approximate ratio of FTE 3:1:1 to the FTE of the Schools of Computer Science and Mathematics, respectively. The School covers research topics ranging from theoretical physics and astronomy to concrete applied projects, such as a design of thin-film nanocatalysts for on-chip fuel cell technology. Both physics and astronomy, and material sciences ranked 251-300 at CU in QS2019. During that period the School participated actively in several distinguished large international projects, such as the ATLAS project in particle physics at CERN, Switzerland, the Daya Bay neutrino experiment in China, projects at the Material Science Beamline at the Elettra synchrotron in the ICTP Trieste, Italy, the ThALES project at Institut Laue-Langevin in Grenoble, France, et al. Two international patents - one US, and one Japanese - were awarded in 2016 for a new method for preparing oxidation catalysts developed at the Faculty. The School has also been hosting two ERC Starting grants, one on trans-spin nanoarchitectures, and one on accuracy and precision for molecular solids. Yet another ERC Starting grant in astronomy was awarded in the last year of the evaluated period. There were also two centers of excellence in basic research supported by GAČR active in the School (The *Albert Einstein Center for Gravitation and Astrophysics*, and the *AdMat Multidisciplinary Research Center for Advanced Materials* based in the School), as well as two centers funded from the European structural funds via a national operational program supporting excellent research teams: *Center of nanomaterials for advanced applications* and *Physics of martensitic transformations for the functionality enhancement of crystalline materials and nanostructures.*

Most of the research done at the Faculty was unique within the CU, but often done in collaboration with scientists from the Czech Acad. Sci. and other Czech universities, as well as individual collaborators and research teams from various European and American academic institutions. The Faculty had an extraordinary position in and responsibility for educating graduate students in about 25 areas of specialization in computer science, mathematics, and physics, as well as didactics of these subjects. The exceptionality stems from the fact that graduate studies are accredited only at universities, not institutes of the Czech Acad. Sci., as prescribed by the Czech University Law. Thus, even if a supervisor of a graduate student is an employee of an institute of the Czech Acad. Sci., the education of the student must take place under the auspices of the Faculty.

Despite the relatively good standing of CU in the areas mentioned above in the QS2019, CU falls behind by two ranking criteria: **citations per academic staff member, and number of international academic staff members**. The Faculty has therefore taken a number of concrete measures in the evaluated period, and started new programs in order to improve its standing.

To foster excellent research, it provided special support to ERC and H2020 applicants, and regularly granted awards and bonuses to authors of outstanding papers and books. While postdoc

and assistant professor positions gradually became open to applicants from abroad, the Czech University Law and University regulations made it very difficult for foreign applicants to enter the University at higher stages of their careers, i.e. as Associate Professors and Full Professors. Though the Faculty was free to employ applicants at any stage of their careers in researcher positions, these regulations did not allow people at these positions to teach at the University. An amendment of the Czech University Law tried to solve the problem by introducing the post of an Exceptional Professor. Such posts, however, are really exceptional, the nominees can only be appointed with the approval of the Rector and th e Scientific Council of the University.

In order to partially overcome the problem, the Faculty started in 2013 the **Fulbright Distinguished Chair program** jointly with the Fulbright Commission in Prague the aim of which is to support long term stays of distinguished professors at the Faculty. In the evaluated period, four distinguished professors (from Ohio State Univ., Univ. Arizona, Univ. Maryland, and Mississippi State Univ.) introduced new courses and did long-term research at the Faculty. A similar model, financed by European structural funds, was started in 2017 at the Faculty and has since spread across CU; it has provided resources for several positions of Visiting Professors at the Faculty who came primarily from European universities.

Another important change contributing to internationalization of the Faculty was the opening of the (paid) **undergraduate English program of Bachelor studies in Computer Science, and of Master studies in Computer Science and Mathematics** in 2013. From the very beginning, the Faculty kept standards of these programs high, whence numbers of students increased slowly over the evaluated period. The strategy paid back: especially the Computer Science program is now a clear success, both financially, and in quality recognition (e.g., one of the computer science bachelors graduating in 2017 has recently received the Best Foreign Graduate Award from the Czech Ministry of Education).

There were also a number of foreign graduate (PhD) students studying at the Faculty in the evaluated period. These students were enrolled in Czech graduate programs, the point being that there was no tuition fee for the Czech programs, and the tuition of graduate students was always on an individual basis, supervised directly by the thesis advisors; seminars and specialized lectures were mostly taught in English anyway. (A recent measure of the Rector has made graduate studies in English free, which further opens these studies to foreign students.)

In 2017 CU started activities aiming at obtaining the HR Award. The Faculty supported, and took active part in, some of these activities, notably the preparation of a new Competitive Hiring Process Code at CU which will (starting from January 2020) make it possible to bring the hiring standards closer to the standards of good European as well as overseas universities.

Over the evaluated period, the Faculty has implemented a protected electronic voting system for Habilitations that makes a secret distant vote of Habilitation Committees possible. This allows the Dean to name renowned international experts as members of these committees and increase the quality of evaluation of the applicants' research. However, as indicated above, the legal requirements of an *a priori* Habilitation, i.e. obtaining the Czech degrees of an Associate Professor and a Full Professor *a priori*, remain the principal hindrances of direct hiring of mid-career and distinguished professors from abroad at the Faculty.

2. RESEARCH AREAS AND THEIR STANDING

Here we list the research areas pursued at the Faculty following the internal CU classification, and discuss their standing in the evaluated period in more detail using their partitioning into CU fields of research.

Our comparisons are based on the detailed internal **Bibliometric Support for Evaluation of Research at Charles University 2014-2018 (henceforth BS2019)** supplied by the CU Rectorate in November 2019. *However, we do keep in mind several particularities of BS2019, notably the fact that for the CU fields related to more FORD fields, the composition of the top decile journals of the CU field may be affected by different publication practices in the respective FORD fields. Moreover, BS2019 is less precise in the area of Computer Science since it does not take into account publications in proceedings of CORE A* and A conferences that are generally viewed as more valuable than typical journal papers in that area. Similarly, BS2019 was obviously not designed to capture the complex publication practice involving large-scale collaborations (such as those with CERN).*

For the CU research area of Mathematics, we will also make use of the **Pilot Evaluation of Research (henceforth PE2017)** completed under the auspices of the CU International Advisory Board in January 2017. PE2017 consisted of two parts, the *Bibliometric support for a pilot evaluation of R&D performance at Charles University*, and the *Ranking of excellent publications.* The *Ranking* was carried out in all the respective CU Fields of Mathematics by a panel consisting of renowned experts from Dutch, French and German universities; the panel members were selected by the CU International Advisory Board.

More details on research activities in the fields discussed below are available in *CU Major Research Areas* at https://cuni.cz/UKEN-450.html.

CU Research Area: COMPUTER SCIENCE

CU Field: Theoretical Computer Science

Research in this field focused on top-level theoretical computer science and discrete mathematics, with motivation from and impact into several applied areas. The main topics included the traditionally strong research in combinatorics and graph theory, as well as in algorithms and optimization, computational complexity, discrete and computational geometry, knowledge representation, and the more recent topic of hypercubes. The Institute for Theoretical Computer Science, a center of excellence in basic research supported by GAČR, provided an umbrella for various research activities in the field in the evaluated period. It hosted an **ERC Consolidator grant**, investigating lower bounds for combinatorial algorithms and dynamic problems. The School has a tradition of successful ERC applications in the field: an ERC Starting grant was awarded in 2010, and a prestigious ERC Synergy grant in 2019. By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 6.2 (including contributions to one paper in *Nature* and one in *Science*), with the total of 140 persons from the Faculty (including PhD students) specialized in the field. One CU Primus grant has been running in this field since 2018. CU supported the University Center of Excellence **(UNCE)** *Center for Modern Computer Science* both within the 1st UNCE call (2012-2017), as well as the second one (i.e., since 2018).

CU Field: Software Systems

The main research activity in this field was carried out in data engineering, software systems, visual computing, and artificial intelligence. The School regularly participated in industrial and EU projects (H2020), such as the recent publicly funded projects of AFarCloud and FitOptVis (ECSEL). The field gained worldwide esteem in computer graphics by its strong focus on realistic image synthesis and 3D printing. Many of the results have been adopted by the renowned graphics production houses, such as Weta Digital, PIXAR, or the Chaos Group. By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 5.5, with the total of 136 persons from the Faculty (including PhD students) special-

ized in the field. (The remark above on the disregard of CORE A* and A conference papers by BS2019 applies here in particular.) One CU Primus grant has been running in this field since 2017.

CU Field: Mathematical Linguistics

The research in this field focused on language technologies such as machine translation, text analytics, information retrieval and information extraction, as well as dialogue systems. These research areas represented attractive interdisciplinary tasks relying on computer science, linguistics, statistics and mathematical modeling, with specific challenges to software engineering – as the volume of the data processed typically reached tens of billions of words. Research in the area of language technologies was supported by the Research Infrastructure LINDAT / CLARIAH-CZ, a joint distributed national node of the Czech Republic in the European research infrastructures CLARIN ERIC and DARIAH ERIC. The infrastructure collected and prepared open language resources necessary for all research areas in natural language processing and digital humanities. It also provided open tools and services for both fundamental as well as applied research in these dynamic areas. By BS2019, the total of 100 persons from the Faculty (including PhD students) specialized in the field, with no publications in the top decile journals in the field over the evaluated period. *Note: A similar discrepancy occurred for the field of Linguistics at the Faculty of Arts of CU. The BS2019 ranking of these two fields is thus in stark contrast to the ranking of Linguistics at CU by QS2019 mentioned above.*

CU Research Area: MATHEMATICS

CU Fields: Mathematical Analysis, and Mathematical and Computer Modeling

These two fields have traditionally been intertwined at the School of Mathematics. The research in the first one focused on real and functional analysis, the second on scientific computing and non-equilibrium thermodynamics. Each of the fields hosted an ERC.CZ grant in the evaluated period. The PE2017 panel ranking of excellent publications *on the scale from 1 (the best) to 4 (the worst)* in Mathematical Analysis was 2.13, and it was 1.69 for Mathematical Modeling and Computational Mathematics. By BS2019 the number of author-prorated publications in the top decile of journals in the field over the evaluated period was 18.0 and 17.6, with the total of 60 and 54 persons from the Faculty (including PhD students) specialized in the first and second field, respectively. In the 2012-17 UNCE call, and since 2018 again, CU supported the UNCE project *University center of mathematical modeling, applied analysis and computational mathematics*.

CU Field: Probability and Mathematical Statistics

The core research activity in this field was in stochastic geometry, stochastic analysis, and spatial statistics. Since 2017, this activity has been supported by a DFG-GAČR grant. Further activities included applications of statistics to medical research, and contract research for several financial institutions. The PE2017 panel ranking of excellent publications in Probability and Mathematical Statistics was 2.67. By BS2019 the number of author-prorated publications in the top decile of journals in the field over the evaluated period was 3.2, with the total of 67 persons from the Faculty (including PhD students) specialized in the field. One CU Primus grant has been running in this field since 2018.

CU Field: Structural Mathematics

This field covers three subfields of mathematics: algebra, geometry and logic. The only ERC grant at the School of Mathematics (an **ERC Consolidator grant** awarded in 2017), investigating complexity of constraint satisfaction problems using tools of universal algebra, is in this field. In 2012-18, geometers and part of algebraists working in representation theory at the School par-

ticipated in the activities of the Eduard Čech Institute, a center of excellence in basic research supported by GAČR. The PE2017 panel ranking of excellent publications in Structural Mathematics was 1.33. By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 8.0, with the total of 57 persons from the Faculty (including PhD students) specialized in the area. One CU Primus grant has been running in this field since 2017. Since 2018, CU supports the UNCE project *Methods in Algebra and Logic*.

CU Research Area: PHYSICS

CU Field: Astronomy and Astrophysics

The core research activity in this field was in general theory of relativity and its applications in astrophysics and cosmology. The research profile encompassed mainly mathematical problems of general relativity and its higher-dimensional versions. Moreover, the applications of computers to non-stationary problems involving very strong fields (the so-called numerical relativity) have also been developed. The research groups have traditionally maintained extensive international contacts, supported by a number of grant projects, notably the *Albert Einstein Center for Gravitation and Astrophysics*, a project of excellence awarded by GAČR. In 2012-17, the *Earth and Space Research by the Methods of Theoretical, Computer and Experimental Physics* UNCE project was supported by CU. In 2018 an **ERC Starting grant** in this field was granted to study catastrophic interactions of binary stars and associated transients. By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 1.9 (including contributions to two papers in *Nature* and one in *Science*), with the total of 43 persons from the Faculty (including PhD students) specialized in the field.

CU Fields: Subnuclear and Nuclear Physics

These two fields combined theoretical research with complex experiments, making use of frameworks of the world leading experiments at CERN, KEK, Daya Bay NPP, et al.
The research in theoretical particle physics concentrated mainly on an adequate description of the Higgs sector of the electroweak theory, possible phenomena beyond the SM such as baryon and lepton number violation, the study of low energy meson interactions, calculations of the effective field amplitudes, and deeper study of some specific mathematical methods of quantum field theory. The main experiments were the ATLAS and NA62 at CERN, Belle and Belle II at KEK, and the Day Bay neutrino physics experiment. Besides the participation in the celebrated Higgs boson experiment, the group was among recipients of the Breakthrough Prize in Fundamental Physics 2016 awarded to five big experiments investigating neutrino oscillations.
The research in nuclear physics concentrated on the following three topics: 1. experimental study of nuclear properties at high excitation energies, notably the measurement of cross sections of the neutron-induced reactions in the n_Tof experiment at CERN. 2. microscopic theory of collective nuclear dynamics, and 3. the theory of quantum phase transitions and chaos in algebraic models of nuclei and other bound many-body systems.

Since 2018 CU has supported the UNCE project *Research in Elementary Particles and the Atomic Nucleus.* By BS2019 the total of 11 and 64 persons from the Faculty (including PhD students) specialized in these two fields over the evaluated period. The number of author-prorated publications in the top decile journals was 1.2, and 2.7, respectively, including contributions to one paper in *Nature* and one in *Science* in the latter case. *However, we do keep in mind that the BS2019 bibliometry does not capture the complex publication practice involving large-scale collaborations so typical for these fields. Moreover, the discussion at the Scientific Council of the Faculty demonstrated that the list of the top decile journals in Subnuclear and Nuclear Physics in BS2019 does not match the quality of these journals as perceived by the community of researchers in these fields.*

CU Field: Condensed Matter Physics

This field was represented by two research groups at the Faculty: one dealing with the structure of thin layers and nanoparticles, and one concentrating on the study and development of new materials. The research employed a broad range of X-ray-based methods, such as X-ray diffraction, X-ray scattering and X-ray spectroscopy for the study of various types of materials and nanostructures. The research included also the study of new materials, like antiferromagnetic semiconductor layers and topological insulators. The research was carried out in a broad international collaboration, involving large synchrotron sources, such as ESRF and ILL (Grenoble), ANKA (Karlsruhe), ELETTRA (Trieste), et al. In 2016, the **ERC Starting grant** *Trans-spin nanoarchitectures - from birth to functionalities in magnetic field* was awarded (Note: this ERC grant spans several related fields). In 2012-17 CU supported the UNCE project *Physics of condensed matter and functional materials.* By BS2019 the number of author-prorated publications in the top decile journals in the field was 13.6 over the evaluated period (including a contribution to one paper in *Science*), with the total of 250 persons from the Faculty (including PhD students) specialized in the field.

CU Field: Physics of Molecular and Biological Structures

The research in this field concentrated primarily on two subfields, the physics of macromolecular systems, and open quantum systems and quantum biology.
Physics of the plasma polymer group focused on the preparation of nanoparticles and macromolecular nanoparticles, as well as on the study of new types of polymer networks and hydrogels with unique mechanical and optical properties. The collaboration with Japanese research groups in NIMSe was of particular importace as it resulted in characterizing supramolecular complexes of porphyrin derivatives with pharmaceutically and biologically important molecules.
The Open Quantum System Group created at the Faculty studied open quantum systems, such as biological photosynthetic antennae, in order to obtain deeper understanding of nature's way of harvesting light energy from the Sun by uncovering principles behind ultrafast processes initiated by light energy capture. The main tools here were modern methods of ultrafast time resolved spectroscopy.
In 2017, the **ERC Starting grant** *Accuracy and precision for molecular solids* was awarded in this field. By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 2.6, with the total of 16 persons from the Faculty (including PhD students) specialized in the field.

CU Field: Plasma Physics

The research in this field dealt with diagnostics of hot and low temperature plasma, the study of processes occurring during the plasma–surface interaction, and of the formation of atomic clusters, with a focus on elementary processes in plasma such as reactions of ions with molecules and ion–electron recombinations. The methods developed made it possible to study reactions of specific quantum states of molecules and ions in the temperature range of 10–300 K, thus enabling a direct comparison with quantum mechanics calculations. By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 7.5 (including a contribution to one paper in *Nature*), with the total of 81 persons from the Faculty (including PhD students) specialized in the field.

CU Field: Physics of the Earth and Planets

The research in this field concentrated on two directions: the investigation of the solar wind and its interactions with planets and other bodies in the solar system, and the geophysics.

In the first direction, a unique experimental set-up for simulations of the interaction of dust grains with particle and photon beams was created and a number of instruments for measurements of plasma parameters were flown on-board satellites orbiting the Earth and missions to other planets. Eventually, this approach provided solar wind plasma parameters with the time resolution of two orders of magnitude better than any other extant plasma spectrometer. International collaboration included participation in the European Space Agency projects, notably the Bepi Colombo Project investigating Mercury, the Solar Orbiter Project, missions of the French Space Agency (notably Taranis, investigating lightning in the ionosphere), and of the Russian Space Agency (Luna Glob, Stranik).

In geophysics, the research focused on understanding physical processes in the Earth and planetary interiors using the methods of mathematical modeling and computer physics. It covered a broad spectrum of topics, from general problems of formal mathematical description of complex geophysical phenomena to interpretations of standard geophysical data by means of inverse modeling. More specifically, the research areas included earthquake physics and seismic wave propagation, thermal evolution and deformation of the Earth, planets and moons on various time scales, and the study of the Earth's structure from gravity and electromagnetic data measured with artificial satellites. Strong emphasis on developing new modeling tools, rigorous mathematics, and profound experience in geophysical computing were the main features that distinguished this research group from most other geoscience teams.

By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 6.7, with the total of 36 persons from the Faculty (including PhD students) specialized in the field.

CU Field: Quantum Optics and Optoelectronics

This field was represented at the Faculty by two research directions: optical spectroscopy of individual nanoobjects, and optospintronics.
The first direction concentrated on the luminescence microspectroscopy in a broad optical far-field, a topic much less explored than confocal approaches. The reason for such a choice was the focus on studies of silicon nanostructures whose luminescence flux was extremely low due to the indirect band gap energy structure and related long excited-state lifetimes. A unique cryo-micro-spectroscopy device had to be developed for this purpose. The micro-spectroscopy techniques had then been extended into the near-infrared spectral region, and applied to study other inorganic and organic materials as well as living cell cultures.Reasearch in optospintronics was done primarily in the Laboratory of OptoSpintronics, a joint venture of the Faculty and the Institute of Physics, CAS. Since 2017 this research has been supported by a H2020 Future Emerging Technologies Program called *ASPIN*. Three CU Primus grants have been running in this field since 2017. Since 2018, CU also supports the UNCE project *The Center of Nano- and Bio-Photonics*.
By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 3.5, with the total of 24 persons from the Faculty (including PhD students) specialized in the field.

CU Field: Surface Physics

The group of surface physics developed and applied refined experimental and theoretical methods to understand surface physico-chemical phenomena on the fundamental research level, and to apply the knowledge obtained to the development of new nanotechnologies. The research concentrated on catalysts for energy conversion in fuel cells, notably on optimizing the Platinum efficiency and minimizing the resource cost of the advanced catalysts. Other research topics included studies of sensors of non electrical observables and development of semiconductor nanostructures, as well as research in the hydrogen energy. The group is a major participant in the CERIC consortium working in the synchrotron beam line laboratory at the Elettra synchro-

tron in Trieste (Italy). By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 5.9, with the total of 62 persons from the Faculty (including PhD students) specialized in the field.

CU Field: Theoretical Physics

Besides the areas mentioned above, theoretical physics at the Faculty concentrated on research in quantum turbulence, with the Superfluidity Laboratory serving as the center of this research at the Faculty. Several theoretical and experimental methods were developed to generate and study quantum turbulence in superfluid 4He at cryogenic temperatures below 1K. These included small mechanical oscillators and second sound attenuation. The Laboratory was the first in Europe to directly visualize quantum flows using micron size particles of frozen hydrogen/ deuterium.
By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was approx. 8.4 (including a contribution to one paper in *Nature*), with the total of 63 persons from the Faculty (including PhD students) specialized in the field.
Note: The discussion at the Scientific Council of the Faculty demonstrated that the list of the top decile journals in Theoretical Physics in BS2019 does not match the quality of these journals as perceived by the theoretical physics community.

CU Research Area: HIGHLY INTERDISCIPLINARY (SCI)

CU Field: Atmospheric Physics, Meteorology and Climatology

The focus in this field was on studying the dynamics of complex atmospheric systems, notably by carrying out comprehensive studies of physical and chemical processes in the lower and middle atmosphere in a wide range of spatial and temporal scales. The more specialized tasks included the study of the dynamics and evolution of climatic systems, applications to the problems of climate change and climate modelling, synoptic meteorology, atmospheric modelling, weather analysis and forecast, dynamics and changes of atmospheric circulation, transport of air pollutants and links to natural and anthropogenic sources. Further topics included interactions with physical processes in the atmosphere, studies of turbulent flows and turbulent diffusion, and of energetic transformations in the Earth atmosphere. This research was directly connected to the only undergraduate program at Czech universities covering physical research of atmospheric processes and their mutual and complex interactions.

By BS2019 the number of author-prorated publications in the top decile journals in the field over the evaluated period was 2.7, with the total of 31 persons from the Faculty (including PhD students) specialized in the field.

COMPARISON WITH SELECTED BENCHMARK UNIVERSITIES

Both PE2017 and BS2019 included bibliometric comparisons with selected European universities.

Unlike the PE2017 panel *Ranking of excellent publications*, the **PE2017** *Bibliometric support for a pilot evaluation of R & D performance at Charles University* was not restricted to Mathematics. It was carried out in the following WOS categories: Statistics & Probability, Mathematics, Mathematics – Applied, Physics – Condensed Matter, and Geochemistry & Geophysics. CU was compared with the following universities: **KU Leuven** (Belgium), **University of Vienna** (Austria), and **University of Warwick** (UK).

Since PE2017 contained no information on the number of FTE academic staff at these universities, the PE2017 bibliometric comparisons were restricted to comparing the shares of articles by quartiles of journal AIS (the higher the shares in the top decile and first quartile, the better; the higher the share in the third and fourth quartiles, the worse). In all the compared WOS categories, CU ended up the worst, though often by a narrow margin:

Statistics & Probability: CU came out somewhat worse than KU Leuven (ranked 3), and much worse than Univ. Vienna (2) and Univ. Warwick (1).
Mathematics: CU came out somewhat worse than KU Leuven (3) and Univ. Vienna (2), but much worse than Univ. Warwick (1).
Mathematics – Applied: CU came out somewhat worse than Univ. Vienna (3), and much worse than KU Leuven (2) and Univ. Warwick (1).
Physics – Condensed Matter: CU came out somewhat worse than Univ. Vienna (3), and much worse than Univ. Warwick (2) and KU Leuven (1).
Geochemistry and Geophysics: CU came out somewhat worse than Univ. Warwick (3) and Univ. Vienna (2), but much worse than KU Leuven (1).

The **BS2019** comparison was coarser in the sense that it compared only the broad FORD areas of Computer and Information Sciences (this comparison involved 495 journals), Mathematics (including econometrics and statistics, involving 676 journals), Physical Sciences (502), and also the subject of Nano-technology (92). CU was compared with the following universities: **University of Copenhagen** (Denmark), **University of Heidelberg** (Germany), **KU Leuven** (Belgium), **University of Milan** (Italy), **University of Vienna** (Austria), and **University of Warsaw** (Poland). The results of comparing the shares of author-prorated papers by quartile of the journal AIS were as follows:

*Computer and Information Sciences***:** CU shares were similar to those of Univ. Warsaw and Univ. Milan (ranking 5-7), worse than Univ. Copenhagen, KU Leuven and Univ. Vienna (2-4), but much worse than Univ. Heidelberg (1).
Mathematics (including econometrics and statistics): CU shares were similar to those of Univ. Warsaw (6-7), worse than Univ. Copenhagen, Milan and Vienna (3-5), but much worse than KU Leuven and Univ. Heidelberg (1-2).
Physical Sciences: CU shares were similar to those of Univ. Warsaw (6-7), somewhat worse than Univ. Milan (5) and KU Leuven (4), worse than Univ. Vienna (3) and Univ. Heidelberg (2), but much worse than Univ. Copenhagen (1).
Nano-technology: CU shares were somewhat worse than those of Univ. Warsaw (6), worse than Univ. Milan (5), but much worse than KU Leuven (4), Univ. Vienna (3), Univ. Heidelberg (2), and Univ. Copenhagen (1).

3. RESEARCH POLICY AND MANAGEMENT

Establishment of new research teams and ensuring of conditions for the emergence of new research topics

New research teams bringing new research topics to the Faculty were primarily established with the support of **ERC grants** and of the CU **Primus program**. The teams were largely international, composed of young researchers, but quite small. The Faculty provided strong support to these teams, despite the critical lack of office and laboratory space. The Faculty also strived to make it possible for these researchers to participate in education of students, notably by supervising graduate students (the Czech University Law and University regulations no not allow researchers at non-academic positions to be involved in teaching). To establish new groups on a more advanced level (headed by foreign senior or even mid-career professors) was very hard due to

the limitations for long term employment of foreign senior academic staff at CU mentioned in Part 1.

The ERC grant success rate was rather low in the evaluated period compared to the quality of research at the Faculty suggested by the evaluations presented in Part II. In particular, there was no ERC Advanced grant awarded to any member of the Faculty. In fact, even the number of ERC applications was very low. Both the Faculty and CU reacted to the negative state of affairs by providing financial and administrative support to potential applicants, organizing workshops with former Czech ERC panel members and successful applicants, and creating the **ERC-pipeline** for finding potential candidates, helping them to improve their standings and prepare successful ERC projects. The long term effect of these measures is still to be seen. However, in order to achieve the desired substantial improvement, the scope of and support for the ERC-pipeline will have to increase by an order of magnitude rather than in small steps.

Organization and promotion of doctoral studies

Doctoral studies at the Faculty were supervised by **Doctoral Study Boards** covering their respective fields of research (corresponding approximately to the CU fields listed above). The Boards consisted of leading Czech experts in these fields, including experts from other universities as well as the Czech Academy of Sciences. Each doctoral student followed her or his individual study plan which had been compiled at the beginning of the studies by the PhD Thesis Adviser together with the student, and approved by the respective Board. The study plan already contained *a priori* the (envisaged) topic of the PhD Thesis, the list of recommended research seminars and lectures, stays abroad, etc. The PhD study lasted 4 years, and included an exam in English (during the first or second year of study), the State Doctoral Exam (a comprehensive exam requiring deeper knowledge of the main topics of the field - at the end of the third year), and the PhD Thesis defence.

Most doctoral students spent at least one semester at a research center or university abroad, with the support of the Erasmus+ program and various international and national grants of their Advisors. Some of the students were studying within the Cotutelle/Joint Degree schemes negotiated with several French and German universities. CU also ran the **GAUK** grant agency awarding 1-3 year research grants to students or groups of students of up to 12.000 EUR per project. Though the algorithm for dividing the GAUK budget into the respective research areas had repeatedly been questioned, GAUK did contribute to improving the standing of many active doctoral students. Further institutional support to doctoral students was provided by the SVV projects of the Czech Ministry of Education.

The main problem in the evaluated period lied in miserable stipends (a couple hundred EUR per month) for doctoral students provided by the Ministry. The Faculty helped by regularly offering paid TA positions; additional income came from various grants, including the GAUK. Still, many doctoral students were forced to take part-time non-academic jobs in order to earn their living.
To improve the situation, the Faculty introduced stipend supplements for students that already published some of their research, and the Schools started to employ students at (low-level) assistant positions. The Faculty also introduced obligatory annual student self-evaluations. These helped to decrease the number of very weak or extra year students (the Czech University Law allowed doctoral studies to span as much as 9 years).

Though both the Czech and English doctoral studies coexisted at the Faculty over the evaluated period - the Czech ones being free, the English studies requiring paying a non-trivial tuition fee - there were almost no students in the English doctoral programs. The reason was obvious: since essentially all the Advisors spoke English, study plans were individual, and all the seminars and most lectures were given in English, a foreign student could easily enrol in the Czech program

and avoid paying the fee. In this way, a number of foreign students successfully graduated in the Czech doctoral study programs over the evaluated period.

Internationalisation of the internal environment

As mentioned in Part 1, despite the less favorable general conditions, the Faculty fostered internationalization in the evaluated period by starting the Fulbright Distinguished Chair Program, the Visiting Professor scheme, and implementing a protected electronic voting system for habilitation and professorship committees. The successful introduction of paid studies in Computer Science and Mathematics contributed to internationalisation of the student community.

Moreover, several Departments got ahead of the HR Award activities (aiming at a new Competitive Hiring Process Code) and implemented their own proceedings in order to open the hiring process to international academic staff. Often, these Departments ranked higher in the research evaluation mentioned in Part 2.

A pertinent comment on this topic comes from the recent (December 2019) report on CU by the team of the European University Association's Institutional Evaluation Programme (see https://cuni.cz/UK-4058-version1-iep_follow_up_report.pdf):

The team does not believe that the percentage of international staff working at the institution is commensurate with the standing of a university such as Charles University, and while some initiatives such as "extraordinary professors" have been introduced in an attempt to change the staff make-up the team recommends that the university explores all avenues in its attempts to break down the barriers relating to international staff recruitment.

Involvement in international research community

The Faculty is involved in numerous international research networks. For more details on these networks/projects over the evaluated period, we refer to *Attachment 1* .

Open Access

It is important that new scientific results be publicized and made available to the public in order to further and disseminate knowledge. Some projects even require their research outputs to be published in the gold open access mode, and provide resources for that purpose. Moreover, given the plagiaristic scandals at CU in the evaluated period, the possibility to access and compare results of Theses and other scholarly publications became essential.

However, one also has to protect scholarly works from being misused by plagiarists (as was the case of a Diploma Thesis in theoretical physics defended at the Faculty and stored unprotected in the CU student works repository), take into account publishers' copyright rules, and last but not least, think of protection for the case of future patent applications.

These issues are certainly not specific to our Faculty, and most academic staff already follow the recommended rules of their scholar communities (e.g., to upload their preprints to the arXiv.org server prior to submitting them to research journals). The balance between unrestricted access to a repository, and protection of copyright/authorship is subtle, still the subject of an ongoing discussion within the European academic community. The Faculty certainly agrees to follow the recommendation on open access given by the CU International Advisory Board at its meeting in May 2019: "*CU should not be on the forefront of something undecided*."

Internal evaluation of research

Over the evaluated period, the Faculty generally followed the **National Research Evaluation Methodology** currently in force when evaluating the research of and distributing research resources to the respective Schools.

The Schools, however, employed different independent strategies for research evaluation and distribution of the research resources received. The School of Computer Science had a central system with the dominant role of the Head of the School and the board consisting of Heads of the Departments. The School of Mathematics used its own specific rules, taking into account numbers of publications rather than journal impact factors, total grant resources, etc. (However, excellent publications were evaluated and their authors rewarded separately, by the Progress/Prvouk Board in Mathematics). The School of Physics chose to apply a modified version of the National Evaluation Methodology in order to distribute the resources to its departments.

The Dean of the Faculty exercised his right to honor extraordinary research achievements by special awards (e.g., for outstanding monographs).

4. RESEARCH FUNDING

Overview of and reflection on financial resources for research

The Grant Agency of the Czech Republic (GAČR) remained the main source of research funding to the Faculty in the evaluated period, with approximately 40 new three-year grants awarded to research teams from the Faculty each year.

Other important resources included the Technological Agency of the Czech Republic (TAČR), European structural funds (provided via various national operational programs, mediated mainly by the Czech Ministry of Education), H2020 programs (including ERC, RISE, et al.), the NAKI program of the Czech Ministry of Culture et al. Student research was funded by the CU GAUK grant agency and via the SVV scheme (direct support of graduate research coming from the Czech Ministry of Education).

As most research teams at the Faculty represented top Czech research in their respective areas and were involved in active national and international collaborations, the financial resources available for them were generally sufficient for maintaining the quality of research over the evaluated period. Thus, space limitations rather than financial resources remained the main hindrances of a more extensive development. This became clear especially when the Faculty tried to accommodate the new research teams coming with the prestigious support of the ERC grants.

Distribution of resources amongst individual research areas

The distribution of institutional financial resources among the individual research areas generally followed the National Research Evaluation Methodology currently in force (see the end of Part 3 above for more details). Of course, the distribution of the project/grant resources followed the rules of the respective grant agencies.

Funding of doctoral studies

Doctoral studies were funded from institutional resources (stipends, SVV projects) and by grants (notably the GAČR and GAUK grants). We refer to Part 3 for more details.

Support for obtaining foreign and international grants

The Office for Research and International Relations of the Faculty provided support both for applicants and researchers, starting from distributing information on new calls over help with preparation of projects, to checking the intermediate and final grant reports. Special care was given to ERC applicants (see the part on the ERC-pipeline above for more details).

Examples of the most important grants and projects

1. The **LBCAD ERC-2013-CoG** project of Prof. Koucký brought new results in algorithm complexity with applications to design of dynamical data structures.
2. The **TSuNAMI ERC-2016-STG** project of Assoc. Prof. Kalbáčová Vejpravová on nanoarchitectures has provided new functionalities for biomedicine and nanoelectronics.
3. The **CoSym ERC-2017-CoG** project of Assoc. Prof. Barto has investigated the complexity of constraint satisfaction problems; applications include complexity analyses in the theory of optimization.
4. The **APES ERC-2017-STG** project of Dr. Klimeš has included applications to precision problems for molecular solids.
5. The **chipCAT FP7-NMP-2012-SMALL-6** project of Prof. Matolín resulted in the design of thin-film nanocatalysts for on-chip fuel cell technology-

5. PERSONNEL POLICY

Principles of HR policy

Since 2018, the Faculty has taken active part in the preparation of the new Competitive Hiring Process Code at CU (valid since January 2020) which introduced the key principles of HR policy in recruitment at CU. In fact, several Departments of the Faculty got ahead of the CU HR Award activities and implemented their own recruitment proceedings, thus bringing their hiring standards closer to the standards of good research universities already during the evaluated period.

Hiring of and support for junior researchers

Hiring junior researchers was much simpler for non-academic research positions (such as various temporary positions covered by grants), i.e., restricted to research only (no teaching). The hiring committee did not have to abide by the Competitive Hiring Process Code at CU, though it was recommended to follow the principal guidelines of the Code to assure fairness and high quality of the hiring process.

Junior researchers applying to academic positions (such as junior assistant professors) were hired according to the Code.

Following the Czech Labor Code, the Faculty can hire an employee with a temporary contract only for at most three years, and there may be at most three such contracts in a row signed with such employee. This affects the tenure track scheme at the Faculty: it consists of three consecutive temporary positions of an Assistant Professor spanning at most three years each. Within that period (of at most 9 years), the Assistant Professor is expected to obtain a Habilitation in order to be eligible to the permanent position of an Associate Professor. (Also the positions of Full Professors at the Faculty are permanent.)

Hiring and retaining of senior academic and research staff

As mentioned in Part 1, the Czech University Law and University regulations essentially restrict possibilities for a foreign Associate Professor and Full Professor to get the corresponding positions at CU. The recent amendment of the Czech University Law trying to resolve the problem by introducing the post of an Exceptional Professor had only limited positive effect.

Career development of academic and research staff

A major step towards making career development stages at the Faculty defined clearly was taken by the Scientific Council of the Faculty in October 2017. The Council approved the desired **Profiles of an Associate Professor and a Full Professor**, respectively, for habilitation and professorship proceedings at the Council. The English versions of these profiles read as follows:

1. An **Associate Professor** *is an internationally accomplished researcher, has successful teaching experience and an active approach to service to the academic community*.

Research*: The applicant will have her/his own clearly defined research programme and international accomplishments proven in a way standard for her/his research field, supported by letters written by distinguished experts in the area. Depending on the area in question, quantitative metrics used will include (co-)authorship of original publications, adequately cited and published in international IF-journals or proceedings of renowned conferences; important contributions to the creation of reviewed artefacts; invited talks at international conferences, etc. Authorship of survey or review papers and chapters in research books and monographs is also appreciated. The applicant will have submitted project applications to major national and international grant agencies and will have been a grant recipient at least at a national level.*

Teaching: *The applicant will have experience in teaching university courses, receiving for them good student evaluations, and in supervising undergraduate theses. Experience in the supervision of graduates is appreciated.*

Service: *The applicant is expected to have served the international research community, e.g., as a reviewer for journals, conferences, and grant agencies, as a (co-)organizer of conferences and workshops, and as an active member of professional organizations. She/he will actively participate in committees and the administrative and service activities of her/his Department.*

2. A **Full Professor** *is an internationally recognized personality, both for her/his research and for educational activities*.

Research*: The applicant has a distinguished research programme with international recognition supported by letters written by distinguished experts in her/his research field. She/he has become a key and influential personality of the relevant Department. She/he has authored a number of highly cited publications relevant to her/his research programme. She/he has been recognized by the research community, for example by being an invited or plenary speaker and member of programme and steering committees at renowned international conferences. The distinguished position of the applicant will also be documented by authoring invited surveys, reviews, books or monographs. The applicant takes part in important national and international projects.*

Teaching: *The applicant has a leadership position in teaching and guarantees the quality of the education programmes in her/his research field, which she/he has created and/or substantially modified, effectively establishing a new "school of research." His/her former undergraduate and graduate students are expected to be successful both inside and outside academia.*

Service: *The applicant assumes important roles in serving the international academic community (such as being an editor of a research journal, or as an organizer or other key role at important conferences). She/he plays an essential part in committees and the administrative and service activities of her/his Department and fulfills the role of mentor to her/his younger colleagues.*

The Council also approved the desired Profile of an Assistant Professor at the first attestation, that is, after the first three year contract at the Faculty. For more details, see https://www.mff.cuni.cz/data/web/obsah-puvodni/fakulta/vr/20171004p1.pdf

6. INFRASTRUCTURE FOR RESEARCH

As mentioned above, the academic staff of the Faculty was able to secure substantial support for their research both from national and international resources. Space limitations remained the main obstacle for a more extensive development of the Faculty research infrastructure.

The accessibility of electronic resources, notably of the relevant research journals, was very good thanks to the participation/subscription of the Faculty/CU to the **CzechELib project.** The access included general bibliometric databases (WOS, Scopus), journal packages from big publishing companies (Elsevier, Springer, Wiley) as well as specialized databases containing reviews of the publications (such as MathSciNet and Zentralblatt). All key online resources were accessible from the university networks as well as by remote access via faculty proxy servers.

The **Library of the Faculty** had specialized branches within the respective Schools of the Faculty, storing mainly research books, textbooks, and providing e-readers. With the increasing role of online access to resources, classic library rooms are gradually changing from classic journal/book storage spaces into study and seminar/meeting rooms.

7. SOCIAL IMPACT OF RESEARCH

We refer to *Attachment 1* for more details and concrete examples.

8. OTHER TOPICS

In the evaluated period, the Faculty publishing house **Matfyzpress** published several popularizing books (such as *A Rendez-vous with Physics*) as well as translations (e.g., of Johannes Kepler's *Strena Seu de Niue Hexangula*, the bilingual edition in Latin and Czech of Kepler's original booklet written in Latin in 1610 in Prague).

In 2017, the Faculty received two prizes of the National Heritage Institute Patrimonium pro futuro and in 2018, the prestigious EU Prize for Cultural Heritage **Europa Nostra Award** for reconstructing the ruins of st. Wenceslas rotunda discovered inside the building of the School of Computer Science, and for making the premise partially available to the public. The reconstruction was possible thanks to a generous support by an EEA and Norway grants as well as to donations of Faculty alumni.

9. STRENGTHS, WEAKNESSES, OPPORTUNITIES AND RISKS

During the evaluated period, we have witnessed an increase of the international presence at the Faculty and the introduction of new research topics, partly thanks to several ERC grants awarded, and the Primus scheme being introduced at CU. The Faculty contributed to the international-

ization mainly by introducing new (temporary) visiting professor positions (Fulbright Distinguished Chair, et al.) and (paid) study programs in English. Also the evaluation of research started to put more stress on quality of top publications rather than quantity of medium quality ones. This helped to fight the two main weaknesses of the Faculty (and CU) at international rankings, namely, the low numbers of citations per academic staff member, and the low number of international academic staff members. Space limitations and obsolete legal restrictions remained the main obstacles of a more rapid development.

The Faculty maintains research collaborations with a number of universities and research institutes worldwide. We believe that relevant new research collaborations arise bottom-up, that is, at personal meetings of researchers at conferences, seminars, and workshops, rather than top-down, at official meetings of university representatives. Once a successful collaboration starts bottom-up, it is of course the duty of the Department, School and Faculty to support it. We do not see much of a benefit in maintaining expensive networks/alliances created from above, with limited positive impact on research. In this context, we quote again from the recent report on CU by the team of the European University Association's Institutional Evaluation Programme (https://cuni.cz/UK-4058-version1-iep_follow_up_report.pdf):

Notwithstanding the excitement and potential of the 4EU+ Alliance initiative, the team recommends that the challenges and threats of the enterprise are kept under close and careful scrutiny by both the executive and deliberative branches of the university.

10. FUTURE PLANS

Key priorities for the next five years

The key priority of the Faculty is to further its current standing in research by creating better conditions for obtaining more prestigious research grants, notably the grants of the **European Research Council**. Following the recent recommendation of the team of the European University Association's Institutional Evaluation Programme, the Faculty will also strive for breakdown of the existing barriers relating to international staff recruitment.

The Faculty will also aim at increasing its involvement in various research and innovation programs of the EU supported by the forthcoming **Horizon Europe** programs. Of particular importance for us is the new initiative of the *Strategic Plan for Horizon Europe* titled *Widening participation and spreading excellence* which will in particular create new or upgrade existing H2020 programs in order to make them more accessible for EU countries (such as the Czech Republic) that are lagging behind in terms of numbers of applications and success rates.

Examples of specific planned measures or changes in the field of research and development.

The scheduled **opening of a new multipurpose building** of the Faculty in the Troja mini-campus in 2020 will partially resolve the poignant space problems of researchers in the School of Computer Science (notably in the field of robotics). The part of the School of Physics located in the mini-campus may also benefit by closing some of the current small lecture rooms (the new building comprises both a big lecture hall and a number of small ones). In order to relieve the burden of space problems for the part of the School of Physics located in Karlov, the Faculty plans to reconstruct the attic of one of its buildings in order to obtain more office space.

An example of a successful recent collaboration based on the bottom-up approach is the current extension of collaboration of the Faculty with researchers in mathematics and physics at **Brown University**. Brown representatives even suggested a further step, involving **CASA**, a non-profit

academic consortium of eleven leading comprehensive research universities formed for the purpose of organizing and delivering rigorous education abroad programs in collaboration with leading world universities. The idea is to create a new regional CASA center in Prague. Given the quality of these universities (mostly members of the Ivy League), the Faculty looks forward to joining the Faculty of Arts to help materialize this idea.

11. APPENDICES

Revenues per research areas in 2018 (in thousands of Euros), including foreign revenues

research area	total revenue	research revenue
Arts and Humanities		
Arts and Culture Studies		
History and Archaeology		
Linguistics	2022	1692
Literature		
Philosophy and Religion		
Social Sciences		
Economic Science		
Law		
Media and Communications Studies		
Political Science and Area Studies		
Psychology		
Social Work		
Sociology		
Teachers Education and Non-teaching Pedagogy		
Natural Sciences		
Atmospheric Physics, Meteorology and Climatology		
Biology		
Chemistry		
Computer Science	8316	6034
Earth Sciences		
Geography		
Mathematics	8380	5449
Physics	24515	20338
Medical and Health Sciences		
Medicine and Medical Disciplines		
Pharmacy		

12. ATTACHMENTS

Attachment 1

Faculty self-evaluation report for the National Evaluation Methodology module M3 - Social Relevance.

This report was discussed by the Scientific Council of the Faculty on March 4, 2020.