



**SILESIAN
UNIVERSITY**
INSTITUTE OF PHYSICS
IN OPAVA

Self-evaluation report

**on scientific activities of the Institute of Physics in Opava
for the period 2017-2021**

**Institute of Physics in Opava
Silesian University in Opava
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INTRODUCTION

Institute of Physics in Opava (IoP) of the Silesian University in Opava was founded as an independent constituent of the Silesian University in Opava on January 1, 2020. Its predecessor was Institute of Physics of the Faculty of Philosophy and Science in Opava since the foundation of this faculty in 1991. Thanks to its qualified academic and scientific staff, the IoP developed systematically acquiring doctoral programme in 2000 and authorization to perform habilitation (associate professor) and full professor appointments (2005) in the field of Theoretical Physics and Astrophysics. At present, IoP is an established and internationally recognized scientific institution, being incorporated into ICRANet since 2020. More than two thirds of its budget is allotted for scientific activities with relevant part coming from funding distributed in open competitions. Furthermore, three fourths of the academic and scientific staff have significant parts of their workloads allotted to research activities, some of them are fully involved in research. The research is focused in two centres – Research Centre of Theoretical Physics and Astrophysics (RC TPA), focused on theoretical research using analytical and computational approaches, and Research Centre for Computational Physics and Data Processing (RC CPDP), focused on observational astrophysics. Both centres are involved in preparation of X-ray cosmic missions and testing of theoretical predictions by observational data. The centres were founded in 2013 as a continuation of the main scientific project realized in the period 2005 – 2011, the so-called Institutional Research Plan MSM 4781305903 “Relativistic and particle physics and their astrophysical applications”.

In the period 2014 – 2018, IoP was one of the four institutions participating in the project No. 14-37086G “The Albert Einstein Centre for Gravitation and Astrophysics”, as a centre of excellence financed by the Czech Science Foundation. For the period of 2021 – 2025, IoP has been participating in the excellence project of the Czech Science Foundation No. 21-06825X “Accreting black holes in the new era of polarization missions”. IoP carries out six bachelor (2), master (3) and doctoral study (1) programmes. The doctoral one, Relativistic Physics and Astrophysics, is closely related to scientific activities of both research centres.

ORIENTATION AND STRATEGIC GOALS

IoP is focused on fundamental theoretical research in the field of relativistic and particle physics and their applications to astrophysics, where all the other branches of physics and a lot of mathematical disciplines are necessary. The research combines analytical and computational methods. The main strategic goal is to develop extended and deep studies related to the so-called multi-messenger astrophysics related to phenomena connected to the large variety of compact objects (black holes, wormholes, superspinars, gravastars, neutron stars, quark stars, etc.) treated within the framework of the Einstein gravity or alternative theories of gravity, both with inclusion of effects of strong electromagnetic fields treated within the Maxwell theory or alternative non-linear electrodynamic models. Parallely, the role of dark energy and dark matter in cosmology and astrophysics is investigated. In RC TPA, the research is focused on five large topics: Accretion processes in strong gravitational and electromagnetic fields of compact objects, including test by observational data; Optical effects around compact objects and their observational

signatures; Dark energy and dark matter in cosmology and astrophysics; Physics in backgrounds governed by alternative (higher – dimensional) gravity models with relation to conformal connection to gauge fields; Search of new complex solutions of Einstein gravity, or alternative gravity theories, by the gravitational decoupling method, and study of their astrophysical consequences. In RC CPDP, the research is focused on the processing of observational data and comparison of theoretical predictions with data obtained from physical processes around compact objects. The centre intensively collaborates on preparation of the X-ray satellite projects (ATHENA, eXTP , etc.).

Due to the mentioned scientific activities and high response on the published results of the research centres, IoP maintained high level prestige, being worldwide renown in the scientific community related to the research in theoretical physics and astrophysics.

MANAGEMENT OF SCIENTIFIC ACTIVITIES

Scientific activities of IoP are managed once per year during joint meeting of its centres that are related to preparation of the RAGtime meeting that is organized each year. At the joint meeting, research plans are updated for every year in advance. At the RAGtime meetings, members of the centres and related doctoral students present their results in front of an international community. At the meetings of the centres, also participation in projects of the Czech Science Foundation are discussed and planned. We plan to introduce evaluation of academic and scientific staff and doctoral students during such meetings in the future (with grades: outstanding recognise, very satisfactory, satisfactory, partly satisfactory and unsatisfactory).

MESURES ADOPTED TO SUPPORT THE DEVELOPMENT OF SCIENTIFIC ACTIVITIES

Outcomes of the internal evaluation process based on the Methodology 17+ of the Ministry of Education, youth and sports (point system) enables to evaluate all individual members of the researchers centres and can be used as basis for salary bonuses from the science budget that are established according to the actual situation in research (in a given year), and the summary of the individual scientific activities for a four-year (or five-year) period. The summary of gained points for the research centres and the rest of IoP are presented in Table 1 in Appendix.

ACADEMIC PERSONAL STRUCTURE AND CAREER ADVANCEMENT

At IoP, at present, there are 30 members with full-time workload, comprising of 4 full professors, 7 associate professors (habilitated “docents”) and 19 assistant professors (Ph.D. degree). There are also 10 part-time members, comprising 4 assistant professors (Ph.D. degree) and 6 assistants (master degree). In the researcher centres, the members are divided into senior researchers (6 RC TPA, 3 RC CPDP), junior researchers (8 RC TPA, 3 RC CPDP) and postdocs (5 RC TPA, 2 RC CPDP). Any centre member who satisfies the criteria required for the habilitation or full professor appointments is encouraged to apply for the related procedure. We plan at least 3 assistant professors to become associate professors in near future, and 2 associate professors to become full professors. Usually, only full

professors and associate professors, or senior researchers, are employed within permanent-term contract.

SCIENTIFIC ACTIVITIES OF STUDENTS, ESPECIALLY DOCTORAL STUDENTS

Scientific activities of doctoral students are crucial and basic. For doctoral students, it is necessary to be involved in researcher activities of the research centres, exceptionally also in the educational centres. The doctoral study programme of IoP is successful at this point as it can be seen from the list of publications in the impact journals. The scientific projects of doctoral students are composed in agreements with plans of the research centres. Their scientific work is thus an integral part of the research activities of the centres and could be sometimes partly based on research activities of both centres. The results of the student scientific works have to be published in impact journals. In some cases, even master students participate in the published results in both the research centres. In the period of 2017-2021, there were 80 papers published with participation of students.

UNIVERSITY, NATIONAL AND INTERNATIONAL SCIENTIFIC PROJECTS

In the evaluation period, there were many projects realized, among them 2 projects of excellence supported by the Czech Science Foundation where members of the two research centres were (are) co-investigators, as these projects contain several groups from various research institutions in the Czech Republic, and some standard projects supported by the Czech Science Foundation with principal investigators from IoP. There were participations in international projects, the special projects of EU for the Czech Republic, or internal projects of the Silesian University in Opava, such as Internal Grant Support (IGS) and Student Grant Support (SGS). The details can be found in Table 2 in Appendix. The total financial support coming from these projects to IoP in the period 2017-2021 represents 96 037 925 CZK.

NATIONAL AND INTERNATIONAL COOPERATION IN SCIENCE

On the national level, the cooperation is focused on the Astronomical Institute of the Academy of Sciences of the Czech Republic, and on the Institute of Theoretical Physics and Institute of Astronomy of the Faculty of Mathematics and Physics, Charles University, Prague. On the international level, the cooperation is extended across the whole world. Starting by participation in ICRANet, it is spread on many very relevant institutions whose research is focused on theoretical physics and astrophysics, e.g., University of Oxford, Harvard university, MIT, SISSA Trieste, Chalmers University, INAF Rome, Tashkent University of Uzbekistan, Fudan University Shanghai, University of Bremen, University of Cologne, Eberhard Karls Universität Tübingen, Max Planck Institute in Bonn, Institute of Nuclear Physics of the Polish Academy of Sciences, Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences, University of Bologna, Universidad San Francisco de Quito USFQ and many others. The details are presented in the Annual Reports of IoP. There are a lot of papers published in impact journals with co-authors from about 20 countries (USA, UK, Italy, France, Spain, Chile, Ecuador, China, Uzbekistan, Greece, Poland, Ukraine, Russia, Germany, Iran, Pakistan, Kazakhstan, India, Switzerland, etc.). IoP systematically attracts visiting

scientists, starting thus new directions of the research. Some of the visiting leading experts even decided to accept permanent position at IoP.

SOCIAL RELEVANCE OF SCIENTIFIC ACTIVITIES

The scientific activities belong mostly to the fundamental research in theoretical physics and astrophysics, but there are successful attempts to transfer some methods developed in the field of the astro-informatics into applied physics or medicine research (cooperation with the Medical Faculty of the University of Ostrava is under preparation). The research in the field of the theoretical physics and astrophysics brings results of very high quality – the results are mostly published in impact journals of Q1 category, affecting significantly the world-wide research activities as many published papers are frequently cited, some of them (approx. 10) belong to the category of highly cited paper on WoS.

RESULTS AND AWARDS

In the evaluated period, IoP members published more than 200 papers in impact journals, most of them in the Q1 category journals, some of them also belong to D1 category. The details are presented in the Annual Reports of IoP. These papers were highly recognized across the world; in 2020, there were 12 Highly Cited papers (some of them even Hot-papers for a while), in 2021 there were 10 Highly Cited papers. The separation of the published papers among the research centres, and their ranking (quartiles Q1 – Q4 according to Web of Science) are presented in Table 1 in Appendix. The table also clearly shows a comparison of the results obtained in the period 2018-2019 (IoP was a part of the Faculty of Philosophy and Science in Opava), and in the period 2020-2021 (IoP was independent constituent of the Silesian University in Opava). The enormous increase of the number of the published papers in the independent era of IoP proves high increase of the scientific power of IoP, clearly because the formal independence enables efficient managing of the scientific activities as well.

There is also a large variety of awards obtained by the members of IoP, especially of RC TPA. These are: Ovalle, J., Proyecto Regular Fondecyt 2021, Ministry of Science, Government of Chile, 2021; Tursunov, A., Vaclav Votruba Prize, 2020; Tursunov, A., Milan Odehnal Prize, 2020; Tursunov, A., Behounek Prize, 2020; Tursunov, A., Siemens Prize, 2020; Stuchlik, Z., Frantisek Nusl Prize, 2019; Toshmatov, B., Prize of the Minister of Education of the Czech Republic, 2019; Toshmatov, B., Behounek Prize, 2019; Tursunov, A., Prize of the Minister of Education of the Czech Republic, 2018; Stuchlik, Z., Prize of the Astronomical Union of the Czech Republic – Kopal lecture, 2017; Pugliese, D., Woman of Science 2017, UNESCO L’Oreal Prize Italy, 2017.

We can conclude that both centres are successfully developing fundamental research in theoretical physics and astrophysics in the modern framework of multi-messenger astrophysics, and its applications in cosmic research, by participation in the X-ray satellite mission preparation, or also in other branches of sciences, e.g. medicine.

In the future, we expect the development of IoP research, extension and deepening of its activities, and, especially, further extension of the international cooperation that was strongly suppressed by the Covid-19 pandemic in the period 2020-2021. Thus, we could expect a slight increase of the scientific activities in near future, however, the situation will be also strongly influenced by funding of scientific activities.

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Appendix

Table 1

Institute of Physics – number of papers and related points (2017-2021)				
	Sum 2020-2021	Sum 2018-2019	Sum 2017	Sum 2017-2021
RC TPA				
Q1	60,87	47,00	21,20	129,07
Q2	37,40	12,00	5,50	54,90
Q3	6,00	9,00	2,00	17,00
Q4	2,00	4,00	1,00	7,00
D1				
Points	422	272	123	817
RC CPDP				
Q1	16,19	9,90	1,80	
Q2	3,60		0,50	
Q3				
Q4		2,00	1,00	
D1				
Points	92	52	11	153
IoP without RC				
Q1	3	1	1	
Q2	2	4	1	
Q3	1			
Q4	1	2	1	
D1	1			
Points	28	17	8	53

Table 2

Summary of grants and projects – budget in CZK (2017-2021)							
		2017	2018	2019	2020	2021	Summary
Development projects	ISIP	236 000	160 000	69 850	69 850		535 700
	IRP/IP	524 000	684 500	415 000	415 000	679 236	2 717 736
	MSK	400 000					400 000
The Czech Science Foundation (GACR)	GACR 16-03564y	3 287 000	2 577 000				5 864 000
	GACR 14-37086G	2 000 000	2 000 000				4 000 000
	GACR 17-162887S	2 547 000	1 939 000	2 620 000			7 106 000
	GACR 19-03950S			2 956 000	3 375 000	3 375 000	9 706 000
	GACR 21-06825X, EXPRO					1 968 000	1 968 000
Scientific international cooperation	IGS	50 000					50 000
	SGS	1 285 395	2 662 177	2 528 619	1 681 892	1 887 476	10 045 559
	Lab for antiprotons research LM	710 000	749 000	758 000	1 045 000	866 000	4 128 000
	Research of baryonic systems in FAIR centre	500 000	825 000	750 000	637 500	750 000	3 462 500
	LTT	1 990 841					1 990 841
	INFORM		2 129 097	2 501 196	3 156 827	799 470	8 586 589
	INTER-COST		1 072 099	1 100 000	1 075 000	968 000	4 215 099
	INTERREG SK-CZ		1 042 399	1 247 258			2 289 657
	Visegrad Fond			509 870		99 998	609 868
	ESA - PRODEX				35 283	101 372	136 655
European funds	ERDF CLAIRO		164 816	2 173 110	814 171	1 921 781	5 073 877
	RESTART		727 417	4 972 005	4 246 019	3 833 417	13 778 858
	OPEN UNI – ESF II			231 785	938 791	696 935	1 867 511
	ERDF FAIR OP II				332 500	190 000	522 500
	HR AWARD – Development of research capacity				4 189 785	2 793 190	6 982 975
		13 530 236	16 732 505	22 832 693	22 012 618	20 929 874	96 037 925