



agency for science and higher education



Improvement of quality assurance
and enhancement systems in higher education

**Report
of the Expert Panel
on the Re-accreditation
of the University Postgraduate (Doctoral) Programme
in Physics
Faculty of Science
University of Zagreb**

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INTRODUCTION

The Expert Panel appointed by the Agency for Science and Higher Education (ASHE) created this Report on the Re-accreditation of the University Postgraduate (Doctoral) Programme in Physics on the basis of the Self-Evaluation Report of the Programme, other documentation submitted and a visit to the Faculty of Science, University of Zagreb, Department of Physics.

The Agency for Science and Higher Education (ASHE), a public body listed in EQAR (European Quality Assurance Register for Higher Education) and a full member of ENQA (European Association for Quality Assurance in Higher Education), re-accredits higher education institutions (hereinafter: HEIs) and their study programmes in line with the Act on Quality Assurance in Science and Higher Education (Official Gazette 45/09) and the Ordinance on the Content of a Licence and Conditions for Issuing a Licence for Performing Higher Education Activity, Carrying out a Study Programme and Re-Accreditation of Higher Education Institutions (OG 24/10). In this procedure parts of activities of higher education institutions and university postgraduate study programmes are re-accredited.

Expert Panel is appointed by the Agency's Accreditation Council, an independent expert body, to carry out independent evaluation of post-graduate university study programmes.

The Report contains the following elements:

- Short description of the study programme
- The recommendation of the Expert Panel to the Agency's Accreditation Council
- Recommendations for institutional improvement and measures to be implemented in the following period (and checked within a follow-up procedure)
- A brief analysis of the institutional advantages and disadvantages
- A list of good practices found at the institution
- Conclusions on compliance with the prescribed conditions of delivery of a study programme
- Conclusions on compliance with the criteria for quality assessment.

Members of the Expert Panel:

- Prof. Jordi Colomer Feliu, University of Girona, Spain, moderator
- Prof. John Doran, Dublin Institute of Technology, Ireland
- Kateryna Lemishko, doctoral candidate, Autonomous University of Madrid, Spain
- Professor Frank Witlox, Ghent University, Belgium, Panel Chair
- Professor Thomas Nedomysl, Lund University, Sweden
- Doctoral student Rowan Jaines, University of Sheffield, United Kingdom.

The higher education institution was visited by the following Expert Panel members:

1. Prof. Jordi Colomer Feliu, University of Girona, Spain
2. Prof. John Doran, Dublin Institute of Technology, Ireland
3. Kateryna Lemishko, PhD Student, Autonomous University of Madrid, Spain.

In the analysis of the documentation, site visit and writing of the report the Panel was supported by the following representatives of Agency for Science and Higher Education:

- Emita Blagdan, coordinator, ASHE
- Lida Lamza, interpreter at the site visit and Report translator, ASHE.

During the visit to the Institution the Expert Panel held meetings with the representatives of the following groups:

- Management
- Study programme heads/coordinators
- Doctoral candidates
- Teachers and supervisors
- Alumni.

The Expert Panel also had a tour of two laboratories.

SHORT DESCRIPTION OF THE STUDY PROGRAMME

Name of the study programme contained in the licence: Physics

Institution providing the programme: University of Zagreb

Institution delivering the programme: Faculty of Science

Department of Physics and Department of Geophysics, Faculty of Science (PMF), University of Zagreb, and partner institutions (Ruđer Bošković Institute, RBI, Zagreb) and the Institute of Physics (IF, Zagreb)

Scientific area and field: Natural sciences, Physics

Place of delivery: Zagreb

Number of doctoral candidates (all): 180

Number of HEI funded doctoral candidates (assistants employed at that or another HEI or institute): 117

Number of self-funded doctoral candidates and employer-funded doctoral candidates: 63

Number of inactive doctoral candidates (did not enrol in a higher year of study but still have the right to study): 21

Number of teachers at the doctoral study programme (state the ones employed by the HEI as well as the external associates):

A total of 90 lecturers; of these, 36 are from PMF, and 28 from partner institutions (RBI, IF) (according to lecture schedule of new doctoral studies, initially accredited in 2019).

Number of supervisors (state the officially appointed supervisors, but also separately state other types of supervision, such as supervisor – advisor etc., as well as the number of doctoral candidates they supervise):

Number of officially appointed supervisors: 65

Number of study advisors: 58

Number of doctoral candidates to whom an official supervisor was appointed: 72

Learning outcomes of the programme:

1. KNOWLEDGE

LO 1.1. Doctoral candidate knows how to interpret contemporary knowledge in physics at a factual and conceptual level and in correlation with related sciences (mathematics, chemistry, biology, computer science).

LO 1.2. Doctoral candidate can create, evaluate and apply new experimental or theoretical scientific procedures and methods within a specific branch of physics.

2. COGNITIVE SKILLS

LO 2.1. Doctoral candidate knows how to select the theoretical framework and methodology for independent scientific work.

LO 2.2. Doctoral candidate can identify relevant scientific and expert articles on a given topic.

3. PSYCHOMOTOR SKILLS

LO 3.1. Doctoral candidate can execute complex laboratory procedures, and analytical and numerical calculations using contemporary instrumentation and techniques.

4. SOCIAL SKILLS

LO 4.1. Doctoral candidate can communicate about the area of their expertise with colleagues, other experts, the broader scientific community and broader social community.

LO 4.2. Doctoral candidate can organise and participate in the work of a research team, and adapt to the conditions of the working environment with individuals and groups of different opinions and different cultural and ethnic backgrounds.

5. INDEPENDENCE

LO 5.1. Doctoral candidate can independently plan, organise and execute scientific research.

LO 5.2. Doctoral candidate can defend their hypothesis and methodology, and explain the results of their scientific work, both in writing and oral.

6. RESPONSIBILITY

LO 6.1. Doctoral candidate can responsibly execute scientific work and disseminate the results, while abiding by the highest ethical standards.

LO 6.2. Doctoral candidate can give a public interpretation of the general social significance of scientific findings from their field of expertise.

Structure of programme:

The primary component of the study programme is the research work, while classes, which are primarily held during the first year of study, serve students as preparation and facilitate their entry into research, as a means of gaining insight into the broader field.

The study programme is structured into eight distinctive modules:

1. Physics of elementary particles;
2. Nuclear physics;
3. Astrophysics;
4. Atomic, molecular and optical physics (AMO);
5. Condensed matter physics;
6. Biophysics;
7. Medical physics;
8. Geophysics.

Each of these modules has its specificities, though the share of the load through classes is approximately the same. Each module typically has one to two compulsory courses, then a compulsory seminar conceived as a “journal club”, and two to three elective courses (modules AMO and Biophysics have four elective courses, but only one compulsory course). The elective courses can also be taken in the second year of study, and it is possible to enrol in elective courses from other fields or other doctoral programmes, or they can be substituted with active participation in activities such as the international summer schools or workshops by guest professors. Upon passing the compulsory courses, the doctoral candidate can propose the topic of the doctoral dissertation, and becomes more intensively involved in research work, together with the supervisor and research group.

The study programme is completed with the defence of the doctoral dissertation. The candidate first presents the results of their research in the third year of study as part of the scientific seminar (doctoral seminar). Once the doctoral seminar is delivered (and suggestions made integrated), the doctoral candidate completes the dissertation and submits it for assessment. Prior to defending the dissertation, the candidate is required to have at least one internationally peer-reviewed scientific paper published, or accepted for publication, on a topic associated with the dissertation in which the candidate has given a significant contribution.

Pursuant to the recommendations of the European Association of Universities (the Salzburg II recommendations from 2010), the ECTS points system does not apply to this study programme. In structuring the study programme, care was taken to ensure that the classic course load for students do not exceed 20 %.

RECOMMENDATION BY THE EXPERT PANEL TO THE ASHE'S ACCREDITATION COUNCIL

Upon the completion of the re-accreditation procedure and the examination of the materials submitted (Self-Evaluation Report etc.), the visit to the higher education institution and interviews with HEI members in accordance with the visit protocol, the Expert Panel renders its opinion in which it recommends to the Accreditation Council of the Agency the following:

The Panel recommends **renewing the licence and label the programme as 'high quality'**. The recommendation is based on the consideration of 27 **high level of quality** indicators out of the 34 contained in the final assessment (79.4%), which is higher than 2/3. The Expert Panel considers the study programme to be a **high quality** programme.

RECOMMENDATIONS FOR THE IMPROVEMENT OF THE STUDY PROGRAMME

1. Reduce the variabilities in the structural PhD programme (protocols, assessments, involvement in teaching activities, final degree evaluation, etc.).
2. The students could be better formally trained in transferable skills (data management, project management, ethical issues, scientific writing).
3. Increase the number of students enrolled in the PhD programme with optimal financial support for thesis development during three to four years. The financial support should include open access publications and at least, support for a one short international stay with a duration of 3 months (minimum).

ADVANTAGES OF THE STUDY PROGRAMME

1. The quality of the research overall.
2. The new definition of the study programme (rules, procedures, courses, early definition of the thesis, etc.).
3. High level of satisfaction among the student body in terms of quality of supervision.

DISADVANTAGES OF THE STUDY PROGRAMME

1. Disadvantages of the study programme were not detected.

EXAMPLES OF GOOD PRACTICE

1. Examples of PhD theses (in English) were considered as good practice
2. Research in laboratories were considered as good practice.

COMPLIANCE WITH THE PRESCRIBED CONDITIONS FOR THE DELIVERY OF A STUDY PROGRAMME

Minimal legal conditions:	YES/NO notes
1. Higher education institution (HEI) is listed in the Register of Scientific Organisations in the scientific area of the programme, and has a positive reaccreditation decision on performing higher education activities and scientific activity.	YES
2. HEI delivers programmes in the two cycles leading to the doctoral programme, i.e., first two cycles in the same area and field/fields (for interdisciplinary programmes), and employs a sufficient number of teachers as defined by Article 6 of the Ordinance on the Content of a Licence and Conditions for Issuing a Licence for Performing Higher Education Activity, Carrying out a Study Programme and Re-Accreditation of Higher Education Institutions (OG 24/10).	YES
3. HEI employs a sufficient number of researchers, as defined by Article 7 of the Ordinance on Conditions for Issuing Licence for Scientific Activity, Conditions for Re-Accreditation of Scientific Organisations and Content of Licence (OG 83/2010).	YES
4. At least 50% of teaching as expressed in norm-hours is delivered by teachers employed at the HEI (full-time, elected into scientific-teaching titles).	YES
5. Student: teacher ratio at the HEI is below 30:1.	YES
6. HEI ensures that doctoral theses are public.	YES All information about the public defence of the topic to the final public defence of the dissertation are publicly available on the notice boards and website of Departments and PMF. Dissertations are publicly available in the FO library, the NUL (National University Library) repository and HEI repository at the website https://repozitorij.pmf.unizg.hr/en/ (up to the possible, but rarely used embargo of a maximum of 2 years following the defence).
7. HEI launches the procedure of revoking the academic	YES

title if it is determined that it has been attained contrary to the conditions stipulated for its attainment, by severe violation of the studying rules or based on a doctoral thesis (dissertation) that has proved to be a plagiarism or a forgery according to provisions of the statute or other enactments.	
Additional/ recommended conditions of the ASHE Accreditation Council for passing a positive opinion	YES/NO notes
1. HEI (or HEIs in joint programmes) has at least five teachers appointed to scientific-teaching titles in the field, or fields relevant for the programme involved in its delivery.	YES
2. In the most recent reaccreditation, HEI had the standard Scientific and Professional Activity marked as at least "partly implemented" (3).	YES
3. The doctoral programme is aligned with the HEI's research strategy.	YES
4. The candidate: supervisor ratio at the HEI is not above 3:1.	YES
5. All supervisors meet the following conditions: a) PhD, elected into a scientific title, holds a scientific or a scientific-teaching position and/or has at least two years of postdoctoral research experience; b) active researcher in the scientific area of the programme, as evidenced by publications, participation in scientific conferences and/or projects in the past five years (table 2, Supervisors and candidates); c) confirms feasibility of the draft research plan upon admission of the candidate (or submission of the proposal); d) ensures the conditions (and funding) necessary to implement the candidate's research (in line with the draft research plan) as a research project leader, co-leader, participant, collaborator or in other ways; e) trained for the role before assuming it (through workshops, co-supervisions etc.); f) received a positive opinion of the HEI on previous supervisory work.	a) YES (see attached Table 2) b) YES (see attached Table 2) c) YES. Recommendation of the potential future supervisor with framework research plan is suggested at the time of admission. Also, the potential supervisor must agree with the proposed topic of the doctoral dissertation, which must contain a detailed outline, methodology and research plan, and expected scientific contributions. d) YES. As a rule, the supervisor secures funding for the research, participation in scientific workshops and conferences, visits to foreign institutions, etc. through a scientific project (as leader or associate). e) YES. Supervisors regularly acquire experience by supervising graduate theses and informal co-supervision of dissertations with more senior supervisors of their research group. f) YES, as a part of reports of the HEI committees for the (re)appointment of supervisors into scientific-

	teaching titles, their supervision work is assessed separately.
6. All teachers meet the following conditions: a) holds a scientific or a scientific-teaching position; b) active researcher, recognized in the field relevant for the course (table 1, Teachers).	YES
7. The supervisor normally does not participate in the assessment committees.	YES
8. The programme ensures that all candidates spend at least three years doing independent research (while studying, individually, within or outside courses), which includes writing the thesis, publishing, participating in international conferences, field work, attending courses relevant for research etc.	YES
9. For joint programmes and doctoral schools (at the university level): cooperation between HEIs is based on adequate contracts; joint programmes are delivered in cooperation with accredited HEIs; the HEI delivers the programme within a doctoral school in line with the regulations and ensures good coordination aimed at supporting the candidates; at least 80% of courses are delivered by teachers employed at HEIs within the consortium.	Not applicable

QUALITY ASSESSMENT

	Quality assessment (“high level of quality” or “improvements are necessary”) and the explanation of the Expert Panel
1. RESOURCES: TEACHERS, SUPERVISORS, RESEARCH CAPACITIES AND INFRASTRUCTURE	
<p>1.1. HEI is distinguished by its scientific/artistic achievements in the discipline in which the doctoral study programme is delivered.</p>	<p>High level of quality The postgraduate doctoral study programme in Physics, at the Faculty of Science, University of Zagreb has scientific reputation in terms of quality of programme management, supervisors and teachers/researchers at the high quality standards in Europe, as well excellent recognition for the alumni.</p> <p>The total number of scientific papers published by employees of the Department of Physics over the past five-year period (from 1 Jan 2014 to 1 Dec 2018) was 744. These papers were cited a total of 12,460 times, and the corresponding h-index is 55 (according to Web of Science). The total number of scientific papers by employees of the Department of Geophysics, in this five-year period (from 1 Jan 2014 to 31 Dec 2018) was 99. These papers were cited 525 times, with an h-index of 11 (according to Web of Science). A significant number of manuscripts were published in top journals, such as Phys. Rev. Lett. (39 papers), Nature (3), Science (1), Nature Communications (5), Nature Physics (2), Science Advances (1), Physical Review A-E (142), etc. Some manuscripts have been written in collaboration with international recognised scientific institutions,</p>
<p>1.2. The number and workload of teachers involved in the study programme ensure quality doctoral education.</p>	<p>High level of quality The programme is being considered of high level of quality since the teaching workload of staff of PMF is exactly 50% of classes, while teachers from partner institutions (RBI and IF, with which PMF has signed cooperation contracts on teaching in doctoral studies) perform an additional 25%.</p>
<p>1.3. The teachers are highly qualified researchers who actively engage with the topics they teach, providing a quality doctoral programme.</p>	<p>High level of quality The programme is being considered of high level of quality since the average member of the programmes published 37.6 scientific papers in a five-year period (2014 – 2018),</p>

	<p>which have since been cited 1518 times. Most publications are relevant in the field.</p>
<p>1.4. The number of supervisors and their qualifications provide for quality in producing the doctoral thesis.</p>	<p>High level of quality</p> <p>The programme may be considered of high level of quality because since 2014, 129 supervisors have been appointed in the Doctoral studies in Physics, and they have supervised or are currently supervising a total of 160 dissertations, which makes 1.2 doctoral candidates per supervisor, which is a very acceptable workload. A very small number of supervisors have cases of unfinished (abandoned) doctoral dissertations. The dissertations have produced quality research. Over the past five-year period, supervisors have participated in an average of 2.3 international and 2.1 domestic projects, including COST projects, ERC and National Science Foundation projects. Most of the thesis resulted in a fair on number of publications.</p>
<p>1.5. The HEI has developed methods of assessing the qualifications and competencies of teachers and supervisors.</p>	<p>High level of quality</p> <p>The organisation of the doctoral programmes incorporates a committee that acts in accordance with the Ordinance on doctoral studies at the Faculty of Science, which prescribes the minimum qualifications for a supervisor, and which are founded on scientific excellence, and has been appointed into a scientific or scientific-education title. All supervisors are subjected to regular monitoring of scientific publications via the obligation to update the list of papers in the databases Google Scholar and Croatian Scientific Bibliography. The number of papers reported by the doctoral programme has been checked in SCOPUS for all supervisors and has found to be in the category of high level of quality.</p>
<p>1.6. The HEI has access to high-quality resources for research, as required by the programme discipline.</p>	<p>Improvements are necessary</p> <p>The available working area includes the premises of the Department of Physics, Faculty of Science (Bijenička c. 32), Ruđer Bošković Institute (Bijenička c. 54) and Institute of Physics (Bijenička c. 46). The visits to the research laboratories has proved supervisors and students to be involved in state-of-the-art research. The doctoral programme should increase the efforts in providing doctoral students with sustainable access to relevant databases. Therefore, improvements are necessary.</p>

2. INTERNAL QUALITY ASSURANCE OF THE PROGRAMME	
<p>2.1. The HEI has established and accepted effective procedures for proposing, approving and delivering doctoral education. The procedures include identification of scientific/ artistic, cultural, social and economic needs.</p>	<p>High level of quality</p> <p>The Doctoral Study in Physics is found within the very foundations of education focused on STEM fields, and is the only integral study of its kind in Croatia, and as such is very important for the execution of these strategies. The Doctoral Studies in Physics offers students the possibility to learn new methods and to work on top quality devices – virtually all the experimental equipment in Croatia is accessible to students via their supervisors and course teachers.</p> <p>As researchers, doctors of physics are employed at the Ruđer Bošković Institute, Institute of Physics, Institute for Medical Research and Occupational Medicine, and other institutions. Through their work at these institutions, doctors of physics give a significant contribution to the overall scientific activities in the Republic of Croatia. As experts, doctors of physics are also essential in professional institutions, such as the Croatian Hydrological and Meteorological Institute, and the Croatian Air Traffic Control, and in hospitals. In the private sector, doctors of physics are employed in the banking system, and in private companies associated with the development of new materials and technologies, computer sciences, ecology, and ionising and non-ionising radiation.</p> <p>Therefore, the Doctoral Studies in Physics has established regulations on launching and approving doctoral programmes in line with the regulations. The programme justification was documented, and included a thorough analysis of social, academic, economic or other needs of the community, therefore presenting high level of quality standards.</p>
<p>2.2. The programme is aligned with the HEI research mission and vision, i.e. research strategy.</p>	<p>High level of quality</p> <p>The strategic determinants of PMF are described in the fundamental document “PMF - Strategic programme of scientific research 2018-2022”, where the programme prove to be aligned with a quality research strategy, including the programme content and the choice of candidates and supervisors. For that, the Expert Panel considers that the programme is of high level of quality.</p>
<p>2.3. The HEI systematically monitors the success of the programmes through periodic reviews, and implements</p>	<p>Improvements are necessary</p> <p>The Doctoral programme has set the quality of the doctoral programme (ordinances, guidelines, procedures,</p>

<p>improvements.</p>	<p>well established practices etc.). The analysis is set mainly on productivity of research outputs and analysis of students' feedback. Such analysis, but, should consider a reduction of the variabilities in the structural PhD programme: protocols, assessments, involvement of students in teaching activities, and all definition and regulations of the final degree procedures and evaluation. The provided feedback from students should increase its effectiveness based on independent collection and return information to the supervisors. Therefore, improvements are necessary.</p>
<p>2.4. HEI continuously monitors supervisors' performance and has mechanisms for evaluating supervisors, and, if necessary, changing them and mediating between the supervisors and the candidates.</p>	<p>High level of quality The evaluation of the work of supervisors who are employees of PMF, and whose doctoral candidates are junior researchers (assistants) at PMF is performed according to the Ordinance on evaluating the work of junior researchers, post-graduate fellows and supervisors of PMF (adopted in 2017), by which the Council of the Department assesses the work of the (institutional) supervisor, once every two years. The assessment of the supervisor is part of the annual report that each doctoral candidate is required to write for each individual academic year. Each year, the supervisor is required to write a report on the work of the doctoral candidate. The success of the supervision process is also seen in the scientific production by the doctoral candidates, which in period 2014-2018 has averaged 3.1 journal papers per doctoral candidate.</p> <p>The mechanisms of monitoring and improving the quality of supervision have been checked; therefore, the following category is of high level of quality.</p>
<p>2.5. HEI assures academic integrity and freedom.</p>	<p>High level of quality Students of doctoral studies have the guaranteed right to the free expression of opinions on the doctoral studies, and giving suggestions on how to improve the studies, and that lecturers and other staff of doctoral studies treat them in accordance with the Code of Ethics of the University of Zagreb. The Faculty ensures the abidance of high ethical standards in scientific work. In their mutual relations, the student and supervisor, as members of the university community, are required to abide by the principles and rights from the Code of Ethics, University of Zagreb. The procedure of proposing the topic of the doctoral dissertation is aligned with the Ordinance on</p>

	<p>doctoral studies at the University of Zagreb, and with the Ordinance on doctoral studies of PMF.</p> <p>The Council of the Department of Physics or, for the geophysics module, Council of the Department of Geophysics, at the proposal of the Council for Doctoral Studies, appoints the committee for the assessment of the topic and proposal of the supervisor (the committee). The proposed supervisor, except in exceptional cases, may not be appointed as a member of the committee, but must be in agreement with the application. Therefore, the Panel considers that the HEI has procedures that assure academic integrity (prevent plagiarism and other forms of academic fraud) and freedom of research, under the consideration of high level of quality.</p>
<p>2.6. The process of developing and defending the thesis proposal is transparent and objective, and includes a public presentation.</p>	<p>High level of quality</p> <p>The doctoral programme has developed the procedures of producing and defending the doctoral thesis proposal (as described in an ordinance, or some other document); forms a committee, at least one member of which is external (from another institution); has created and published proposal templates and clear presentation guidelines (both have been made available to the Expert Panel).</p> <p>The process of developing and defending the thesis proposal is transparent and objective, and includes a public presentation, therefore the Panel considers the program of high level of quality.</p>
<p>2.7. Thesis assessment results from a scientifically sound assessment of an independent committee.</p>	<p>Improvements are necessary</p> <p>The Panel considers that the regulations at the later stage of presentation of the thesis are unclear and poor regulated, although transparent, and that the regulations should be defined.</p> <p>The Panel considers that the doctoral programme presents a poor regulation for the definition of the members of the committee and consider that the presentation of the thesis should include external members, possible external evaluation and without the consideration of including the thesis supervisor. Final scores refinement might be considered, for a final better assessment. Therefore, improvements are necessary.</p>
<p>2.8. The HEI publishes all necessary information on the study programme, admissions, delivery and conditions</p>	<p>High level of quality</p> <p>All relevant information is published on a separate notice board of the Department of Physics that is dedicated to</p>

for progression and completion, in accessible outlets and media.	doctoral studies. The Panel considers this indicator of high level of quality.
2.9. Funds collected for the needs of doctoral education are distributed transparently and in a way that ensures sustainability and further development of doctoral education (ensures that candidates' research is carried out and supported, so that doctoral education can be completed successfully).	<p>High level of quality</p> <p>The Panel has checked what tuition fees are spent on, and confirms that this complies with the regulations on using own and dedicated funds, i.e., to insure further development of the doctoral programme. Funds are horizontally distributed in some cases, with clear access to them by students in terms of attending international laboratories, assistance to international conferences and organising of the Symposium of doctoral candidates for doctoral studies. Since the system of funding is established with an effort of establishing partnerships, it is being considered of high level of quality.</p>
2.10. Tuition fees are determined on the basis of transparent criteria (and real costs of studying).	<p>Improvements are necessary</p> <p>The HEI explains the amount of the tuition fee when discussing the costs of studying, which is about 1100 EUR per student per academic year, and is usually paid by the researchers/Phd candidates. Therefore, improvements are necessary.</p>
3. SUPPORT TO DOCTORAL CANDIDATES AND THEIR PROGRESSION	
3.1. The HEI establishes admission quotas with respect to its teaching and supervision capacities.	<p>High level of quality</p> <p>The average annual enrolment to the Doctoral studies in Physics is 30.7 students. This is substantially lower than the supervisory capacity of the Departments of Physics and Geophysics of PMF. According to the attached table of supervisors, the current average ratio is approximately one doctoral candidate per supervisor (more precisely 1.2), which is lower than the recommended maximum candidates per supervisor. The teaching workload of supervisors do not exceed the legal thresholds. There are 90 lecturers involved in teaching in the Doctoral studies in Physics, and their course load is aligned with the current regulations.</p> <p>The capacities of supervisors and co-supervisors are clear, and well defined. Therefore, the indicator is being accomplished under the consideration of high level of quality.</p>
3.2. The HEI establishes admission quotas on the basis of scientific/ artistic, cultural, social, economic and other	<p>High level of quality</p> <p>The Strategic plan of the Croatian Ministry of Science and Education for the period 2019–2021 also lists the need to</p>

<p>needs.</p>	<p>increase the enrolment of students in STEM areas that are defined as key areas for driving the economy. This is aligned with the Development Plan for Research and Innovation Infrastructure in Croatia, especially the Smart Specialisation Strategy (S3) and Innovation Stimulation Strategy of the Republic of Croatia 2014 – 2020, which also serves as the national foundation for the priorities and objectives of the strategy for smart, sustainable and inclusive growth of the EU (EUROPA 2020). Outside of academics, physicists and geophysicists are employable in industry, the banking and finance sector, hospitals, IT sector and in R&D. For examples, geophysicists are especially employable in civil engineering and energy (renewable sources and fossil fuels), in environmental protection, health care, sustainable development, agriculture, transport, while physicists are employable in the financial and IT sectors, hospitals, and in technologically innovative companies.</p> <p>Based on this information and that collected from the interviews, the Panel considers that this indicator presents high level of quality.</p>
<p>3.3. The HEI establishes the admission quotas taking into account the funding available to the candidates, that is, on the basis of the absorption potentials of research projects or other sources of funding.</p>	<p>High level of quality</p> <p>The funds for candidates' research are clearly reported, some of them funded or co-funded by research projects, and some others from public source. In addition, some of the candidates will be long-term funded by contracts from the Departments involved, with candidates involved in teaching tasks. Load time dedicated to teaching does not overlap with time dedicated to research. The supervisors are involved with national and international projects that can largely benefit doctoral students. We consider the indicator of high level of quality.</p>
<p>3.4. The HEI should pay attention to the number of candidates admitted as to provide each with an advisor (a potential supervisor). From the point of admission to the end of doctoral education, efforts are invested so that each candidate has a sustainable research plan and is able to complete doctoral research successfully.</p>	<p>High level of quality</p> <p>This indicator is fully accomplished. The doctoral programme has a sustainable individual research plan for the students enrolled and a high percentage of them complete the doctoral research successfully. The advisor is considered to be responsible for monitoring the candidate's progress through the doctoral studies, until the thesis supervisor is official appointed. The advisor submits an annual report on the doctoral candidate's progress to the Council of the department. The Panel considers the indicator of high level of quality.</p>

<p>3.5. The HEI ensures that interested, talented and highly motivated candidates are recruited internationally.</p>	<p>High level of quality The Institution defines clear strategies based on communication settings to enrolled candidates abroad, and published the information both in English and Croatian. We consider the indicator of high level of quality.</p>
<p>3.6. The selection process is public and based on choosing the best applicants.</p>	<p>High level of quality The decision on enrolment is made by the Council of faculty departments, after clear calls for applications in a timely manner. The decision is also based by following the interview with the candidate, as a compulsory part of the selection procedure. Best applicants are enrolled in the doctoral programme under evaluation. Therefore, the programme is being considered as having a high level of quality.</p>
<p>3.7. The HEI ensures that the selection procedure is transparent and in line with published criteria, and that there is a transparent complaints procedure.</p>	<p>High level of quality The results of the selection procedure are announced on the website of the Faculty of Science, and the Department of Physics, using the identification codes assigned to applicants after their application. Notifications are also sent via electronic mail, together with brief instructions, which are also published on the website of the Department of Physics. There have been no appeals to decisions against the selection procedure in the last five-year period. The Panel considers this item as high level of quality.</p>
<p>3.8. There is a possibility to recognize applicants' and candidates' prior learning.</p>	<p>High level of quality Candidates have passed some of the courses offered in the Doctoral studies in Physics as part of prior education, therefore these courses maybe recognised on the basis of the written and substantiated request of the applicant by a decision of the Council for doctoral studies, at the proposal of the coordinator of the module. Furthermore, activities of the candidate that can contribute to attaining the relevant competencies (international summer/winter school, workshops by guest lecturers, etc.) are entered into the candidate's file, and at the proposal of the coordinator of the module, the Council for doctoral studies may approve that active participation in one or more of these activities may replace an elective course. Since criteria is clear, the Panel considers this item as high level of quality.</p>
<p>3.9. Candidates' rights and obligations are defined in relevant HEI regulations and a contract on studying that provides for a high level of supervisory and institutional support to the candidates.</p>	<p>High level of quality The Execution plan of the Doctoral studies in Physics regulates the rights and responsibilities of the doctoral candidate and the supervisor, and at the time of enrolment, the doctoral candidate signs the Study contract. This</p>

	contract regulates the student status, amount and deadlines for payment of tuition and other fees, and the rights and responsibilities of the contracting parties. Since criteria is consider by the doctoral programme, the Panel considers this item as high level of quality.
3.10. There are institutional support mechanisms for candidates' successful progression.	<p>Improvements are necessary</p> <p>The progression of the candidates, although regulated internally every year, should be regulated by some external council in order to fulfil independent and ethical considerations. The progression should be defined in terms of efficiency for clear durations of thesis, maximum of 4 (3+1) years for full time dedication, or 6 (5+1) years for part time dedication. Therefore, improvements are necessary.</p>
4. PROGRAMME AND OUTCOMES	
4.1. The content and quality of the doctoral programme are aligned with internationally recognized standards.	<p>High level of quality</p> <p>The programme is research oriented, with 80% of student effort being directed to research and this research effort starts from the point of commencement of the studies. The quality of the research is high, judging from publication records, theses, citations of publications. This is strong by international standards.</p> <p>The Panel were given titles of the modules offered on the programme and these are appropriately advanced. There is a high number of lectures associated with some of these modules. Web links were provided with more detailed descriptions of the module content.</p> <p>The Panel viewed samples of theses which were produced to a good standard in a traditional monograph style. The theses viewed were quite short in length, but length of thesis is not necessarily an indicator of quality of the work. Therefore, the Panel considers the indicator to have a high level of quality.</p>
4.2. Programme learning outcomes, as well as the learning outcomes of modules and subject units, are aligned with the level 8.2 of the CroQF. They clearly describe the competencies the candidates will develop during the doctoral programme, including the ethical requirements of doing research.	<p>Improvements are necessary</p> <p>The programme learning outcomes are clearly outlined in the SER and are appropriate. These are mapped in a table indicating where the student can engage in such learning. Learning outcomes for individual modules were not clear in all of the module descriptions provided at the web links, but the overall content of those modules was appropriate for the discipline areas in which the programme is covered. The Panel was informed that there had been an updating of the content of the modules.</p>

	<p>It appears that the 'soft skills' element of the programme are delivered in a less formal manner. Current students indicated that they would like some formal delivery on topics such as project planning, research ethics, and data analytics. Therefore, improvements are necessary.</p>
<p>4.3. Programme learning outcomes are logically and clearly connected with teaching contents, as well as the contents included in supervision and research.</p>	<p>High level of quality The programme-level learning outcomes are set out in the SER and mapped to elements of the doctoral programme, and what is presented is sensible. Current students and alumni indicated support for the reduced amount of course material in the revised programme. Overall, these current students and alumni stated that the content of the modules they had taken was appropriate for the discipline areas involved.</p>
<p>4.4. The doctoral programme ensures the achievement of learning outcomes and competencies aligned with the level 8.2 of the CroQF.</p>	<p>High level of quality The SER concentrates on the achievement of the research outputs of the programme and these are of a high quality, as evidenced by the sample of theses and publications viewed through the portal link provided. The Panel also viewed samples of thesis project proposals and the assessment of these proposals. The high quality of the research outputs from the students indicates that the learning outcomes are achieved. Therefore, the Panel considers the indicator to have a high level of quality.</p>
<p>4.5. Teaching methods (and ECTS, if applicable) are appropriate for level 8.2 of the CroQF and assure achievement of clearly defined learning outcomes.</p>	<p>High level of quality Through elective courses, students in the programme come into contact with modern, current, important topics at the highest level. Activities in elective courses often include student seminars, while experimental courses include work in the laboratory. The teaching methods are individualized and flexible in terms of number of students involved in each teaching module. Therefore, the Panel considers the indicator to have a high level of quality.</p>
<p>4.6. The programme enables acquisition of general (transferable) skills.</p>	<p>High level of quality The programme defines enough courses for doctoral students to acquire transferable skills, which are later on practically presented in terms of assistance to congresses, presentations, etc. Therefore, the Panel considers the indicator to have a high level of quality.</p>

<p>4.7. Teaching content is adapted to the needs of current and future research and candidates' training (individual course plans, generic skills etc.).</p>	<p>High level of quality Thanks to a large number of different courses (24 compulsory and 73 elective), students are able to choose from a wide selection of electives. They are required to pass, on average, 2 compulsory courses and 2 – 3 elective courses, which can also be substituted for their active participation in summer schools.</p> <p>In addition, students might have the possibility to enrol in courses from other doctoral studies. Formal individual annual work plans of the doctoral candidate are often a compulsory part of the applications for financing the work position of doctoral candidates. For all of that consideration, the Panel considers the indicator to have a high level of quality.</p>
<p>4.8. The programme ensures quality through international connections and teacher and candidate mobility.</p>	<p>High level of quality Lecturers in doctoral studies and the doctoral candidates have a wide range of opportunities available for international mobility, which result from the notable efforts of the doctoral programme to enhance and foster internationalisation. Many supervisors have established long-term cooperation with foreign universities, and such cooperation forms the main channel for the research mobility of doctoral candidates. International collaboration has been established by the doctoral programmes for best possibilities for the doctoral students. Therefore, the Panel considers the indicator to have a high level of quality.</p>

*** NOTE: RECOMMENDATIONS OF THE EXPERT PANEL TO THE ASHE'S ACCREDITATION COUNCIL AND QUALITY LABEL**

The role of the Expert Panel in the re-accreditation of doctoral study programmes is manifold. The Expert Panel or part of the Expert Panel visiting a higher education institution drafts a report on the basis of a self-evaluation report, the accompanying relevant documentation, and a site visit to HEI. The draft report is adopted by all members of the Cluster Expert Panel, while the president of the Cluster Expert Panel is responsible for coordinating the assessment levels.

The report contains an assessment on whether a doctoral study programme delivered at a higher education institution complies with the prescribed laws and by-laws, as well as any additional/recommended requirements defined by the Agency's Accreditation Council, and whether a higher education institution can obtain a positive, i.e. satisfactory quality assessment according to the criteria set out in this document. Moreover, the Expert Panel must make recommendations for quality improvement.

Based on the assessment of all these elements, the Expert Panel may propose to the Accreditation Council of the Agency to issue either a confirmation on compliance, a letter of expectation for the period up to three (3) years in which period the higher education institution should eliminate the identified deficiencies, or to deny the license.

If the Expert Panel has assessed that a doctoral study programme delivered by a higher education institution does not meet legal and other requirements or that the quality of a study programme is not ensured (i.e. that HEI does not meet additional requirements or recommendations made by the Accreditation Council, or has a very poor quality assessment), they should propose to the Accreditation Council to deny the license.

If the Expert Panel considers that the relevant laws and bylaws have been met by a higher education institution, but that certain elements mentioned above do not meet the quality requirements, while they consider that the identified shortcomings can be corrected within a time frame of three years, they should issue a letter of expectation.

If the Expert Panel considers that all legal and additional/recommended requirements have been met and the quality assessment is satisfactory, i.e. that a study programme fulfils the learning outcomes appropriately defined for that level and scientific area, they may propose the issuance of a certificate and have a HEI commit to quality improvement and reporting to the Agency during the follow-up period.

Finally, if the Expert Panel has, in accordance with the criteria mentioned above, proposed issuing the certificate of compliance and assessed that, in addition to meeting the minimum quality requirements – i.e. the qualification framework level - for a study programme, the programme should be identified as a doctoral programme of a 'high level of quality', the Expert Panel may propose to the Agency's Accreditation Council that such a doctoral study programme be awarded the 'high quality label'. Thus the Agency, with the consent of the Accreditation Council, grants a higher education institution the right to use the label for their academic and promotional purposes.

The 'high quality label' cannot be proposed or awarded to a programme or a higher education institution that does not comply with the requirements laid down by the laws and bylaws mentioned

in this document, and any additional requirements recommended by the Accreditation Council. Moreover, the quality assessment awarded to a study programme should reflect a high level of quality inasmuch that at least half of the sub-criteria in each of the quality assessment criteria are assessed as being of high quality. The Accreditation Council of the Agency issues a final opinion on the label awarded. The content and form of the quality labels shall be prescribed by the Agency in a relevant general act.

The Accreditation Council of the Agency discusses the final report with all recommendations and suggestions, and issues their opinion on the report. Based on a prior opinion of the Accreditation Council, the Agency issues an Accreditation Recommendation to the minister responsible for science and higher education, and upon receipt of the minister's final decision on the outcome of the procedure, awards the 'high quality label' to a higher education institution.