Research Doctorate (PhD) in Quantum Technologies

PhD educational program – 40^{h} cycle, and still active cycles

This document describes the structure and organization of the PhD program in **Quantum Technologies.** The educational program is mainly defined by the *requirements* for its successful completion and thus for acquiring the Italian degree of "*dottore di ricerca*" (research doctor), equivalent to the international PhD degree. Besides the requirements, in this document you will find some general indications about the graduate courses and other educational aspects you should know about.

I. Outline of the program

The normal duration of the PhD program is three years. Only if the doctoral dissertation requires further work it is possible postpone the thesis defence by 6 months (not extending the fellowship).

The official language of the program is English. All courses specifically offered for the PhD program are given in English. The final dissertation or thesis must be written in English. The intermediate reports and seminars must be in English.

By the end of each PhD academic year, every graduate student will write a report on his/her study and research activities *and normally he will also present his/her research activity in a seminar*. At the end of every PhD academic year, the program Faculty Committee will decide on the admission to the subsequent year and, in the third year, to the final examination. During the three years, but preferentially at the beginning of the program, *all graduate students have to perform some coursework* and pass the corresponding exams. Normally *by the end of the first year, each graduate student will have to define his/her research plan for the final dissertation and choose an advisor* (also called "tutor"). During the three years of the program all PhD students must have *at least one experience of contact with the international scientific community*, such as a period spent in some research group abroad or attending an international conference or scientific school.

The results of the research performed during the PhD program must be reported in the doctoral dissertation (or thesis). This dissertation will be the main subject of evaluation in the final examination (or dissertation "defence") for the awarding of the research doctor's degree.

II. Detailed requirements for the program completion

There are *three formal requirements* which must be satisfied in order to be qualified for the final examination of the PhD program:

1) Research activity requirement.
2) Coursework requirement.
3) International experience requirement.

Although these three requirements must be satisfied only by the end of the third year, there will be a formal verification of progress every year. In case of inadequate progress, the Faculty Committee governing the program may propose to the Rector the dismissal of the student.

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1) Research activity requirement

Every PhD student shall carry on research activity in first person, if possible for all the three years of the program and anyway for not less than two years. Motivation, methods and final results of this activity will be described in the doctoral dissertation or thesis.

The student activity will be supported and evaluated in the following way:

- By the end of the first academic year the PhD student shall present his/her research plan in the first-year report and in a short seminar, to be given in English. The Faculty Committee will then approve the proposed plan, or sometimes propose modifications.
- By the end of the first solar year of the program (that is by the end of December), the Faculty Committee will assign an advisor (also called "tutor") to the PhD student. The advisor must be an experienced scientist who will advise the student and supervise his/her research work.
- *Before the end of the second year, the Faculty Committee will select two additional Department faculty members, or external scientists, hereafter named "referees", who will evaluate the student progress and provide him/her with further advise. The advisor and the two referees jointly form the so-called "internal PhD committee" associated with the candidate. To guarantee independent judgment, both referees, at the time of their selection, should not be collaborating directly with the student and therefore should not be anticipated to co-author papers with him/her.*
- By the end of the second and third years (normally in October), the PhD student shall present his/her research work in a seminar, to be given in English, at the presence of the internal PhD committee and of other interested faculty and students. Moreover, the PhD student shall write a report of all his/her research and study activity. Based on these seminars and on other occasions of interaction with the PhD candidate, at the end of the second and third years the two referees and the advisor will each submit to the Coordinator a short written assessment of the student activity progress and results. At the end of the second academic year, the Faculty Committee, based on the opinions of the advisor and of the referees and on the student's report, will deliberate on his/her admission to the third year of the program.
- At the end of the third academic year, the Faculty Committee, based on the opinions of the advisor and of the referees and on the student's report, will determine if he/she qualifies for the final examination and approve an overall assessment of the PhD candidate work to be submitted to the final examination committee. Should the two referees and the advisor be in strong disagreement on their evaluation, the Coordinator will ask them to meet and try to reach a consensus. If the disagreement is not resolved, the Coordinator will seek advice from additional referees.
- If the Faculty Committee determines that the candidate does not qualify for the final examination, it may propose him/her to postpone by one year the final examination in order to improve and complete the work (but the fellowship will not be extended).
- The final examination is organized according to the current University regulation. This prescribes that a three members committee be formed, with one internal (but not a member of the Faculty Committee) and two external members (that is coming from other Italian or foreign universities), sometimes integrated with up to two experts from other research organizations. The committee is designated by the Rector after hearing the Faculty Committee.

2) Coursework requirement

Coursework and supervised reading are quantified in credits. The definition is 1 credit = 20 hours of overall work of the average student (assuming an adequate preparation from the Master's degree). In standard graduate courses, this typically amounts to about 5 hours of lecturing per credit (excluding discussion sections). In order to acquire the credits associated to a course, a student must pass the corresponding examination. The credits associated to a given course will be recognized to the student after the Coordinator receives formal communication from the course advisor on the number of attended lecture hours and on the final examination success.

Every student will propose his/her study plan to be approved by the Coordinator at the very beginning of every year. Modifications to the study plan can be anyway proposed by the student every year. The PhD student will also transmit to the Coordinator the list of courses he/she attended during the Laurea Magistrale or equivalent graduate programs (such

as Master of Science, Master of Technology, Master of Philosophy, etc.), as this is needed to provide the Coordinator with the complete picture of the planned education.

By the end of the three years PhD program, *every student must have acquired not less than 18 credits of sufficiently advanced coursework or supervised study in physics or in quantum technologies.* It is strongly recommended to complete at least 12 credits during the first year and the remaining 6 by the end of the second year, so as to leave the third year totally free for research.

Attending *scientific schools* can be counted toward the coursework requirement only previous approval of the PhD Committee. A scientific school will be organized every year by Research Doctorate in Quantum Technologies itself. In all cases, the number of credits ascribed to each activity is decided by the PhD Committee. In the case of courses offered for the Laurea Magistrale within our Universities, the number of credits attributed for the PhD will be also decided by the PhD Committee.

3) International experience requirement

Every PhD student shall have during the three year program at least one experience of direct and personal contact with the international scientific community among the following ones: (i) a visit for research purposes in a group or laboratory abroad for at least two weeks; (ii) attending an international scientific school of at least 3 days (for the purposes of this requirement, it is enough to obtain an attendance certificate from the school, without a final examination; the latter is needed if one wants to use it also for the coursework requirement); (iii) attending an international conference and presenting in person a research result (oral or poster presentation).

III. Teaching assistance (TA)

If they wish (it is strictly *optional*), the PhD students are allowed to be involved in *teaching assistance* (TA) activity for *no more than 50 hours a year*. The Laurea program in Physics may assign some TA jobs (for up to 40 hours) to PhD students, but only if they are in their second or third year. Other programs may have different rules and the PhD student must contact the program director for more information about opportunities. Most TA jobs are not paid. The TA activity will be mentioned in the final report of the Faculty Committee to be sent to the final examination committee, but it will not affect the judgment on the research and coursework activity of the student.

IV. Activity logbook

Every PhD student shall keep a detailed (electronic) logbook of all his/her educationally-relevant activities carried on during the PhD program. This is needed for doing a complete and accurate reporting when requested (at least once a year). The information items that must be recorded are the following:

1. Courses attended, with the indication of the course title, lecturer, date of examination passing and final mark.
2. Seminars and talks attended (for each talk, indicate: name of the speaker, title, date and location [not the room, just the university and department] of the seminar).
3. Research visits at other universities, research organizations, companies, etc. (indicate: name of the organization, location, dates of the visit).
4. Meetings, workshops and conferences which have been attended AND where the student has personally presented his/her own work (title of the meeting, date, location, and international/national character of the meeting).
5. Meetings, workshops and conferences which attended WITHOUT personally presenting personal work (title, date, location, and international/national character of the meeting). This item includes also those conferences where someone else has presented a work of which the student is co-author.
6. List of publications co-authored by the student and which resulted from the student's work within the PhD program.
7. List of communications to conferences co-authored by the student (including the conferences already mentioned above).
8. Possible teaching assistance performed by the student (only official jobs, others are not allowed).
9. Any other relevant activity the student thinks worth recording.

V. Course offering and other possible educational activities for the PhD program

Courses will be given at three different locations corresponding to the partners of the PhD program, University of Napoli Federico II, University of Camerino and CNR-Firenze. The PhD students may choose the courses to be attended mainly (but not exclusively) from the following list:

Camerino (location: Scuola di Scienze e Tecnologie, Sezione di Fisica, via Madonna delle Carceri, 9B - Camerino MC)

1c) Topics in Condensed Matter Physics
2c) Quantum Computation
3c) Introduction to Topological Quantum Computation
4c) Quantum Annealing and Quantum Monte Carlo Algorithms
5c) Quantum Programming Languages
6c) Dynamics of open quantum systems

Napoli-Unina & CNR (location: Dipartimento di Fisica E. Pancini, Compl. universitario M.S. Angelo, Via Cintia - Edificio 6 - 80126 – Napoli)

1n) Quantum Algorithms
2n) Introduction to Quantum Information
3n) Quantum Superconducting Technologies: Principles, Engineering & Interfaces part 1
4n) Quantum Superconducting Technologies: Principles, Engineering & Interfaces part 2
5n) Quantum Communication
6n) Solid State qubits

CNR-Firenze (location: CNR-INO Sede Centrale, L.go Enrico Fermi 1, Firenze)

1f) Quantum photonic technologies
2f) Quantum Simulations with Atoms
3f) Quantum metrology and sensing

Courses can be also attended on streaming and will be recorded.

Besides these courses offered from the Departments of Physics, you may explore the course catalogues of other Departments and Doctorate Schools in the Universities of Napoli Federico II and Camerino or even in other universities, if matching the interests of the PhD program and prior to approval of the PhD committee.