POLITECNICO DI MILANO

PhD in MODELLI E METODI MATEMATICI PER L'INGEGNERIA / MATHEMATICAL MODELS AND METHODS IN ENGINEERING - 40th cycle

Number of scholarship offered	3
Department	DIPARTIMENTO DI MATEMATICA

Description of the PhD Programme

PhD in Mathematical Models and Methods in Engineering Research Description of the research area.

All Candidates interested in developing their research in one of the areas of interest of the members of Department of Mathematics (see http://www.mate.polimi.it/index.php?view=ricerca) are invited to apply.They will be allowed to choose their specific research topic when the admission procedure will be completed. It should be noted that the number of offered scholarships may be increased before the end of the selection process. The PhD program Mathematical Models and Methods in Engineering aims at training young researchers by providing them with a strong mathematical background and with the ability to apply their knowledge to the solution of real-world problems arising in various areas of science, technology, industry, finance, management, whenever advanced methods are required in analysis, design, planning, decision and control activities. PhD students carry their research both in the development of new mathematical methods and in the implementation and improvement of advanced techniques in connection with specific contexts and applications. Further information can be obtained by consulting the dedicated website http://www.mate.polimi.it/dottorato

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THEMATIC Research Field: EMERGENCE OF A CLASSICAL BEHAVIOR IN QUANTUM FIELD MODELS

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Semiclassical analysis plays a crucial role in several aspects of the mathematics of quantum systems. The correspondence principle is indeed a fundamental check for any theory aiming at describing quantum physics and the development of a rigorous quantization procedure for relativistic interacting systems with infinitely many degrees of freedom is perhaps the foremost open problem in contemporary mathematical physics. In recent years, the field of semiclassical analysis has seen many important developments (see, e.g [1, 2]), focusing on establishing the correspondence principle for ground states, equilibrium states, and dynamically evolved states for various models of physical interest. Among these results, let us single out [3], where quantization and the correspondence principle were used to define the classical dynamics of extended charges in interaction with the electromagnetic field, without resorting to any a priori knowledge on the classical system, apart from uniqueness of the eventual solution. This result serves as a proof of concept of the possibility of taking a quantum detour in studying classical mechanics: since in quantum mechanics interactions, such as Coulomb's, are better behaved than classically, one might be able to define the classical trajectories by lifting the classical initial condition to a quantum state, make the latter evolve, and then look at its classical limit.The project tackles three different

	questions:*Fröhlich's polaron dynamics.* The model describes a quantum charge moving through a crystal, polarizing its components in its motion and thus interacting with the phonon field. Since the Coulomb type self-interaction effectively acting on the particle is too singular at the classical level, we aim to define a classical polaron dynamics using the well-posedness of the quantum dynamics and the correspondence principle.*Quasi-classical fermions interacting through a force field.* The fundamental physical models of high-energy physics are constituted by fermionic matter interacting through a bosonic force field. This track will focus on studying the quasi-classical limit of such models.*A quantum detour for the classical derivation of the Vlasov equation.* The problem of deriving the Vlasov transport equation in the large number limit of classical Newtonian particles interacting through a potential is attracting a lot of attention. The derivation in the most physically interesting case of the Coulomb potential is still open and we aim to study it taking advantage of the regularizing features of quantum interactions. The topics belong to the project "Dipartimento di Eccellenza 2023-2027" - line 3 (https://www.mate.polimi.it/eccellenza/?p=4)[1] Z. Ammari, F. Nier. Ann. H. Poincaré 9 (2008).[2] M. Correggi, M. Falconi, M. Olivieri. J. Eur. Math. Soc. 25, (2023).[2] Z. Ammari, M. Falconi, F. Hiroshima. Ann. Inst. Fourier (2024).
Methods and techniques that will be developed and used to carry out the research	The result proven in [AFH] serves as a proof of concept of the possibility of taking a quantum detour in studying classical mechanics: since in quantum mechanics interactions, such as Coulomb's, are better behaved than classically, one might be able to define the classical trajectories by lifting the classical initial condition to a quantum state, make the latter evolve, and then look at its classical limit through the correspondence principle. Furthermore, in [CFO23], the authors developed quasi-classical analysis, a form of semiclassical analysis suited for the study of bipartite systems consisting of one part that remains quantum (referred to below as "the particles"), and another that behaves semiclassically

	(referred to below as "the field"). The typical physical application is that of a quantum system subjected to a classical force, e.g., a classical magnetic field, or an optical trap: such classical "external force" emerges in the quasi-classical limit from the fully quantum interaction of the particles and the field.
Educational objectives	Besides the scientific goals described above, the main objectives of the educational plan coincide with those of the PhD program in Mathematical Models and Methods in Engineering (see the dedicated website http://www.mate.polimi.it/dottorato).
Job opportunities	Job opportunities are in Italian or international universities, companies and research agencies which are leaders in their respective fields.
Composition of the research group	1 Full Professors 4 Associated Professors 1 Assistant Professors 5 PhD Students
Name of the research directors	Marco Falconi

Contacts
marco.falconi@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)			
Housing - Foreign Students	**1st year**	**2nd year**	**3rd year**
	1000.0 € per student	0.0 € per student	0.0 € per student
	max number of financial aid available: 3, given in order of merit ..		
Housing - Out-of-town residents (more than 80Km out of Milano)	--		

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): financial aid per PhD student per year 1st year: max 1.902,40 euros

1st year: max 1.902,40 euros
2nd year: max 1.902,40 euros
3rd year: max 1.902,40 euros

The PhD students are encouraged to take part in activities related to teaching, within the limits allowed by the regulations.1 individual PC per student +several shared PC.Access to one cluster with 32 processors and 384 GB RAM, and to several multi - processor servers.

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OPEN SUBJECT Research Field: MATHEMATICAL MODELS AND METHODS IN ENGINEERING

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€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	All candidates interested in developing their research in one of the areas of interest of the Department of Mathematics (see http://mate.polimi.it/index.php?view=ricerca) are invited to apply for the grants in this area. The candidates will choose their specific research topic when the admission procedure is completed.
Methods and techniques that will be developed and used to carry out the research	The PhD program aims at training young researchers by providing them with a strong mathematical background and with the ability to apply their knowledge to the solution of problems that may arise in various areas of science, technology, industry, finance, management, whenever advanced methods are required in analysis, design, planning, decision and control activities.
Educational objectives	The PhD students carry their research in the development of new mathematical methods and/or in the implementation and improvement of advanced techniques in connection with specific contexts and applications. Further information can be obtained by consulting the dedicated website http://www.mate.polimi.it/dottorato
Job opportunities	Job opportunities are in italian or international universities, companies and research agencies which are leaders in

	their respective fields.
Composition of the research group	28 Full Professors 52 Associated Professors 44 Assistant Professors 50 PhD Students
Name of the research directors	Michele Correggi

Contacts
Program Chairman: Professor Michele Correggi e-mail: michele.correggi@polimi.it phone:+390223994523 https://sites.google.com/view/michele-correggi

Additional support - Financial aid per PhD student per year (gross amount)			
	1st year	**2nd year**	**3rd year**
Housing - Foreign Students	1000.0 € per student	0.0 € per student	0.0 € per student
	max number of financial aid available: 3, given in order of merit ..		
Housing - Out-of-town residents (more than 80Km out of Milano)	--		

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): financial aid per PhD student per year 1st year: max 1.902,40 euros per student 2nd year: max 1.902,40euros per student 3rd year: max 1.902,40 euros per student. The PhD students are encouraged to take part in activities related to teaching, within the limits allowed by the regulations.1 individual PC per student +several shared PC. Access to one cluster with 32 processors and 384 GB RAM, and to several multi-processor servers.