POLITECNICO DI MILANO

PhD in MODELLI E METODI MATEMATICI PER L'INGEGNERIA / MATHEMATICAL MODELS AND METHODS IN ENGINEERING - 38th cycle

THEMATIC Research Field: MULTISCALE MODELING OF PARTIAL DISCHARGES AND TREEING

Monthly net income of PhDscholarship (max 36 months)
€ 1325.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch, during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The need for the decarbonization of the energetic system has driven a further development of the electric transmission and distribution system. Electric power will be an increasingly key component of our future and its reliability is a very important topic. This depends critically on the ageing of dielectric insulating components, as they are the weakest point of the electric system.Insulating components can be based on gases, liquids or solids. In fact, solid polymers, such as polyethylene, have become one of the best choices as they are, in general, greener and cheaper than other solutions. One of their main drawbacks however, is that the ageing of insulating polymers can hardly be determined and, therefore, it is difficult to estimate the residual life of these kinds of materials. One of the main problems is electrical treeing: a complex and self-propagating internal defect which involves the interaction of small electrical discharges, also known as partial discharges (PDs), with a polymeric surface.The prediction of the evolution of the treeing has been an open problem for decades due to its physical complexity. Our aim is to shed a light on this phenomenon through numerical modelling and simulation.
Methods and techniques that will be developed and used to carry out the research	RSE (Ricerca sul Sistema Energetico) has been developing for several years a model of the evolution of

	the treeing based on first principles and the solution of a set of PDEs which describe the evolution of charged particles in a discharge plasma, and their interaction with a polymeric material. The existing simulation tools, due to the computational cost, are able to simulate only very short periods of times comparable to the ones of plasma evolution. Moreover, due to the geometric complexity of the treeing, it is currently possible to simulate only very small structures.This project aims at improving both aspects, allowing for longer simulation times and more complex structures by applying suitable multiscale techniques and enhancing the numerical methods implemented in the actual simulation code. We will investigate the benefit of hybrid dimensional models (3D-1D coupled PDEs) and the possibility of employing neural networks. [1] Villa A. et al, *An uncoupled implementation of the local mean energyplasma model,* JCP (2021) [2] Villa A. et al, *Simulation of surface-plasma interaction with high surfaceconductivity*, JCP (2022) [3] Villa A. et al, *Discretization of Poisson¿s equation in two domains with nonalgebraic interface conditions for plasma simulations*, **Appl Math Comput (2021)**
Educational objectives	The collaboration between PoliMi and RSE will allow the student to learn some of the most modern and effective numerical techniques used in complex physical problems. The student will follow courses offered by the Ph.D. School of Politecnico and be in contact with a research team in RSE where several skills are available: chemistry, parallel computing, electrical engineering. RSE will also offer access on a dedicated parallel computing machine.
Job opportunities	The research addresses timely, innovative, and advanced topics in Numerical and Computational Modeling.The expertise acquired during the Ph.D., which covers numerical modeling, data analysis, and computer simulations, as well as the experience as an intern in an important center in the energy sector, will provide opportunities for positions in any industrial areas where computational skills and problem-solving attitudes are appreciated. The innovative aspects of the research may

	also open up possibilities for a career in Academia or in RSE where there are several research groups who need a modelling support.
Composition of the research group	8 Full Professors 14 Associated Professors 12 Assistant Professors 27 PhD Students
Name of the research directors	Anna Scotti

Contacts
Responsabili Scientifici (Politecnico di Milano): anna.scotti@polimi.it, luca.formaggia@polimi.it *Referenti scientifici (RSE): Andrea Barbareschi Villa [Andrea.Villa@rse-web.it]*

Additional support - Financial aid per PhD student per year (gross amount)			
	1st year	**2nd year**	**3rd year**
Housing - Foreign Students	1500.0 € 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	662.5 €
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 year1st year: max 1.800,47 euros 2nd year: max 1.800,47 euros 3rd year: max 1.800,47 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 and 1 individual desk per student are granted.