POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 38th cycle

Research Area n. 1 - Advanced Materials and Smart Structures

PNRR_352 Research Field: OPTIMAL CONTROL OF ERCH LAUNCHING AND POLARIZING MIRRORS FOR MICROWAVE ABSORPTION OPTIMIZATION

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	The real-time control of Electron Cyclotron Resonance Heating (ECRH) launchers is a key feature of modern tokamaks, as it enables the suppression a class of plasma instabilities called Neoclassical Tearing Modes. These devices are used to direct high power microwave beams to a moving target in the plasma, by means of steerable launching mirrors. To produce the desired results, the microwave must be efficiently absorbed by the plasma, which requires the beams to be properly polarized. This is obtained by controlling the inclination of a pair of corrugated polarizing mirrors. The real-time control of the launching and polarizing mirrors must be synergic, as the optimal polarization direction depends on the launching direction. This motivates the need for coupled control of launching and polarizing mirrors by a single controller. The Italian project Divertor Tokamak Test (DTT) will be the context for this research. The ECRH plant of DTT, the most powerful in the world at the time of its completion, will need proper polarization control for guaranteeing both, efficient machine operation and structural safety to the internal walls. The research is coherent with missions M2C2: ENERGIA RINNOVABILE, IDROGENO, RETE E MOBILITÀ SOSTENIBILE and M4C2: DALLA RICERCA ALL'IMPRESA of PNRR.

Methods and techniques that will be developed and used to carry out the research	The core activity will be the development of high-level control strategies for the optimization of microwave absorption by synergic control of launching and polarizing mirrors. This goal will be reached by combining the models that describe plasma dynamics with control theory. The candidate will be asked to build on state-of-the-art control strategies to develop a dedicated and efficient algorithm for ECRH systems, based on the knowledge of tokamak parameters. Being the system highly nonlinear, nonlinear control logics will probably provide better performance, but also more traditional approaches will be assessed.
Educational objectives	The candidate will gain expertise in the field of controlled nuclear fusion. Given the main goal of synergic control of launching and polarizing mirrors for maximization of microwave absorption, the activity can be broken down in the following intermediate steps: selection of actuators and mechatronic design of the driving mechanism of DTT polarizing mirrors; development or improvement of local control loops for launching polarizing mirrors; implementation of local control algorithms in DTT specific software and hardware; in case of a collaboration with EPFL, the analysis of the absorption response of the plasma for some imposed polarization trajectories, aimed at building a database to be used in the control algorithms; development of high-level control algorithm for launching and polarizing mirrors synergic control; implementation of high-level control algorithm in DTT specific software and hardware. As a secondary objective, the PhD candidate will have to take into consideration the foreseen developments in the fusion field (ITER, DEMO, etc.) when choosing among design possibilities, so that the designed logic is relevant for future research.
Job opportunities	The PhD candidate will build a significant experience in the field of ECRH launchers design and control by working especially with ENI, ISTP/CNR and other partners of DTT organization. These institutes represent the main job opportunities. However, fusion research and ECRH design has gained momentum in the last decades, and

	many research centres around the world need experts in the field. Moreover, as fusion electricity gets closer and closer to becoming reality, private companies (like ENI) are gaining interest in the subject and may be interested in hiring experts. Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field.
Composition of the research group	1 Full Professors 2 Associated Professors 2 Assistant Professors 1 PhD Students
Name of the research directors	Prof. Francesco Braghin

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
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

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	ENI S.p.A.
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	École Polytechnique Federale de Lausanne (EPFL)
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Financial aid is available for all PhD candidates (purchase of study books and materials, fundingfor participation in courses, summer schools, workshops and conferences) for a total amount of euro 5.707,13.

Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.