ENERGETICS

DM 630/ENEA - Core neutron kinetics of a lead-cooled Advanced Modular Reactor

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] ENEA - Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile [P.iva/CF:00985801000]
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Context of the research activity	One of the new frontiers of nuclear engineering R&D are the so-called Advanced Modular Reactors (AMR), which promise increased safety and sustainability while maintaining economic competitiveness thanks to compactness and modularity. The Italian research and industrial communities have invested for decades in the development of these. This PhD project aims at advancing the design maturity of lead-based AMRs, with a focus on the neutron dynamics of the core, accounting for power modulations and transient situations of interest for safety and control. The project is co-financed in the framework of the Italian PNRR – DM 630/2024 - CUP E14D24002370004
	The research project focuses on the development of methodologies and codes for the dynamic analysis of the neutronics of the core of a lead-based AMR to study, on the one hand, the transient response following postulated initiating events of interest, and on the other hand the linear stability and in general the expected behaviour in the start-up and power transition phases. The focus will be aimed both at cases in which a 0-dimensional approach (point kinetics) may be sufficient, and at situations in which a 3-dimensional in-depth analysis is required. The activity unfolds on a dual track with a part more linked to analysis with reference calculation tools and a part more linked to the development of methodologies and software. For activities related to the analysis side, it is cited, by way of example, the study of incidental transients in which local effects can have global implications (e.g., spurious extraction of a control rod or coolant blockage of a fuel element), for which the use of consolidated and refined calculation tools is necessary to capture all the space-time complexity of the phenomena at play. For activities related to the development side, the focus is first on establishing

Objectives	a sound models and methodologies to tackle the problems of interest and then to translate them into the creation of flexible and reliable computational tools. The situations of interest include linear stability analysis in the various envisaged operating regimes and, more in general, the response of the system in the transition between nominal states, in order to inform the space design of reactor monitoring and control systems. These tools will therefore focus more on situations in which a certain space-time decoupling is present but in which the temporal dynamics remains too complex to be approached with a purely analytical approach, for example the transition between the state of minimum controlled power to that of full power. Additionally, the possibility of extending these tools to situations such as the approach to criticality will be evaluated, as it would require including the subcritical regime and the consequent external neutron source multiplication (if present) in the dynamic analysis. The ENEA Research Centre in Bologna (Italy) has a strong tradition and expertise in the design of AMR reactors core, especially the lead-based technology, and a collaboration with the Nuclear Engineering MOdelling (NEMO) research group at the Energy Department of Politecnico di Torino has been established since many years. This PhD activity will be carried in close collaboration between the two institutions, building on pre-existing activities and research projects.

Skills and competencies for the development of the activity	The candidate is expected to have skills in the following areas: - Reactor and core physics of fission plants, with special reference to the physics of fast reactors; - Deterministic, and possibly stochastic, modelling for the steady-state and transient analysis of fission reactors. - Basics of programming and software development; - Plant design of fast reactors in pool configuration, with particular reference to the components and structures of the core and its interfaces. The candidate must possess basic soft collaborative and communication skills at the service of the ability to work interactively in a research environment