European Research Council

PhD (M/F): Combustion instabilities coupled by pressure waves in non-premixed hydrogen swirled flames

Context: The transition from hydrocarbon fuels to hydrogen in aircraft engines and ground-based gas turbines demands a fundamental redesign of combustion systems. Manufacturers are actively developing new technologies to create gas turbines capable of operating with high hydrogen content—and, in some cases, pure hydrogen. In collaboration with its partners, IMFT has developed new hydrogen injectors operating in a diffusion-controlled mode. These injectors ensure stable CH_4/H_2/air flames over a wide operating range, enhancing safety and significantly reducing nitrogen oxide emissions. However, these systems are also susceptible to develop thermo-acoustic instabilities, which occur at frequencies markedly different from those seen in conventional swirled hydrocarbon flames.

Objectives: This doctoral program is part of the ERC SELECT-H project (European Research Council, Grant Agreement No. 101097984): https://cerfacs.fr/select-h/. The project aims to: (1) Unravel the complex interactions between flame dynamics, the unsteady flow and acoustics that lead to both low- and high-frequency combustion instabilities in a dual-swirl hydrogen-air combustor with adjustable geometry, (2) Characterize the flow behavior during self-sustained oscillations and under external acoustic forcing, and (3) Develop a framework for the prediction of combustion instabilities in non-premixed hydrogen-fueled systems.

Work Program: The research will begin with a thorough review of the scientific literature on hydrogen combustion and flame–flow–acoustic interactions. The candidate will receive specialized training in thermo-acoustics and collaborate closely with fellow PhD students, postdoctoral researchers in the combustion group, and developers of high-fidelity simulation tools at CERFACS. Initial experimental work will focus on the response of hydrogen flames to longitudinal and transverse acoustic modulations, using a recently developed setup at IMFT. Experimental results will be used to validate high-fidelity numerical simulations also performed by the candidate. The research will emphasize the identification of the physical mechanisms underlying flame-acoustic interactions and the development of analytical, physics-based models. A key outcome will be a new predictive framework tailored to thermo-acoustic instabilities in non-premixed hydrogen flames. The candidate is expected to engage actively in the combustion group and contribute to the broader research activities of the laboratory.

Supervision: The PhD candidate will be jointly supervised by Dr. Thierry Schuller (Professor at Université Toulouse & Institut Universitaire de France) and Dr. Selle Laurent (Senior Researcher, CNRS).

Location: The Institute of Fluid Mechanics of Toulouse (IMFT) is a mixed research unit bringing together the CNRS, the INP of Toulouse and the University of Toulouse 3. With around 200 people (65 researchers and teacher-researchers, 35 staff of research support, 80 doctoral students and 20 post-doctoral students), it represents one of the strongest potentials for French or even European research and advanced training in the field of fluid mechanics, both in terms of its size and its spectrum of the research themes addressed there and the fields of application they cover. Located in Toulouse on an island in the Garonne, the laboratory develops a wide range of research which covers both the fundamental aspects associated with the physical phenomena involved in flows and their mathematical description, as well as a vast field of applications.

Requirements: Master Degree or equivalent (Aerospace Engineering, Mechanical Engineering, Energetics, …). The candidate needs to hold a Master of Science or equivalent in mechanical engineering or energetics, with skills in fluid mechanics or combustion. Specific skills: Skills in conducting experiments are appreciated. Fluent in English is mandatory. French is appreciated.

Application: Applicants should apply through the webportal **https://euraxess.ec.europa.eu/jobs/347143** by sending a CV and a cover letter.