ACADEMIC POSITIONS
JOB DESCRIPTION

- **JOB TITLE :** PhD position - Development of vibrational technique for solicitation, measurement and interpretation to characterize the interactions between components of a complex structure in an extreme environment: Evaluation of their application to measurement in the RJH nuclear reactor

- **JOB PROFILE/TYPE :** PhD Candidate

- **RESEARCH FIELD(S) :** Mechanics, Dynamics, Nuclear physics, Instrumentation

- **JOB LOCATION :** 90% at the CEA (Commissariat à L'Énergie Atomique, Cadarache, 13115 Saint-Paul-lez-Durance), 10% at the LMA (Laboratoire de Mécanique et d'acoustique, 4 impasse Nikola Tesla, 13013 Marseille)

- **JOB DESCRIPTION :**

Contract and salary
Aix-Marseille University's 3 years PhD contract

Abstract
Reactor core of the Power Pressure Water Reactors (PWR) are made of hundreds fuel rods containing enriched uranium pellets. At the first step, a gap exists between the rod cladding and the pellets. As the reactor operates, the size of the pellets changes until it comes in contact with the clad. This interaction called Pellet-Cladding Interaction (PCI) is one of the major concerns to guarantee fuel rod clad integrity of PWR. In order to forbid operations leading to clad failure, modeling capability to simulate the mechanism has improved through the years. Today, codes need more and more detailed and precise experimental data. Until now, only post-irradiation data result from dedicated irradiation programs, named "power ramp tests", carried out in experimental devices in Material Testing Reactors are available.
There is currently no instrumentation for online PCI detection although this would be needed for full validation of the modeling scheme.
A previous work has shown that it is possible to measure, under specific conditions, the effects of PCI on the vibrations of a nuclear fuel rod subjected to axial excitation of turbulent flow under external conditions [1]. The objective of this PhD thesis will then be to characterize the effect of the pellet cladding contact on the damping of the structure in order to relate the behavior of the structure to its internal state.

The study will include three aspects: modelling, measurement and data processing. The challenge will be to improve existing methods capable of providing precise information on the mechanical interactions of the components of a complex structure in a very

constrained and specific context (limited space for instrumentation, high temperatures, irradiation, high flow rate, temperature gradients, etc.). The complexity of the structure comes from its nonlinear behavior induced by intermittent unilateral contact and friction between the pellets and the clad.

First a new experimental setup, in air only, will be conceived in order to get accurate data for various solicitations and various PCI states. Then data will be analyzed in order to confirm the possibility to correlate PCI state with vibrational information and to determine the best signal processing to retrieve the most accurate information. Finally, a Finite Element model able to reproduce these experimental data will be developed in order to be able to simulate other limit conditions such as fluid surrounding the fuel rod. All of those results should contribute to propose a passive or active measurement system principle to be implemented in the future experimental devices. The latter will be irradiated in the Jules Horowitz experimental reactor (JHR, https://www.cea.fr/Pages/domaines-recherche/energies/energie-nucleaire/reacteur-de-recherche-jules-horowitz-RJH.aspx) which is a key scientific and technological challenge, a priority for the CEA.

The interest for the student is that the type of approach developed in this PhD is not limited to the nuclear field or energy production industries and applies also to industrial issues encountered in the automotive or aeronautic industries.

Most of the work will take place at the CEA where the experimental facilities will be installed. Some meetings and complementary experiments will take place at the LMA.

[1] V. D'Ambrosi "Detection of the fuel pellet-cladding interaction (PCI) and of the fuel central melting during a power ramp test in the Jules Horowitz reactor (JHR): modeling and real time measurement of the fuel element deformation" - 2020 - http://www.theses.fr/2020AIXM0141 Mention SFEN J. Bourgeois 2021 Prize http://www.lma.cnrs-mrs.fr/spip.php?article1018

- **QUALIFICATIONS/SKILLS/EDUCATION & RESEARCH REQUIREMENTS/DUTIES :** in Instrumentation, Mechanical Engineering (including structural dynamics aspects), Nuclear Physics, data processing

- **APPLICATION DEADLINE** (If applicable) : As soon as possible

- **REQUESTED DOCUMENTS OF APPLICATION :**
  - Grades from last completed degree
  - Cover letter & Curriculum Vitae
  - Letter of recommendation if applicable
  - The internship report at the end of the study possibly

- **SUPERVISORS**:
  - Frédéric Lebon (AMU/LMA, Dir.)
  - Stéphane Bourgeois (ECM/LMA)
  - Christophe Destouches (CEA)
  - Guillaume Ricciardi (CEA, Co-Dir.)

- **CONTACT TO APPLY (EMAIL OR WEBSITE)** :
  Please send any information request at the two following addresses:
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