

2025 Nuclear Global Internship Job Description

1. Basic Information

- Expected Internship duration: *6 months*
- Internship Area/Topic: *Materials Science, modelling, nuclear fuel, irradiation*
- Division/Department Placement: *CEA - IRESNE/DEC/SESC/LM2C at CEA-Cadarache center*
- Supervisor's contact information: *Serge MAILLARD, serge.maillard@cea.fr*

2. Responsibilities

- 1) Main Purpose : *A digital twin to predict the microstructural evolution of the grain boundary of a fuel under irradiation*

Like other industrial sectors, the nuclear industry is developing 'digital twins', applications that simulate the behaviour of an industrial component, such as a car, plant, reactor or, in our case, a fuel rod. The proposed work is part of this approach and contributes to the development of a digital twin of a grain / grain boundary that can be used to simulate its microstructural evolution under irradiation.

The microstructure of nuclear fuel (uranium oxide) is severely damaged during irradiation in a reactor: the atoms produced by the fission of uranium nuclei displace the atoms in the material in a cascade, creating irradiation defects (vacancies and interstitials) whose aggregation leads to the gradual appearance of cavities and dislocation loops. These extended defects influence the volume of the material, its creep and its retention of fission gases. The physical model of the phenomenon is cluster dynamics: a set of kinetic equations representing the chemical reactions of defect aggregation by diffusion in the material.

Rare gases can migrate towards grain boundaries and give rise to the same type of bubble nucleation-growth phenomenon. The aim of the internship is therefore to extend the use of cluster dynamics to predict the microstructural evolution of the grain boundary.

This internship offers the candidate the opportunity to contribute, from a central position and from a synthetic point of view, to the development of numerical physics applied to multiscale modelling and to discover diverse and complementary activities in this field (theory, numerics, simulation-interpretation). It will allow students to experience for themselves how simulation tools, based on the most fundamental microscopic data, can be used to treat and explain practical situations.

- 2) Tasks/ Key Results Expected

The main steps planned to achieve this are :

1. *Theory: adapting the model to the case of a planar medium (while the grain is three-dimensional), in particular studying how to write the kinetic parameters of the chemical reactions that lead to the aggregation of defects.*

2. *Computation: Coupling the DA model of the grain to that of the joint. This will be a specific*

development in the CEA-EDF Crescendo code.

3. Simulation-interpretation: The model will then be applied to new situations, such as irradiation in fuel cells, with the aim of predicting the microstructure (density of bubbles or loops and dislocation lines, both in volume and at grain boundaries).

3) Knowledge, Skills and Abilities

- *Materials Science or Materials Physics*
- *Chemical kinetics*
- *Modelling or numerical physics*

3. Qualifications (Education)

- ☐ (1) Bachelor degree (3rd year ☐, 4th year ☐)
- ☒ (2) Master degree (or candidate)
- ☐ (3) Ph. D. degree (or candidate)
- ☐ (4) Does NOT matter

4. Required documents

- ☒ Resume / Curriculum Vitae
- ☒ Cover letter
- ☒ Academic transcript
- ☒ Recommendation letter written by academic supervisor
- ☒ English Test score (TOEFL, TOEIC, IELTS, etc.)
- ☐ Others ()

5. Is the host organization providing any additional financial support in addition to the funding from KONICOF?

- ☒ Yes
 - The amount of stipend: EUR 700 per month /~~week~~
 - Purpose of the stipend: *ex) assist housing, required minimum wage, etc.*
- ☐ No



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