Ph.D Thesis

Multi-scale modeling of UO$_2$ plasticity: on the role of irradiation defects

Uranium dioxide (UO$_2$) is used in fuel pellets of nuclear power plants. Its mechanical behavior under irradiation has a major impact on fuel cladding structural integrity assessment under normal and off-normal operating conditions. One issue concerning the fuel mechanical behavior is a detailed understanding of deformation processes at the scale of the microstructure heterogeneity in order to be able to predict stress and strain inside the grains and at their interfaces.

The main goal of the Ph.D is to develop a constitutive model based on dislocation interactions with irradiation loops. This model is needed to compute inelastic strains induced at high temperature and under irradiation. First, dislocation mobility and reactions between defects will be characterized using the atomic scale LAMMPS molecular dynamics (MD) package. Then, atomistically-informed dislocation dynamics (DD) simulations will be performed at the grain scale to quantify strain hardening induced by irradiation defects.

The Ph. D will be done in the framework of a collaboration between INSA-Lyon (jonathan.amodeo@insa-lyon.fr), the University of Lyon (david.rodney@univ-lyon1.fr) and the CEA at Cadarache (bruno.michel@cea.fr, emeric.BOURASSEAU@cea.fr), where a high expertise is available in the field of multi-scale and multi-physics materials modeling. Short stays at the CEA Saclay are intended. Results valorization will be done through publications and international conference participation in order to have discussions with foreign researchers and/or share experiences with other domain of activities outside the nuclear field.

The selected student will hold a master degree in materials science, mechanics of materials or condensed matter physics. He/she should have a pronounced interest for theoretical modeling and basic knowledge in programming. Good writing and oral skills are expected in french and/or english. CV and application letters should be sent to david.rodney@univ-lyon1.fr, jonathan.amodeo@insa-lyon.fr, bruno.michel@cea.fr.