Sujet de post-doctorat

Simulation aux grandes échelles de la déflagration de mélanges H2/air/vapeur d'eau ; application aux expériences ENACCEF2

FRENCH INSTITUTE FOR NUCLEAR SAFETY AND RADIATION PROTECTION

Lieu de travail : Cadarache – Bouche du Rhône - France

Champ scientifique principal :

Applied Mathematics, Fluid Mechanics

Mots clés

Large Eddy Simulation, numerical scheme

Fonction

Education and research

1 EMPLOYER

IRSN, a public expert with industrial and commercial activities, was set up in 2001.The Institute is placed under the joint authority of the French Ministries of Defense, Environment, Industry, Research, and Health.

IRSN is the nation's public service expert in nuclear and radiation risks, and its activities cover all the related scientific and technical issues. It interacts with all parties concerned by these risks (public authorities, local authorities, companies, research organizations, stakeholders' associations, etc.) to contribute to public policy issues relating to nuclear safety, human and environmental protection against ionizing radiation, and the protection of nuclear materials, facilities, and transport against the risk of malicious acts.

Site web :

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2 POSITION AND MISSIONS

2.1 Context

Gas explosions, and more particularly hydrogen explosions, are a major source of accidents in both conventional industrial and nuclear facilities. To prevent these risks and limit their consequences, it is essential to have software able to predict the pressure and temperature loads generated by gas explosions.

The CALIF^{3}S-P^{2}remics (Partially Premixed Combustion Solver) software was developed by IRSN for this purpose. It can be used to treat compressible reactive turbulent flows, such as those encountered during an explosion. This software is based on an experimental database. Some of the experiments are calculated for interpretation by Large Eddy Simulation (LES). The objective of this post-doctoral fellowship is to apply this approach to some hydrogen deflagration experiments in a large flame acceleration tube (ENACCEF2 experiments).

The numerical scheme of the CALIF^{3}S-P^{2}remics software is based on staggered meshes (degrees of freedom for scalars at the centre of the mesh and at the faces for velocities). It is explicit, based on the Heun scheme (Runge-Kutta scheme of order 2) and has the interesting property of verifying a second order accurate conservation

identity of the kinetic energy. It is now routinely used with structured meshes. The work proposed in this post-doc will require extending it to unstructured meshes.

2.2 Missions

The work proposed in the framework of this post-doctorate is divided into two stages.

1) Firstly, it consists in extending the space discretization for LES applications on unstructured meshes. This type of development is a difficult problem. In particular, it seems that it is necessary to choose the richest possible approximations of the pressure, while preserving stability (discrete inf-sup condition). Such work has been proposed in the literature for Crouzeix-Raviart finite elements, for the simulation of incompressible flows. The objective is to extend these ideas in two directions:

a) adaptation to compressible flows, within the framework of schemes developed over the last ten years by the Institut de Mathématique de Marseille (I2M) and the IRSN,

b) extension to discretization in space of the same type (i.e. with velocity degrees of freedom associated with faces) but based on cells of different shape: hexahedra (Rannacher-Turek elements), prisms and pyramids.

2) In a second step, the validation of these schemes will be done on hydrogen, air and water vapour deflagration tests in a flame acceleration tube (ENACCEF2 experiments, performed at the ICARE Laboratory of the CNRS in Orléans). The simulations should make it possible to characterise the turbulence in the flow and the structure of the flame front.

3 PROFIL

The candidate must hold a PhD in the field of applied mathematics (numerical fluid mechanics). The candidate should have a good level of written and spoken English and will be expected to promote this work in the form of conference papers and/or scientific publications.