Postdoctoral position in modeling and numerical simulation of shockwaves in porous materials

A postdoctoral position is available immediately in the Laboratory of Microstructure Studies and Mechanics of Materials (LEM3) of the University of Lorraine (UL) in Metz, France.
Candidates must be self-starter and have a solid background in numerical simulation of high strain rate phenomena. The candidate must also be familiar with analytical approaches (continuum mechanics, plasticity, viscoplasticity, …).

Keywords:
Dynamic behavior; Shockwaves; Finite Element Modeling and Numerical Simulation; Micro-inertia effects;

Start Date: As soon as possible **Duration:** 12 months **Monthly gross salary:** 2 770 €

Application
To be considered, applicants should send an email to Dr. Christophe Czarnota: christophe.czarnota@univ-lorraine.fr with the following documents:
a CV, the list of publications and conferences, a PhD abstract, a motivation letter, a recommendation letter, scientific references.
Note that only applications providing all application requirements will be further considered. Review of applications will begin immediately and continue until the position is filled.

Scientific context and objectives
Dynamic response of porous materials is of primary importance in numerous fields whether it concerns optimization of blast mitigation devices, collision processes in the solar system, clinical applications such as kidney stones fragmentation by shock wave lithotripsy. Upon impact at high velocity, a shockwave is generally formed and propagates in the impacted sample. For porous materials, the structure of steady shockwaves is a complex phenomenon involving in general the interplay of micro-inertia effects with the nonlinear elastic viscoplastic response of the matrix. Micro-inertia effects are due to the important acceleration of material particles near the collapsing voids. An explicit relationship has been derived from a dynamic homogenization approach by the UL team (Molinari and Mercier, 2001) where relationship between the microstructure of the porous material (pore size and mean separation distance) and the dynamic behavior was clearly highlighted. This modeling has been implemented in a FE code (Abaqus) and extended to account for nucleation of voids in an initially dense tantalum material (Czarnota et al., 2008, Versino & Bronkhorst, 2018). Due to the presence of micro-inertia in the modeling, free surface velocity profiles obtained from impact tests under various loading configurations have been successfully restituted from numerical simulations;
More recently, micro-inertia effects were shown to strongly influence shockwave propagation in porous aluminum. An analytical approach has been developed in Czarnota et al. (2017) where the shock width (a true signature of a shockwave) was found to be scaled by the microstructure of the porous material.

The goal of the post-doctoral project is to develop finite element models and conduct numerical simulations of shockwave propagation in porous media. The objectives are to analyze local acceleration fields and to highlight, using a discrete finite element model, the connection between the microstructure and the overall response. The study would also allow to clarify and identify various collapse mechanisms that can occur during shockwave propagation. This work will be useful to develop a better knowledge of the dynamic damage in porous materials, in order to optimize protective devices subjected to dynamic loading.

References
A. Molinari and S. Mercier, J. Mech. Phys. Solids, 49, 1497-1516 (2001).
C. Czarnota, N. Jacques, S. Mercier and A. Molinari, J. Mech. Phys. Solids, 56, 1624-1650 (2008).
C. Czarnota, A. Molinari and S. Mercier, J. Mech. Phys. Solids, 107, 204-228 (2017).
D. Versino, C. A. Bronkhorst, Comput. Methods Appl. Mech. Engng 333, 395–420 (2018).

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About the University of Lorraine and LEM3

• **A large multidisciplinary university, open to international collaboration**: with more than 3,700 teaching and research faculty and approximately 54,000 students, including nearly 8,000 foreign students, the University of Lorraine is one of France's largest multidisciplinary universities. Its location in the heart of Europe offers to UL a privileged position for strong international partnerships. UL is committed to numerous European and international collaborations and exchanges, including multi-partnership projects.

• **Strong scientific expertise:** the scientific activity of the UL is organized in 60 research laboratories located in 10 scientific centers and 6 research federations covering a wide range of disciplinary fields and topics. In addition, the university houses several technology platforms including large-scale facilities and large measurement instruments, providing research teams with the most efficient equipment. The UL has also been attributed by the French Prime Minister, early 2016, the label of excellence "I-SITE". With this label, the university is recognized for its capacity to develop strong cooperation with the industrial partners and to implement innovative actions of joint research.

• The University of Lorraine **reached top 3 of French universities** in Shanghai's global ranking of subjects "Mechanical Engineering" and "Metallurgical Engineering".

• The LEM3, a joint research center of the University of Lorraine, the French National Center for Scientific Research (CNRS) and the Arts et Métiers ParisTech, is **one of the largest research institute in physics of materials and engineering within France (**more than 150 permanent staff, 80 phd and 10 post-docs). The Laboratory is a center of expertise in experimental characterization, fundamental, analytical and numerical approaches of mechanical behavior and structural evolution of polycrystalline and poly-phase materials.