LABO – Institut Pascal (UMR6602 UCA/CNRS) – Group M3G/ME

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***Title of the thesis:** Characterisation of the couplings between the phase transformation and the thermomechanical behaviour of shape memory alloys.*

Abstract
Shape memory alloys (SMA) have known a growing interest in the last two decades because of their appealing features (e.g. super-elasticity, memory effect…). One of their most interesting features is that SMA show the ability to recover large strain during their phase transformation that occurs at low temperature. This leads to the so-called shape-memory effect, which named this group of materials. SMA also exhibit high corrosion resistance and biocompatibility, which enable them to be used in numerous applications (aerospace, micromechanical systems, infrastructure, etc.) [1]. It follows that the development and use of SMA is a very topical subject in many industrial domains.

In order to better understand the thermomechanical response of SMA, different testing configurations have been proposed in the literature. A phase transformation takes place in the SMA during deformation. This phase transformation is usually spatially localized and is then responsible of heterogeneities in the stress/strain distributions within the specimen. Full-field measurement techniques are then commonly used to measure these heterogeneities [2]. The kinematic and thermal fields are usually obtained using digital image correlation (DIC) and infrared (IR) thermography imaging, respectively. Using these means of measurements in different testing conditions led to rich data on the thermomechanical behaviour of SMA, and on the role of phase transformation on this response. However, although a large amount of data seems to be available, few studies have focused on the characterisation on thermomechanical models coupled with the metallurgical state of the material.

In this thesis we propose to take profit of the richness of the full-field data to build and identify thermomechanical models of SMA coupled with the phase transformation of the material. To do so and as a first step, a few experiments will be conducted on SMA specimens with kinematic and thermal measurements. Then, finite element (FE) models will be developed to reproduce the experiments. The loading conditions applied in the FE simulations will be directly the ones obtained from DIC and IR thermography measurements. This strategy follows the research idea of using “digital twins” to analyse at best the experimental results with FE support. Different models will then be developed and identified using inverse methods specifically dedicated to deal with full-field data (FEMU, IDIC, etc.) [3]. This global identification process, using at best all the available data, aims to bring fundamental knowledge in the couplings between the temperature, the metallurgical state of the material and its mechanical behaviour.

This thesis will be conducted among the ME team of the Institut Pascal. The ME team has recognised skills in full-field measurement techniques (DIC, LSA, thermography) [4,5] and has experience in SMA. The PI of this project (T. Jailin), who is also part of the ME team, has experience in phase transformation in metals [6] and material characterisation based on full-field data [7]. A collaboration with The University of Manchester is also considered in order to perform metallurgical analyses on the specimen before and after testing.

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