Joint implementation of two state-of-the-art techniques for laser beam characterization of liquid systems at very high temperatures

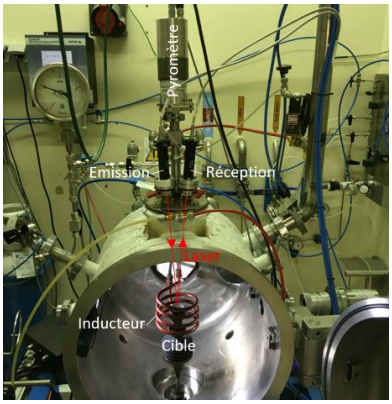
The characterization of materials under extreme conditions is of major interest in many research and industrial applications. Foundries, rockets, reactors ...have as a common denominator high temperature multi-component systems, with high potential for thermochemical aggressiveness. These conditions greatly complicate the implementation of conventional measurement techniques, i.e. based on actuators in contact with the system to be characterized, all the more so if the latter is liquid. The properties of interest governing the behaviour of these real magmas that are high temperature liquid systems, such as density, surface tension and viscosity, must not only be intrinsically measured with great precision, but also closely correlated with the temperature prevailing at the point of measurement.

The purpose of this thesis is to develop a process based on two advanced techniques for laser beam inspection of a liquid surface. First, the doctoral student will have to appropriate and adapt a laser interferometry system applied to molten surfaces, subjected to controlled micro-disturbances, making it possible to determine the density, the surface tension and the viscosity of the liquid at the target locus. Then, it will be necessary to implement the coupling of this module with an existing system, called a pyroreflectometer, which gives access to the temperature value at the laser spot, within a single prototype. The latter thus aims at the direct and original determination of local and instantaneous constitutive laws.

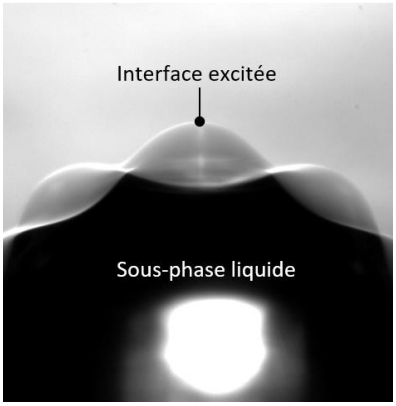
The innovative nature of the proposed thesis work requires a phase of development and qualification of the new instrument, in an environment of scientific excellence. This is the reason why, during the first half of the thesis, it is proposed that the interferometric adaptation of the pyroreflectometer and the qualification tests be carried out at the SIMaP laboratory (CNRS Grenoble), internationally recognized in the field of inspection and actuation of multi-component liquid systems. In a second phase, knowledge transfer and measurements on very high temperature systems of interest will be carried out as part of the expertise developed on the VITI facility, within the Nuclear Technology Department in CEA Cadarache.

Successful work within the framework of this thesis will allow the student to acquire in-depth and transversal skills, in various fields relating to the metrological approach, instrumentation as well as high temperature characterization methods. Beyond this thesis, he / she may apply for a position for a career in academic or industrial research in the fields of instrumentation and / or material characterization.

Application case : artist view of a nuclear severe accident (© NHK)



View of the pyroreflectometer test-bench for laser beam determination of temperature in the VITI facility



Liquid surface actuation for laser interferometry (© Theisen)

MECHANICS, ENERGETICS, PROCESS ENGINEERING – IRESNE/DTN – N°DES-22-0070

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