PhD in Civil and Environmental Engineering

Research Title:
Fluid dynamic approach to pathogenesis of Syringomyelia in the Cerebral Spinal Fluid

Funded by	Università Italo-Francese

Supervisor	Carlo Camporeale (carlo.camporeale@polito.it) Jean-Marc Chomaz (chomaz@ladhyx.polytechnique.fr)

Contact	www.envirofluidgroup.it https://www.ladhyx.polytechnique.fr/en/

Context of the research activity	Fluid dynamics of the cerebral spinal fluid (CSF) plays a fundamental role in the formation and evolution of neurological diseases, such as syringomyelia and hydrocephalus. In particular, syringomelia is a degenerative disorder, with a relevance estimated at 8.4 cases per 100000 people, involving the presence of one or more cysts inside the spinal cord, which can also lead to paralysis or paresis. After several conjectures, the biomedical community is now oriented to link the pathogenesis of these cysts to typical fluid dynamic phenomena (e.g., Venturi effect). Indeed, the waveform nature of the CSF circulation plays a key role in affecting the spinal cord microcirculation, through a semi-permeable membrane (the pia mater), and the porous liquid inside the spinal cord. However the basic mechanisms that underlay cyst formation remain still unexplored. Physically speaking, the problem can be viewed as a poroselastic matter (the spinal cord) which mechanically interacts with an annular cavity where the CSF flows in a pulsating way (max velocity 7 cm/s). The subject allows for a mathematical approach through the classical techniques of hydrodynamic instability, funded in fluid mechanics, and developed in the analysis of fluid-structure interactions, that have been commonplace in Civil and Environmental engineering.

Objectives	Some recent studies have approached the modeling of gray and white matter of the central nervous system as an application of the multiple network poroselastic theory (MPET). The aim of the present project is to couple a novel MPET approach of the spinal cord with a fluid dynamic description of the CSF and the capillary microcirculation in order to pursue the following goals: 1) Formulate a complete model where capillaries, CSF and the matter costituting the spinal cord interact each other dynamically 2) Perform a stability analysis of the linearized problem with different analytical tecniques (weakly nonlinear analysis, Floquet analysis, non modal analysis, etc.) 3) Assess the parametric conditions that allow to unstable pattern, such as cyst formation 4) Integrate the developed model with a 1D modeling of the whole circulatory system already developed by the supervisor and his coworkers of the same research group 5) Consider some particular clinical cases

Skills and competencies for the development of the activity	It is required a basic training in fluid mechanics, hydraulics or similar courses (min 6 credits)