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Author: Mr. Álvaro Romero-Calvo
Politecnico di Milano, Italy, alvaro1.romero@mail.polimi.it

Mr. Antonio J García-Salcedo
Politecnico di Milano, Italy, aj.garcia.salcedo@gmail.com
Ms. Inés Rivoalen
Politecnico di Milano, France, ines.rivoalen@mail.polimi.it
Mr. Francesco Garrone
Politecnico di Milano, Italy, francesco.garrone@mail.polimi.it
Prof. Gabriel Cano Gómez
University of Seville, Spain, gabriel@us.es
Prof. Elena Castro-Hernández
University of Seville, Spain, elenacastro@us.es
Prof. Miguel Ángel Herrada Gutiérrez
University of Seville, Spain, herrada@us.es
Dr. Filippo Maggi
Politecnico di Milano, Italy, filippo.maggi@polimi.it

LATERAL SLOSHING OF MAGNETIC LIQUIDS IN MICROGRAVITY

Abstract

The term sloshing refers to the forced movement of liquids in partially filled tanks. In a low-gravity environment, the liquid mixes with pressurizing gas bubbles and adopts a random position inside the container, resulting in unwanted perturbations and a complicated tank design. Liquid sloshing has consequently been a major concern for Space engineers since the beginning of the Space era.

The sloshing of magnetic liquids has distinctive characteristics that suggest a different approach to the topic. Magnetic fields can be used to shift the natural frequencies and increase the damping ratios of an oscillating fluid. Due to the short range of the magnetic interaction, research has been historically focused on what is known as magnetic liquid positioning. In the age of nanosatellites, however, propellant tanks are much smaller, and a significant control can be implemented with a low mass penalty.

The future implementation of magnetic sloshing dampers for spacecraft control passes through the accurate understanding of basic physics and modelling capability of magnetic liquid dynamics. In this respect, the prediction of the forcing dynamics response of a ferrofluid pushed the authors to develop a dedicated model and to identify a roadmap for the collection of reliable experimental data in a Space-like environment.

In the framework of an ESA CORA Drop Tower proposal, an experiment to study the lateral sloshing of a water-based ferrofluid solution in microgravity was designed. The experimental setup was composed by two identical vessels containing the magnetic liquid, a pair of coils that imposed a static magnetic field, a newly developed visualization device and an actuation system. During microgravity the actuation system starts an oscillatory movement that is left to rest under the action of the magnetic field. The free surface movement is recorded and reconstructed for a range of current intensities, obtaining the first two natural frequencies and their corresponding damping factors.

The access to ZARM's Drop Tower in Bremen would provide unprecedent measurements of the lateral

sloshing of ferrofluids. The experimental results are required to validate a semi-analytical inviscid and CFD sloshing models already developed by the authors.