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PAPELL: INTERACTION STUDY OF FERROFLUID WITH ELECTROMAGNETS OF AN EXPERIMENT ON THE INTERNATIONAL SPACE STATION

Abstract

On May 9th the student experiment PAPELL (Pump Application using Pulsed Electromagnets for Liquid reLocation) is scheduled for launch as part of the transport mission OA-9 with a Cygnus vehicle to the International Space Station. During the "Überflieger" competition, organized by the German Aerospace Center (DLR), three student experiment ideas were selected to be conducted on the International Space Station (ISS). The experiment is designed and build by members of KSat e.V. and is going to utilize electromagnets to manipulate ferrofluid, a fluid with suspended ironoxide nanoparticles, which give it paramagnetic properties, and realise a pumping mechanism without mechanical components inside a container of 10 x 10 x 15 cm. As a result of the surface tension and magnetic forces the ferrofluid forms droplets, which can be moved along by utilising the magnetic field of the phased activated magnets. Later the space between individual droplets will be used to transport tiny solids through a tubing system.

This paper analyses and describes the interaction between the electromagnetic fields of two or three electromagnets and ferrofluid. The ferrofluid is nominally non-magnetic, but when introduced to a sufficiently strong magnetic field the ferrofluid is magnetized and is attracted to the magnetic field source. This is due to the fact that suspended ironoxide nanoparticles will align with the magnetic field. The microgravity environment on the ISS will help to get an accurate picture of the microgravity behaviour of the ferrofluid and shows in-orbit technology demonstration. In relation to the micro gravitational forces the magnetic fields and surface tensions are stronger and unique fluid behaviour is expected to be observed. Cameras are integrated for experiment monitoring, two are placed with perpendicular viewing angle onto the individual electromagnet experimental areas and a third with an angular view. This third camera is dedicated for overall experiment monitoring and producing footage for outreach purposes. Pictures and videos of the experiment in action is utilized to analyse the interactions between ferrofluid and electromagnets. Additional quantifying data is obtained by measuring the current flowing through individual electromagnets and the magnetic field strength with strategically placed magnetometers inside the experiment.

Using the data - collected by the cameras, magnetometers and current sensors - a characterisation of the ferrofluid-magnet interactions can be made, which will improve future development efforts for