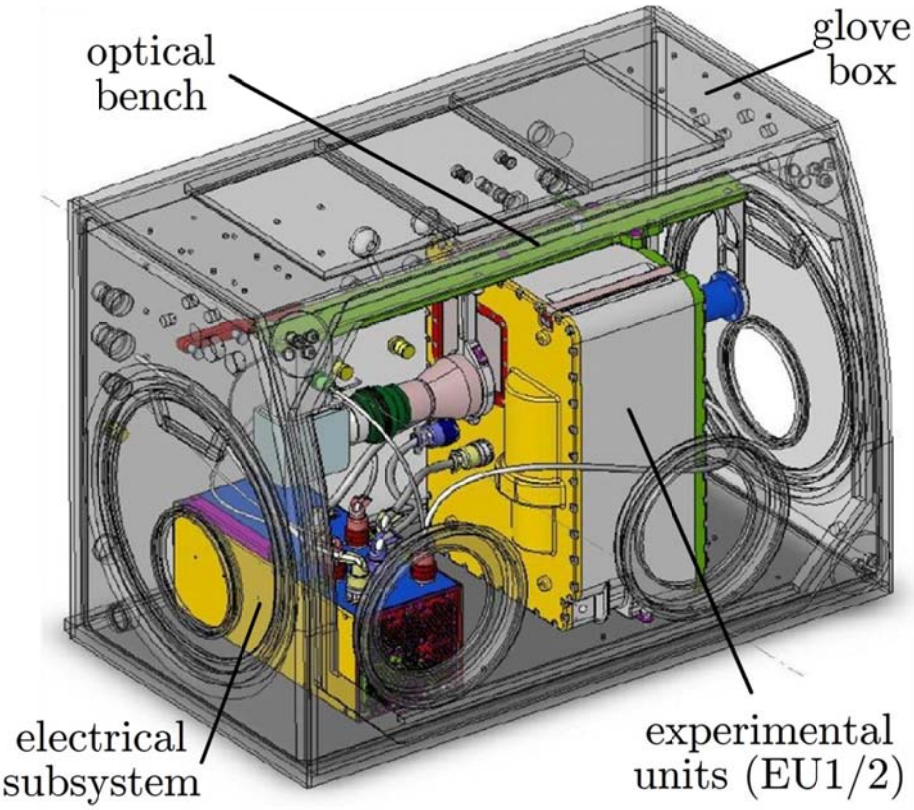
German scientists commence remote-controlled experiments onboard the International Space Station

Introducing the CCF experiment

Huntsville, Alabama, 02.01.2011 A new experiment has begun operating onboard the International Space Station (ISS) today. The purpose of the CCF experiment – CCF is short for Capillary Channel Flow - is to investigate the behaviour of capillary flows through open capillary channels in an environment of compensated gravity. During the 50 day period of operations, a team of scientists from the Centre of Applied Space Technology and Microgravity (ZARM) will control the experiment from a ground station located at their institute in Bremen, Germany. One of the most pressing issues they are eager to resolve is to determine the maximum flow rate of capillary flows that is possible before the free surface of the liquid becomes unstable and collapses - a phenomenon that in fluid mechanics is referred to as 'choking'.

In terms of international collaboration, the CCF project is already a full success. The experimental unit was constructed in Germany by Astrium Friedrichshafen and in April of 2010 it was transported to the ISS onboard flight STS-131 of the space shuttle Discovery. Supervised by Astrium engineers at Marshall Space Flight Center (MSFC) in Huntsville, Alabama, NASA astronauts installed the unit into the Microgravity Science Glovebox onboard the ISS. Having passed initial tests, CCF operations have commenced today. The scientists from ZARM will be assisted by colleagues from Portland State University in conducting the actual experiments.



CCF Experiment in the Microgravity Science Glovebox onboard the International Space Station

One of the many possible applications of the CCF experiment results is propellant management. In space, liquid fuel will not remain at the bottom of a tank like it would on the Earth inside a car's tank. Due to the reduced influence of gravity, liquids attach themselves to any surfaces within the tank, whether located at the top, bottom, or on the side walls. Obviously then, a device is required to position and transport fuel or other liquids to where they are needed. Such fluid management devices often make use of the increased importance of adhesive and cohesive forces. Adhesion describes the tendency of dissimilar molecules to adhere to one another causing liquids to cling to surfaces within a fuel tank. Cohesion describes the tendency of similar molecules to cling together like liquids generally do.

In space, fluid management devices may consist of two parallel plates through which fuel is transported through the tank towards the engine. A vane consisting of parallel plates is open on two opposing sides. The liquid that runs through the vanes stays within the channel because of the aforementioned forces and the resulting surface tension. Previous tests have shown that free surfaces of capillary flows remain stable up to certain critical flow rates. Increasing the flow rate above the critical causes the liquid surfaces to collapse, allowing gas to enter the stream as bubbles, at which point the flow is choked. This upper limit of flow rate in capillary flows has been described extensively and is defined by the so-called Speed Index, which bears similarities to the Mach number. Amongst other things, the CCF experiments will help determine maximum flow rates for liquids within capillary channels before choking occurs and gas bubbles are ingested into the liquid stream.

For years, scientists have been developing and improving methods to use capillary channels liquid transport whilst preventing contamination of the liquid with gas bubbles. This particular experimental setup has already been tested in the drop tower at ZARM and in ballistic rocket flights, but these experiments were extremely limited by the duration of the state of reduced gravity, typically not longer than a few seconds or minutes. Onboard the ISS, scientists will be able to utilise the compensated gravity environment to perform a great deal more and longer experiments. Also they will be able to vary parameters such as channel length, flow rates, and even accelerations and oscillations of flow. The experiment is equipped with numerous sensors and a high-speed camera which will produce an abundance of data that will be down-linked to the ground station at ZARM. The newly acquired data will be used to validate current mathematical models of capillary flows helping optimise the development of liquid management systems in space.

INFOBOX:

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The international team of scientists consists of:

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