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FUNBOE - Follow-Up Nucleate Boiling On-flight Experiment: A Systematic Study of Nucleate Boiling in Microgravity

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A Systematic Study of Nucleate Boiling in Microgravity

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Get Away Special Microgravity Research Team

Abstract

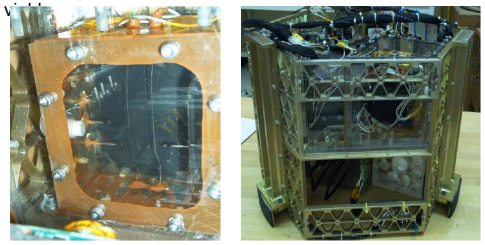
Utah State University's Get Away Special (GAS) team, was awarded the opportunity to participate in Reduced Gravity Student Flight Opportunities program administered by NASA. Six members of the GAS team will fly in a specialized jet which will simulate microgravity where the experiment can be performed in 30 second intervals. The purpose of the experiment is to determine the properties of nucleate boiling of water in weightlessness. The experiment will be monitored with temperature sensors, accelerometers, and high definition cameras and the results will be analyzed frame by frame. This will provide important information related to the dynamics of heat transfer using thin wire heating elements in microgravity. Under these controlled conditions, the boiling dynamics will be under specific scrutiny. Additionally, other observations related to varying power inputs and the effects of alternate surface geometries of the platinum wire will be made. The GAS team flies June 17-26, 2010 at Johnson Space Center, Houston, TX.

The Team

The GAS team at USU is a Multidisciplinary group of driven graduate and undergraduate Students interested in space research. In operation since 1976, the team has become one of the world's premier student space research Teams and is responsible for Designing and building many experiments that have flown in space. It contributes significantly to Utah State's reputation as the university that sends more student projects into space than any other university in the world.

Nucleate Boiling in Space

Using nucleate boiling in space could help reduce mass and complexity of systems required to heat a liquid in addition to significantly reducing the time it takes to do so. Buoyancy driven convection does not operate in microgravity. This has lead to some speculation that if nucleate boiling were to be used in space, the liquid around the heating element would vaporize but form a large bubble around the heating element, insulating it and cause it to burn out. A previous experiment conducted by the USU GAS team that flew on the space shuttle in 2001 demonstrated that this was not the case and that using nucleate boiling in microgravity is



Previous experiment flown on STS-108

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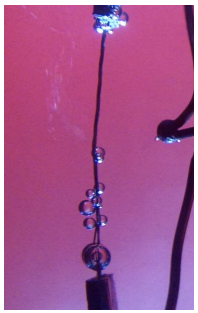
The previous experiment was excellent at demonstrating the viability of nucleate boiling in space; however, it was not able to provide enough data to properly analyze the behavior. Key areas needing improvement were identified and a new experiment was designed and proposed to NASA under the Reduced Gravity Student Flight Opportunities Program. Some of the key improvements were in the areas of visual data acquisition and the inclusion of accelerometers. The team's plan was judged critically by experts in the scientific community and was selected to be one of the few experiments to fly. The team is in the process of developing and constructing both the experiment and hardware to house the experiment in a manner that will meet NASA's stringent flight and safety requirements for the Vomit Comet.

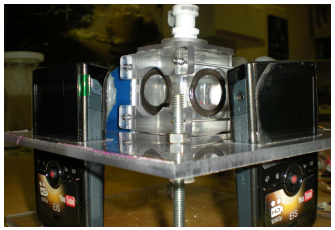
Video Data

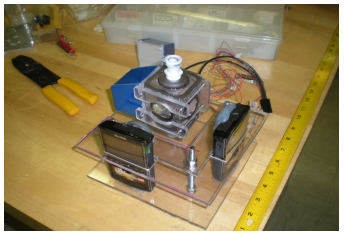
The previous experiment had a visual resolution of about 100 pixels per mm^2 This severely limited the accuracy of measurements that could be taken of the bubble size. Due to technological advances the new experiment has a resolution of 2500 per mm^2



Velocity and Location

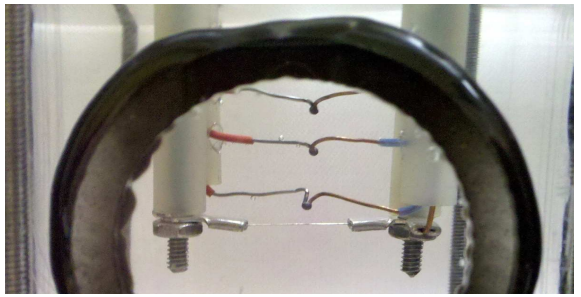
One of the key improvements to the experiment is the ability to know how well the bubbles leave the heating element, what speed they depart, and where they end up. This data is hard to collect if the bubble's position is not known in 3D space, so the team is using multiple cameras with views 90 degrees apart to collect this data.





Temperature Data

The experiment performed on the space shuttle could not record meaningful temperature data close to the heating element. As seen in the picture below, the new design contains four highly accurate thermocouples positioned in half centimeter increments from the heating element.



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