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Facilities and Operations of Microgravity Experiments (5)

Author: Prof. Tatsuaki Hashimoto
Japan Aerospace Exploration Agency (JAXA), Japan, hashimoto.tatsuaki@jaxa.jp

Prof. Shujiro Sawai
Japan Aerospace Exploration Agency (JAXA), Japan, sawai.shujiro@jaxa.jp
Dr. Nobutaka Bando
Japan Aerospace Exploration Agency (JAXA), Japan, bando@nnl.isas.jaxa.jp
Dr. Kazuhisa FUJITA
Japan Aerospace Exploration Agency (JAXA), Japan, fujita.kazuhisa@jaxa.jp
Prof. Yuko Inatomi
ISAS/JAXA, Japan, inatomi@isas.jaxa.jp
Dr. Tetsuo Yoshimitsu
ISAS/JAXA, Japan, kikko@nnl.isas.jaxa.jp
Dr. Hiroaki Kobayashi
Japan, koba@chofu.jaxa.jp
Mr. Shin-ichiro Sakai
Japan Aerospace Exploration Agency (JAXA), Japan, sakai@pub.isas.ac.jp
Prof. Yoshitaka Saito
Japan Aerospace Exploration Agency (JAXA), Japan, saito.yoshitaka@jaxa.jp
Prof. Takehiko Ishikawa
Japan Aerospace Exploration Agency (JAXA), Japan, ishikawa.takehiko@jaxa.jp

DEVELOPMENT OF BALLOON-BASED MICRO-GRAVITY EXPERIMENT SYSTEM

Abstract

Today, there are various kinds of micro-gravity experiment systems. A drop tower is the lowest cost facility but its duration of micro-gravity is only several seconds. A parabolic flight by an airplane realizes about 20 seconds duration and its cost is not so expensive. However, the quality is not so good due to air turbulence, etc. On the other hand, a sounding rocket, a satellite (unmanned orbital system), Space shuttle, and International Space Station can achieve long duration of micro-gravity but they are expensive systems. This research aims to develop a moderate cost, medium duration, and excellent quality of micro-gravity experiment system that is not yet realized by other systems. We proposed and developed a system that uses a free-fall capsule released from a high altitude balloon.

The flight capsule consists of an outer shell, an inner shell, and a propulsion system. In the inner shell, about 0.02 m2 experimental space is installed where a micro-gravity experiment is performed. The inner shell is isolated from the outer shell and no disturbance force is worked to it. Therefore ideal free-fall is realized unless the outer shell collides with the inner shell. The outer shell, namely the body of the capsule, has rocket-like shape to reduce aerodynamic disturbance. The propulsion system is controlled for the outer shell not to collide with the inner shell, measuring the space between the outer shell and the inner shell. For attitude stabilization, the capsule has four fixed or movable wings.

The first flight was performed in May, 2006, aiming system verification and all system was functional as expected. As an example of micro-gravity experiment, fluid dynamics in micro-gravity was done. That is, a behavior of a bubble between two layers of liquids with different specific gravity and surface tension is

observed. The second flight aimed to demonstrate a micro-gravity experiment of longer than 30 seconds. Drag-free control was successful till super-sonic region. A super-sonic parachute was also functional and the capsule was successfully retrieved on the sea. As a micro-gravity experiment, combustion of Japanese traditional toy firework ("Senko hanabi") was examined. The lack of convection cased less oxygen supply and the behavior of the firework was different from that under gravity. The third flight is planed in the spring of 2009.

In the presentation, latest status of the development and future plan will be shown.