Investigation of the Influence of Microgravity on Transport Mechanisms in a Virtual Spaceflight Chamber - A Flight Definition Program

James D. Trolinger, PI
MetroLaser Incorporated
E-mail: jtrolinger@metrolaserinc.com

Roger Rangel, Co-I
Department of Mechanical and Aerospace Engineering
University of California at Irvine

William Witherow, Co-I, and Jan Rogers, Co-I
NASA Marshall Space Flight Center

Ravindra B. Lal, Co-I
Department of Physics
Alabama A&M University

Background and Introduction

A need exists for understanding precisely how particles move and interact in a fluid in the absence of gravity. Such understanding is required, for example, for modeling and predicting crystal growth in space where crystals grow from solution around nucleation sites as well as for any study of particles or bubbles in liquids or in experiments where particles are used as tracers for mapping microconvection. We have produced an exact solution to the general equation of motion of particles at extremely low Reynolds number in microgravity that covers a wide range of interesting conditions. We have also developed diagnostic tools and experimental techniques to test the validity of the general equation. This program, which started in May 1998, will produce the flight definition for an experiment in a microgravity environment of space to validate the theoretical model. We will design an experiment with the help of the theoretical model that is optimized for testing the model, measuring g, g-jitter, and other microgravity phenomena. This paper describes the goals, rationale, and approach for the flight definition program.

Objective

The primary objective of this research is to understand the physics of particle interactions with fluids and other particles in low Reynolds number flows in microgravity. This includes the following:

(1) validate an exact solution to the general equation of motion of a particle in a fluid, observe and

(2) quantify g-jitter effects and microconvection on particles in fluids,

(3) characterize the ability of vibration isolation platforms to isolate experiments containing particle in liquids.

The objectives will be achieved by recording a large number of holograms of particle fields in microgravity under controlled conditions, extracting the precise three-dimensional position of all of the particles as a function of time, and examining the effects of all parameters on the motion of the particles. The feasibility for achieving these results has already been established in the ongoing ground-based NRA.

Summary of Tasks

The project tasks include adapting the theoretical analysis to help define the flight experiment matrix and conducting both computer and breadboard experiments to establish measurement requirements to meet the science objectives. The measurements planned in the study will address particle movement in controlled force fields, residual gravity/g-jitter, and particle interaction with other particles and surfaces. In the breadboard experiments, we will record holograms of particle distributions with g-jitter simulation and with controlled acceleration. Ultimately, microgravity is needed to test the model. The project will produce a Science Requirements Document (SRD) and will prepare for a Science Concept Review (SCR) and a Requirements Definition Review (RDR).

The paper will present the equations of motion and the analytical solution that is under test in the project. Also, preliminary experiments will be described that show that the experiments required to test the model are feasible.