SHIVA (Spaceflight Holography Investigation in a Virtual Apparatus)

by

James D. Trolinger
MetroLaser Incorporated

Roger Rangel
University of California Irvine

Carlos Coimbra
Drexel University

and

William Witherow and Jan Rogers
Marshall Spaceflight Center

ABSTRACT

This paper provides the description and results of a ground-based experiment designed to support the spaceflight program SHIVA, which started its flight definition in 1998. SHIVA will apply new diagnostic tools and experimental techniques to test the validity of a newly discovered analytical solution to the general equation of motion of a particle in a fluid. We have designed a spaceflight experiment with the help of the theoretical model that is optimized for testing the model, and for measuring g, g-jitter, and other microgravity phenomena. Our ongoing, ground-based particle/fluid experiment supports both the experimental and theoretical aspects of the project. The ultimate spaceflight experiment will be similar to the ground-based experiment.

The "virtual spaceflight chamber" concept asserts that certain spaceflight experiments can be recorded in holograms in such a manner that having the holograms on earth is optically equivalent to being back in space with unlimited time to conduct the experiment. Properly exploited, this concept can save a significant amount of experiment time in space by effectively bringing the experiment optically back to earth.

SHIVA will accomplish the following: record a large number of holograms of particle fields in space under controlled conditions, extract the precise, three-dimensional position of all of the particles as a function of time, examine the effects of all parameters on the motion of the particles, and test these against predictions of the Coimbra-Rangel solution to the general equation of motion. Particle sizes will range from hundreds of microns up to about 2 mm in diameter and will cover a range of densities and fluid viscosities.

Forcing functions will be introduced onto the particle field, including at least the following:

- No isolation in the Spacelab vibration environment.
- Isolation from Spacelab.
- Oscillatory motion from 1 to 100 Hz with amplitudes of a few millimeters.
- Convective fields to be introduced mechanically.

The first objective of this research is to understand the physics of particle interactions with fluids and other particles in low Reynolds number flows in microgravity. Secondary objectives are to: (1) observe and quantify g-jitter effects and microconvection on particles in fluids, (2) validate an exact solution to the general equation of motion of a particle in a fluid, and (3) to characterize the ability of isolating platforms to isolate experiments containing particles in liquids.