MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Microgravity Experiments from Sub-orbital to Orbital Platforms (3)

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ELECTROMAGNETIC FORCE IN PARTICLE-PARTICLE AGGREGATION

Abstract

Introduction

The mechanism of fine particles aggregation is of great importance in many areas of research, in particular environment sciences where the state of aggregation defines the removal speed of dust from the atmosphere. The study of this mechanism is also important to understand the first stage of planet formation from the solar nebula. The aggregates formed are generally fractals and, as mentioned in the literature [1], the fractal dimensions and the site growth probability measures of the resulting fractal structures strongly depend on the properties of the forces that cause the aggregation.

Theory and experimental apparatus

We began this study by the aggregation between two charged particles and we are now considering the aggregation between two magnetized particles. The aggregations are produced in a gas at a pressure between 10 and 1000 mbar and by using the applicable simplifications; we find that the distance (r) between the particles as a function of time (t) is given by the following equations:

$r = Ce(tf - t)^{1/3}$ for the electrical attraction

$r = Cm(tf - t)^{1/5}$ for the magnetic dipoles aligned in an external magnetic field.

The apparatus built for these measurements consists of an experimental cell from which two perpendicular views are combined via an optical system in one image recorded by a video camera. From the video, we can then measure the distance between the particles as a function of time and reconstruct the trajectories in 3-D. The horizontal and vertical resolutions are respectively 0.86 and 0.92 microns per pixel. With a depth of field of 250 microns, the usable volume for 3-D observation in then 250 microns x 250 microns x 443 microns.

Results and discussion

A first version of the apparatus was tested on an electrical force aggregation and the results [2] show that the corresponding equation is a good representation of the phenomenon. From these results, we believe that we can discriminate between the two forces and knowing the constants, it will be possible to obtain the product of the charges (or of the magnetic moments) without disturbing the aggregation process. This will result in a powerful diagnostic instrument to further the study of the fine powder aggregation mechanism.

[1] A. Block, W. von Bloh and H.J. Schellnhuber, J. Phys. A 24, L1037 (1991).

[2] C. Rioux, L. Potvin and R.J. Slobodrian, Phys. Rev. E, vol. 52, p. 2099 (1995).