N89-15030

NUCLEATION AND PARTICLE COAGULATION EXPERIMENTS IN MICROGRAVITY

NUTH, J., CODE 691, NASA-Goddard Space Flight Center
Greenbelt, MD 20771

Measurements of the conditions under which carbon, aluminum oxide, and silicon carbide smokes condense and of the morphology and crystal structure of the resulting grains are essential if we are to understand the nature of the materials ejected into the interstellar medium and the nature of the grains which eventually became part of the proto solar nebula. Little information is currently available on the vapor-solid phase transitions of refractory metals and oxides. What little experimental data do exist are, however, not in agreement with currently accepted models of the nucleation process for more volatile materials.

The major obstacle to performing such experiments in Earth-based laboratories is the susceptibility of these systems to convection. Consequently, it has so far proved impossible to controllably nucleate carbon, aluminum oxide, and silicon carbide smokes. Such smokes should be among the first condensates in stellar outflows.

Evaporation of refractory materials into a low-pressure environment with a carefully controlled temperature gradient will produce refractory smokes when the "critical supersaturation" of the system has been exceeded. Measurement of the point at which nucleation occurs, via light scattering or extinction, can not only yield nucleation data but also, information on the chemical composition and crystal structure of the condensate. If optical monitoring is continued, the measurements will yield data on the sticking coefficients of newly formed submicron refractory particles by determining the time evolution of the particle-size distribution. It might also be possible to deposit a volatile mantle over the dispursed refractory cores in order to study the optical properties and the coagulation efficiencies of such core/mantle grains. Optical methods should be supplemented by active particle collection (and subsequent analysis) in order to determine the morphology and degree of crystallinity of the newly formed particles as well as the structure of the core/mantle grains.

Experimental Requirements

Low pressure conditions ($<10^{-6}$ Pa) and cryogenic temperatures together with $\leq 10^{-5}$g are necessary. Total ambient temperature range is 4-400K; crucible temperature range up to approximately 3000K. Power requirements are ~ 100 Amp at 28 volt. Local heating with a CO_2-laser might be required. Total volume is about $4m^3$. Run duration is up to 24 hours. Experiments can be monitored remotely. Real-time video and still photography are required and continuous crew interaction, or the capability for remote control of the experiment from the ground, is preferred. The experiments require on-board facilities for analysis of surface properties, scanning and transmission electron microscopy, and mass-spectrometric analysis. These could be built into the experimental system where the use of on board analytical capability would be impractical.

NUCLEATION EXPERIMENTS IN A MICROGRAVITY ENVIRONMENT

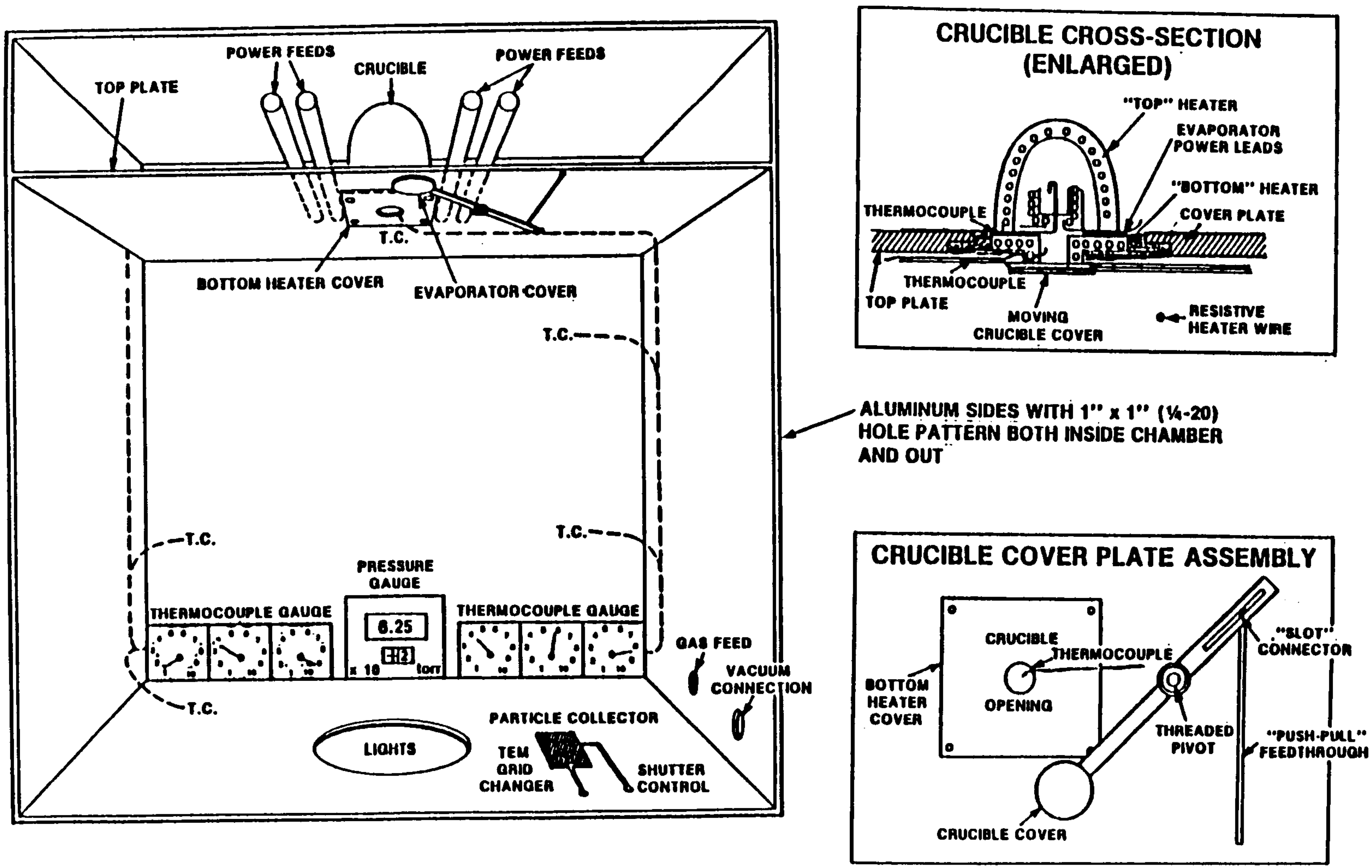
J.A. Nuth (NAS/NRC), J.E. Allen Jr. (GSFC), L.U. Lilleleht (U Va), I.D.R. Mackinnon (Microbeam, Inc.), F.J.M. Rietmeijer (LEMCO), J.R. Stephens (LANL)

A simple experimental apparatus (Figure 1) will be described in which a wide variety of vapor phase nucleation studies of refractory materials could be performed aboard NASA's KC-135 Research Aircraft. The chief advantage of a microgravity environment for these studies is the expected absence of thermally driven convective motions in the gas. The absence of convection leads to much more accurate knowledge of both the temperature distribution in the system and the time evolution of the refractory vapor concentration as a function of distance from the crucible.

We will describe the evolution of the apparatus as we gain more experience with the microgravity environment. Expected modifications include the addition of a programmable thermal gradient away from the crucible and a dye laser probe coupled with a detector system based either on a reticon array or a series of diodes. This latter system should make it possible to obtain a great deal of information not only on the conditions under which nucleation occurs, but also on the optical scattering and absorption characteristics of the particles produced in the experiments. These particles will be collected for SEM/TEM analysis. Comparison between the experimental results and the predictions of Mie theory for the measured particle size distribution will be made. In addition, an attempt will be made to measure the coagulation coefficient for a variety of materials and particle sizes by monitoring the time evolution of the size distribution.

We expect that a significant amount of nucleation data can be collected using the KC-135; considerably less information will be collected on the coagulation of the particles due to the short period of time in which the data can be obtained. Nevertheless, such experiments will be used to prepare for similar ones carried out aboard either the Shuttle or the Space Station where considerably longer duration experiments are possible.

FIGURE 1



ORIGINAL PAGE IS
OF POOR QUALITY