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Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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CLOUD MANIPULATION SYSTEM: THERMAL CHARACTERIZATION AND DROP TOWER EXPERIMENT

Abstract

We summarize research activities on the Cloud Manipulation System developed in the framework of the scientific program Interaction in Cosmic and Atmospheric Particle Systems (ICAPS) of the European Space Agency attributed for the International Space Station. The primary object of ICAPS project is to increase our knowledge about dust agglomeration in astrophysical processes mostly related to proto-planetary matter formation. A new dynamic balance based on thermophoretic effect has been developed during recent years. Thermophoresis refers to the motion of a particle inside a gas in response to a thermal gradient. One of the most interesting applications of this effect is the development of an advanced dynamic balance to manipulate dust clouds of micrometre size particle in reduced gravity environment where particle sedimentation is strongly suppressed. Cloud positioning and squeezing (i.e. increase of dust particle number concentration in a particular volume of interested) and finally highly intensified Brownian agglomeration can be obtained by the application of a controllable time-space variation of temperature fields. Main advantage of the Cloud Manipulation System is that, contrary to common electro-dynamics balance, the agglomeration of micro-meter size inert particles can be investigated without additional forced interaction between the particles. The operation of the system has been investigated in a set of microgravity-experiments at the ZARM drop tower in Bremen that provided in catapult mode up to 9.3 seconds of weightlessness with a residual acceleration of 10-6g or less. In addition, a number of on-ground research activities have been performed. They included: development of mathematical model to analyse the trap behaviour; numerical investigation of the gas temperature and velocity fields; laboratory characterization of the temperature fields inside the trap. From the laboratory measurements we quantified thermal fields and compared to the results of numerical simulation. Particle trajectories in microgravity environment have been analysed both numerically and experimentally. Controlled cloud displacement, trapping and formation of complex three-dimensional clouds patterns have been observed during the experiments. Results showed feasibility of the thermo-phoretic trap as clouds manipulation system and revealed additional perspectives for the investigation of dust clouds in microgravity environments.