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Fluidisation of cometary mantles

M.S. Bentley, N.I. Kömle, G. Kargl and E. Hütter

Institut für Weltraumforschung, 8042 Graz, Austria (mark.bentley@oeaw.ac.at)

Abstract

The formation and evolution of a dust mantle is of key interest to understanding many of the observed characteristics of comets. It is generally assumed that such a mantle is thermally insulating, due to the low effective thermal conductivity of such a porous granular material. However, it is likely that during periods of enhanced activity, sublimating gases can create a partially fluidised state.

In a critical range of gas velocities and flow rates the gas-drag and weight of the mantle are similar and dust particles can behave as a fluid; Figure 1 shows the evolution of this state under terrestrial conditions. In such a "fluidised bed", heat exchange between the gas and dust phases is high, and convection of solid material may provide an effective mechanism for heat transfer through the mantle. Thus, under certain conditions, the physical and thermal properties of the mantle could be dramatically altered; indeed this provides one explanation for the smooth terrains observed during several recent asteroid and comet encounters.

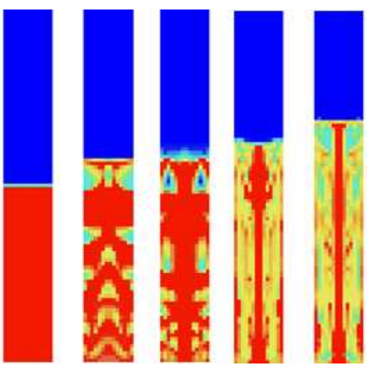

Figure 1: A two-fluid model of air fluidisation of 0.4 mm particles under terrestrial conditions, for gas velocities of 0.2, 0.3, 0.4, 0.5 and 0.6 m/s respectively.

Understanding these processes requires a detailed model of the dust and gas flow. Such models are well-developed for industrial use, but the cometary environment poses some interesting challenges. In particular the low gravity results in a bed weight considerably less than inter-particle cohesive forces.

The importance of cometary fluidisation and ongoing work to describe and model these processes using both a two-fluid (Eulerian) and a discrete particle (Eulerian-Lagrangian) approach will be discussed. In particular, the minimum fluidisation velocity for a range of particle sizes and gas velocities will be presented and compared with likely cometary surface parameters.