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GRAIN DYNAMICS IN ZERO GRAVITY

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The dynamics of granular materials has proved difficult to model, primarily because of the complications arising from inelastic losses, friction, packing, and the effect of many grains being in contact simultaneously. One interesting limit for which it has recently been possible to construct a theory[1,2] is that where the grain-grain interactions are dominated by binary collisions. The kinetic model of granular systems is similar to the kinetic theory of gases, except that collisional energy losses are always present in the former and must be treated explicitly. Few granular materials on Earth are describable by this limiting model, since gravity tends to collapse the grains into a high-density state where Coulombic friction effects are dominant.

The planned Space Station offers an unusual opportunity to test the kinetic grain model and to explore its predictions. Without gravity, we will be able to investigate the regime of low interparticle velocities, where an elastic description of the collision is still valid. This will allow for direct interpretation by dynamical computer simulations as well as by kinetic theory.

One effect predicted by the kinetic theory is the tendency for inelastic grains to cluster together away from a source of energy. For instance, if one wall of a box partially filled with grains in the absence of gravity is vibrated, the density of grains close to this wall will become small, while near the opposite (cold) wall the grain density approaches its maximum value (see Figure 1a). Correspondingly, as illustrated in Figure 1b, kinetic grain models predict that grain "thermal" velocities become very small at a characteristic distance from the "hot" wall. Computer simulations of this situation also predict that the particle velocities should fall and that they should cluster away from the "hot" wall.[3]

We propose a basic experiment to be performed on the Space Station which would examine the dynamics of spherical grains inside a clear box. Data would be obtained primarily from a film of the experiment and analyzed using techniques we are presently developing. Results would be compared with the predictions of the kinetic theory and computer simulations. In addition, the effect of grain rotations would be studied.

Planetary rings can be theoretically modeled using the kinetic theory of granular dynamics.[4] We would like to use this experimental apparatus to investigate some of the parameters needed for such a model. In particular, we could study the clustering effect for realistic materials, as well as the details of individual two-body collisions.

REFERENCES

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FIGURE CAPTIONS

Fig. 1. One wall of a box partially filled with inelastic grains is heated (the left wall in the figure). A kinetic theory of grain dynamics is used to calculate the dimensionless density (a) and the dimensionless thermal velocity (b) as a function of position in the box for seven sets of parameters. Note that for run (g), the far wall is cool but not cold.

Run	% free space in box	thermal conductivity coefficient	coefficient of restitution
a	10	1	.9
b	10	10	.9
c	50	1	.9
d	50	10	.9
e	50	1	.6
f	90	1	.6
g	90	10	.6

Figure 1a.

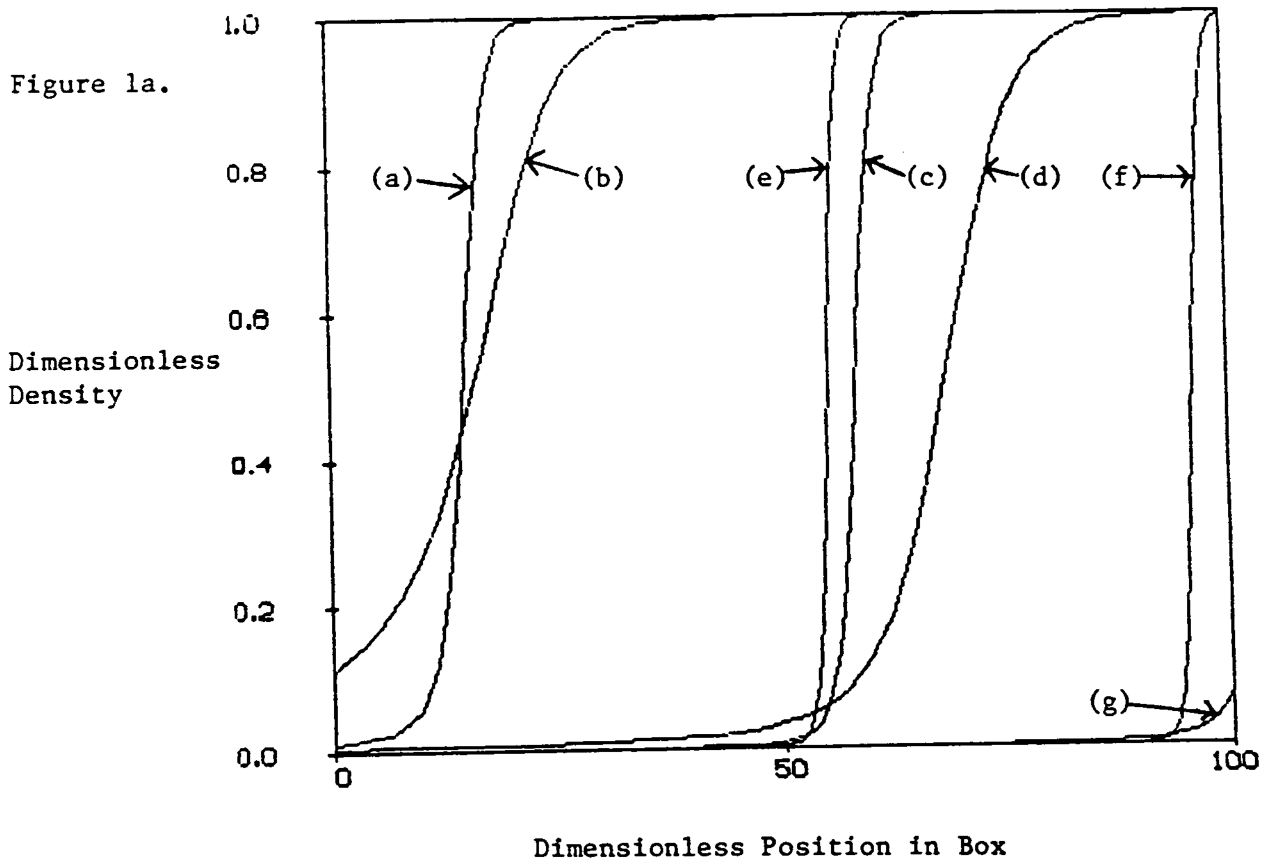

Figure 1b.