Energetic approach of the gas-cluster transition in microgravity

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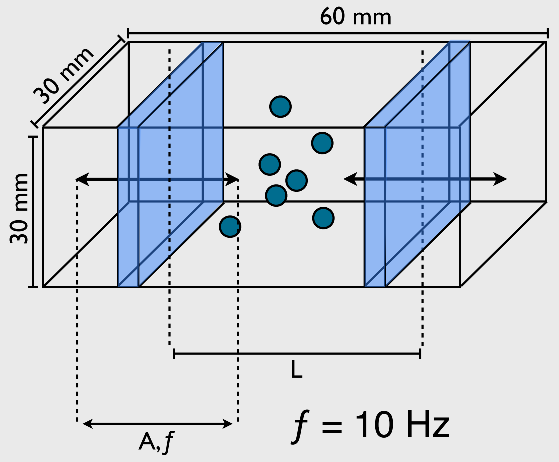
SpaceGrains [1]

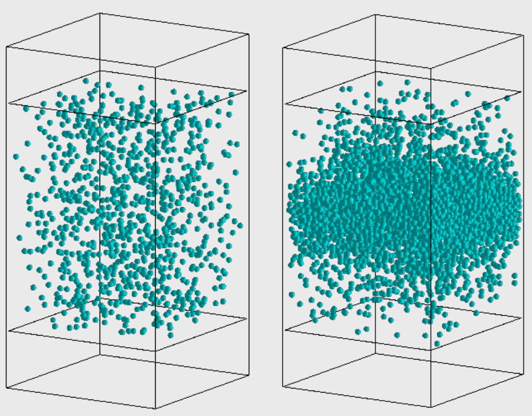
- study of dilute systems in 0g
- observe phase transitions
- find condensation criteria



f = 10 Hz

ε = 0.9 (restitution)

MD Simulations

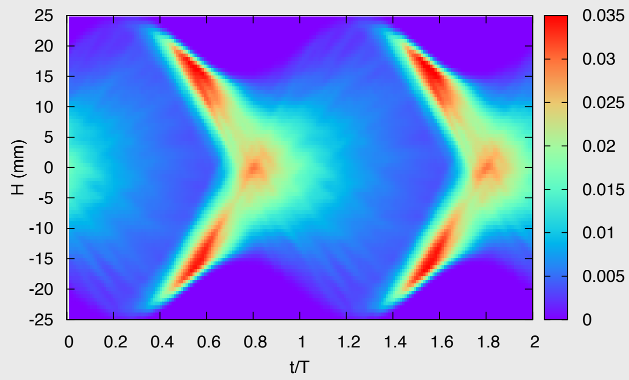


N = 1000   N = 4500

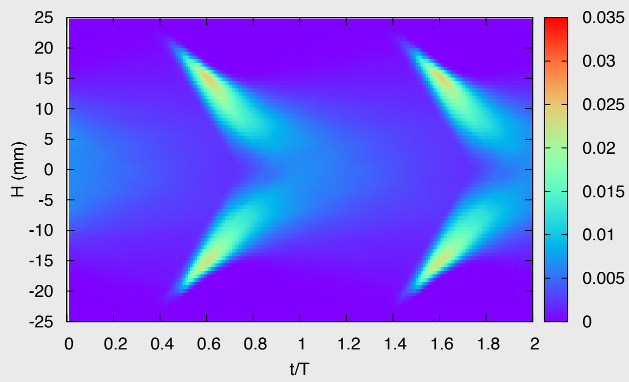
Energy propagation

- mean kinematic energy (mJ) spatio for gas and cluster regime

N = 1000



N = 4500



- energy injection near pistons
- collision cascade (loss of energy)
- deviation of trajectories
- periodic patterns (stability)

Two phenomena in competition

- energy injection and propagation
- cooling due to inelastic collapse

Propagation time

$$\tau_P = \frac{\delta}{N^*}\left(\sum_{i=0}^{N^*}\frac{1}{v_0\varepsilon^i}\right)$$

δ mean exploration

N^* encounterd particles

v_0 injection velocity

Haff time [2]

- characteristical relaxation time

$$\tau_H = \frac{2}{v_0(1-\varepsilon^2)\eta\sigma}$$

η number density

Cluster condition: $\tau_H < \tau_P$

Transition curve

- cluster condition leads to equation

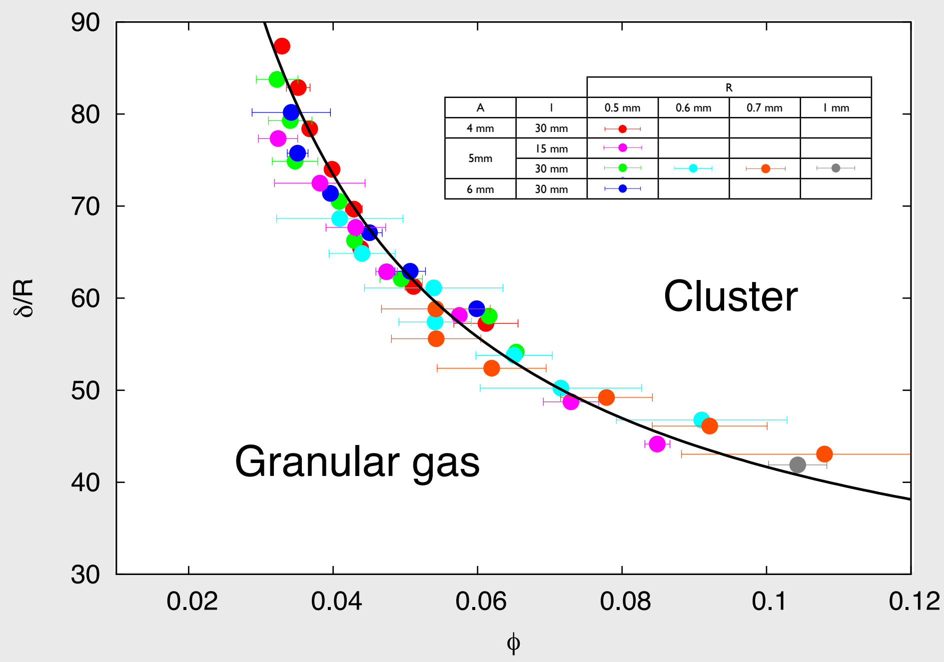
$$\frac{\delta}{R} > \frac{1}{3}\left(\frac{\xi}{\phi}\right) + \frac{\delta_0}{R} \quad \text{with} \quad \xi = -\frac{\ln\left(1+\frac{2}{\varepsilon(1+\varepsilon)}\right)}{\ln\varepsilon} - 1$$

- δ_0 is the only fitting parameter
- R is the grain radius

> - 2 sample Kolmogorov-Smirnov adequation test
> - testing against uniform distribution of the grains in the constraint-free zone [3] *

Results

- theoretic curve in good agreement with the statistical detection (KS test*) of the cluster



A	l	R: 0.5 mm	0.6 mm	0.7 mm	1 mm
4 mm	30 mm	● (red)			
5mm	15 mm	● (magenta)			
	30 mm	● (green)	● (cyan)	● (orange)	● (grey)
6 mm	30 mm	● (blue)			

[1] S. Vincent-Bonnieu, SpaceGrains ESA Poster ESTEC (2012)
[2] C. C. Maaß *et al.* , Phys. Rev. Lett. **100**, 248001 (2008)
[3] E. Opsomer, F. Ludewig and N. Vandewalle, Phys. Rev. E. **84**, 051306 (2011)