FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

ENGINEERING OF ADVANCED MATERIALS

INSTITUTE FOR MULTISCALE SIMULATION OF PARTICULATE SYSTEMS

Sedimentation of a granular dust cloud

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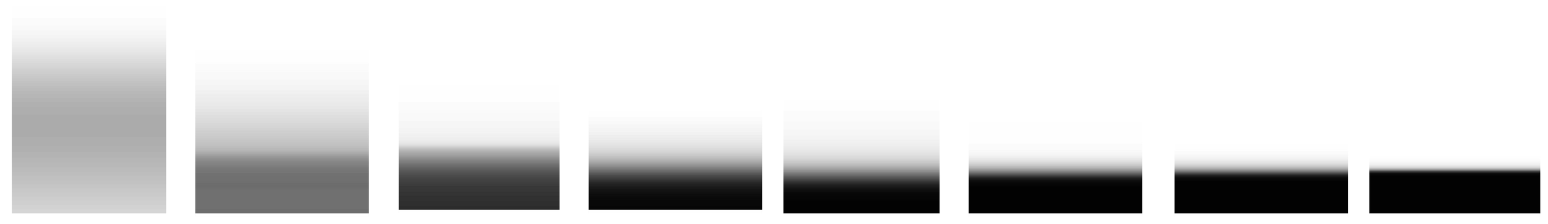
Motivation

A previously thermally exited granular gas collapses under gravity resulting in shock waves propagating through the material. This behavior has been observed in a sedimentation experiment [1] and a profound understanding is needed.



State of the Art

We consider granular fluid composed of smooth inelastic hard disks. We solve numerically the Hydrodynamic equations for 2D granular gas considering the Jenkins-Richman transport coefficients

$$\frac{\partial n}{\partial t}+\vec{\nabla}\cdot(n\vec{u})=0,$$

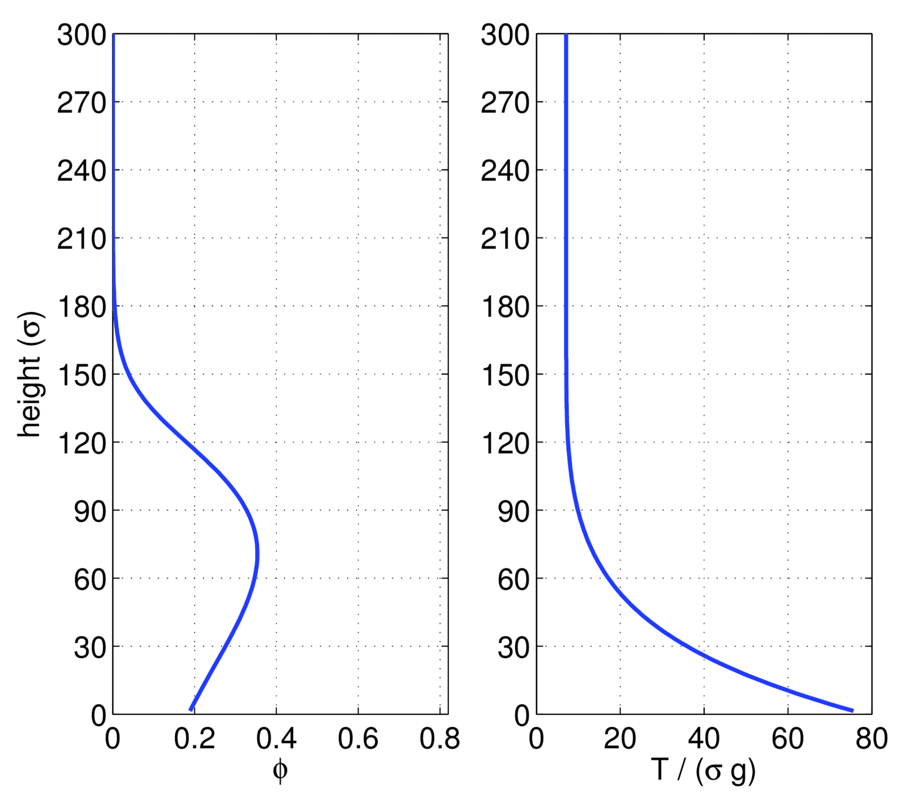
$$n\left(\frac{\partial \vec{u}}{\partial t}+\vec{u}\cdot\vec{\nabla}\vec{u}\right)=-\vec{\nabla}\cdot\hat{P}-n\vec{g},$$

$$n\left(\frac{\partial T}{\partial t}+\vec{u}\cdot\vec{\nabla}T\right)=-\nabla\cdot\vec{q}-\hat{P}:\vec{\nabla}\vec{u}-\xi n T$$

The Navier-Stokes terms are treated by centered high-order explicit in time finite difference approximations and considered as sources for the method of lines in the time approximation. The Euler terms are solved in local coordinates by a fifth-order explicit in time finite difference characteristic-wise WENO method. Complete details on the numerical scheme [2].

We consider the barometric initial condition [3] because mimics the state of a system with a thermal bottom plate which gives energy to the system.

The boundary conditions for the top and bottom walls are adiabatic and impenetrable.



Conclusions

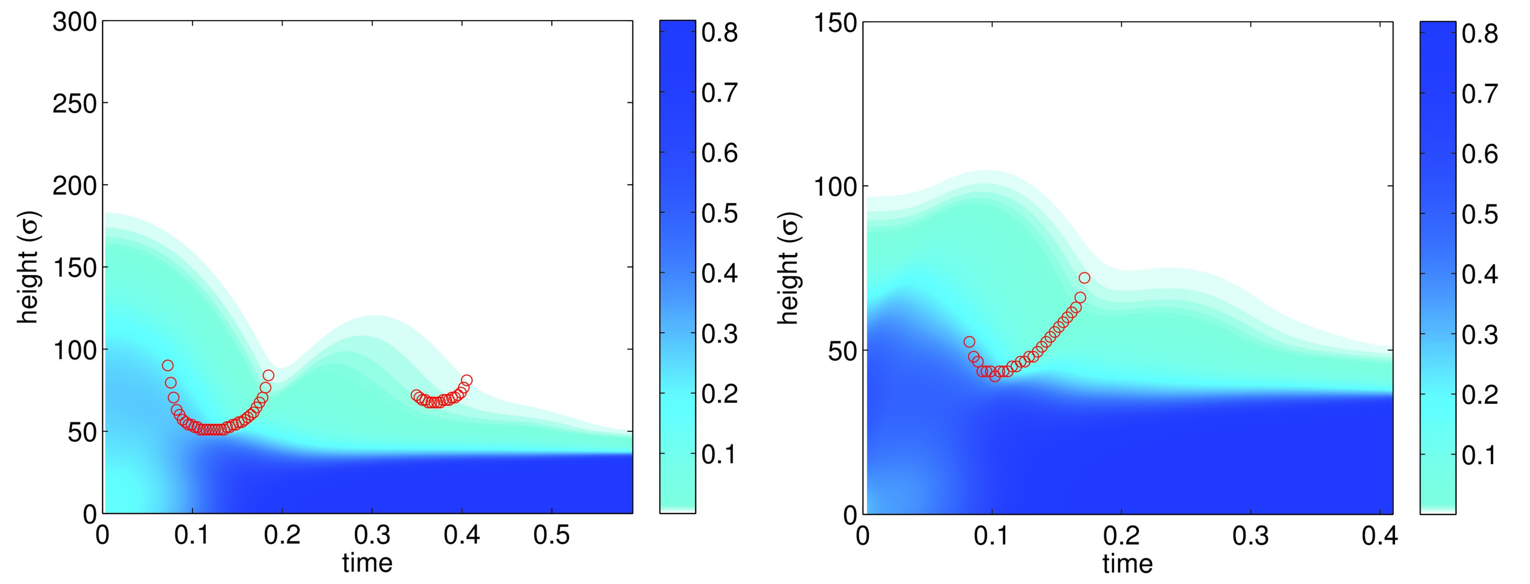
- The number of shock waves depends on the initial condition of the system as well as the coefficient of restitution.
- Each shock wave is followed by the expansion of the material and by the increase of temperature.
- The shock waves follow the sharp profiles of temperature and density field.

[1] Reuben Son, John Perez, and Greg Voth. Experimental measurements of the collapse of a two-dimensional granular gas under gravity. Physical Review E, 78(4):1–7,October 2008.
[2] J. A. Carrillo, T. Pöschel, and C. Salueña. Granular hydrodynamics and pattern formation in vertically oscillated granular disk layers. J. Fluid Mech., 597:119, 2008.
[3] Baruch Meerson, Thorsten Pöschel, and Yaron Bromberg. Close-packed floating clusters: Granular hydrodynamics beyond the freezing point? Phys. Rev. Lett., 91:024301, 2003.

Results

We have made the simulations for different initial heights and different coefficients of restitution where similar behaviors are observed.

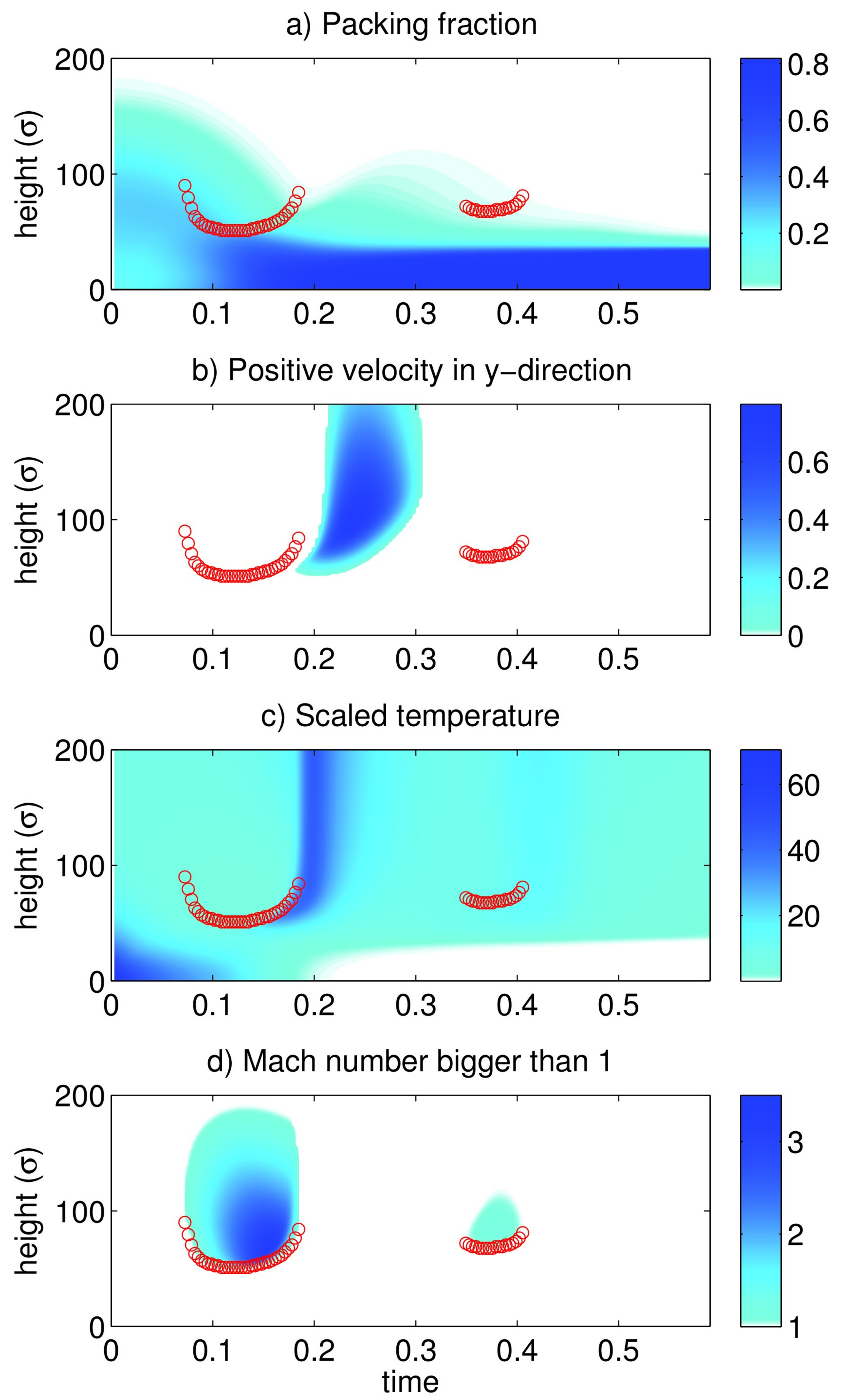
Although we solve the system in 2D, the system is physically 1D, thus the relevant variables are the vertical coordinate and time.



Red circles are the vertical position where the mach number

$$M=|\vec{v}|/c_s>1$$

it means that there is a supersonic wave propagating through the material.



The blue and red lines follows the minimum of the vertical gradients temperature and packing fraction respectively. It means that the shock wave is accompanied by sharp profiles.