Project Description:

Project Name

submitted by
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Specific academic field (specialization): Planetology?

Supervisor and first expert reviewer for recommendation letters: Prof. Dr. Frank Spahn

Further expert reviewers (name, academic field; these do not have to be identical with the second reviewer of the PhD thesis): ???

Working environment: Please briefly explain how you are integrated in colloquia, a working group, a research training group etc. Please indicate if you are an individual doctoral student.

Abstract

Clear and comprehensible presentation of the project, short characterization of your project's objectives (not longer than 15 lines)

A. Summary of the research topic

The model we consider is a granular gas with polydisperse size-distribution of constituents in a sheared environment. In our further discussion, we will be using the term *granular temperature* or simply *temperature*, referring to the mean kinetic energy of constituents, and not molecular heat energy.

Unlike molecular gases, a granular gas is always subject to dissipation of inner energy or temperature decay over time [1, 2]. Even more interesting phenomena can be observed when granular gas consists of species with different masses. In this case, due to non-equal partitioning of energy, each species attain unique granular temperatures [3, 4]. The time evolution of these temperatures is in the next form:

$$\frac{dT_i}{dt} \propto H_i - A_i T_i + \sum_k B_{ik}(T_i - T_k) \;, \tag{1}$$

where T_i and T_k are granular temperatures, $A_i > 0$ is the parameter describing dissipation due to collisions, which depends on size distribution function, collision frequency and restitution. The parameter $B_{ik} = B_{ki} > 0$ describes the inter-species heat flow. This is the main reason why species tend to have different temperatures. H_i is a certain external heating function. If one introduces an external energy pump into the system, the temperatures of species don't reach zero, but attain certain stationary and still unique values, balancing the outer heating [5].

One caveat of these heating models is that they are all artificial. Our goal is to investigate the model with a more realistic heating term, the gravitational shear heating in planetary disks. This heating is in the next form:

$$H_i \propto \nu_i \Omega^2 \;, \tag{2}$$

where Ω is the mean orbital frequency around the considered location of the system, and ν_i is the shear viscosity term. In the case of planetary rings, the viscosity term is split into *local* and *non-local* parts $\nu = \nu_l + \nu_{nl}$ [6, 7, 8]. However, these terms are given only for the mono-disperse case. In the case of a gas with different species, we need to know the viscosity terms for each species. This is the first goal of our project, to obtain the kinetic transport coefficients for each species from the microscopic level of description. By this we mean kinetic description of the system, given a velocity distribution function f, its time evolution obeys:

$$\frac{\partial f_i}{\partial t} + \vec{v} \cdot \frac{\partial f_i}{\partial \vec{r}} - -\frac{1}{m_i}\frac{\partial U}{\partial \vec{r}}\frac{\partial f_i}{\partial \vec{v}} = \sum_k \eta_k I(f_i, f_k) \;, \tag{3}$$

where $I(f_i, f_k)$ is the collision integral and η is the size distribution function.

In order to test the theoretical results, we have developed a molecular dynamics (MD) code, simulating granular particles of different sizes in a Hill's box. *Here some* $\ln T$ *over* $\ln t$ *simulation results graph Fig. 1*

Next, we would like to address the reasons for size distribution in Saturn's rings. From experimental evidence, we that the size distribution obeys a power law with a cut-off at the end [size-distribution tail original works]. There are several attempts to model this phenomenon [9, 10]. All of them assume a certain interplay between two driving processes, aggregation or coagulation process when particles merge, producing larger particles, and fragmentation process, when particles fracture after collision producing smaller constituents. A natural step for us would be to analyze the kinetic equations describing the behavior of the system with inclusion of aggregation and fragmentation processes.

Such an interplay and balance of three different processes, one being separation of temperatures of species, second being the gravitational heating and third being the recombination of particles which lead to dynamical change of size distribution, is already quite interesting. Hence, an external influence, such as periodic driving force acting upon the system should lead to various fascinating phenomena. In planetary systems, such periodic driving forces are resonances with the moons of the planet.

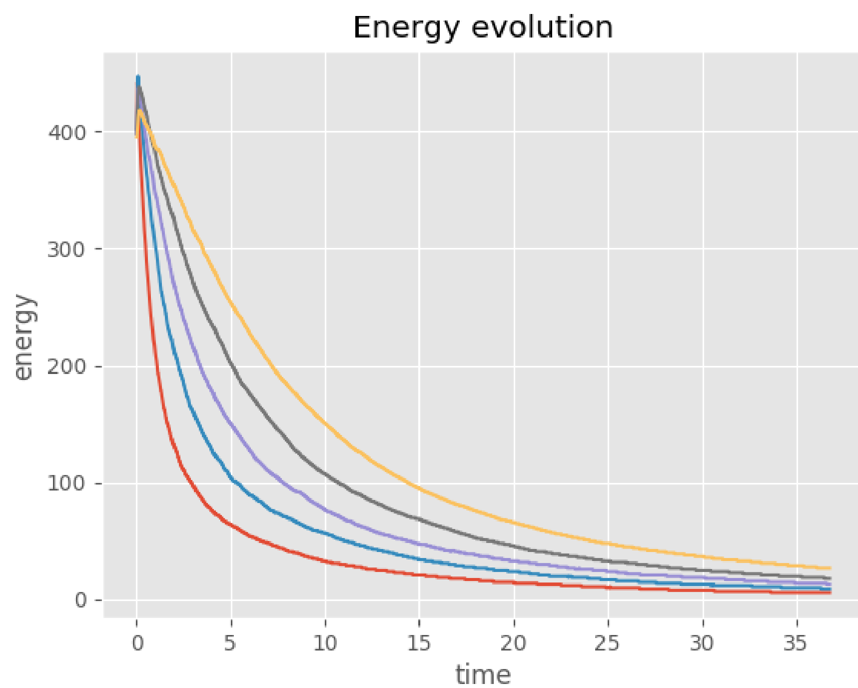

Figure 1: This is only an example plot. Should be replaced by my new simulation results

B.Table of contents and outline of the thesis with an overview of accomplished (sub-) chapter

Please submit your table of contents /outline of your thesis. Please characterize the (sub-)chapter that have already been accomplished. The probability of concluding the project during the funding period must be illustrated. The awarding committee reserves the right to obtain the stated (sub-) chapter in printed form.

C. Working program and intended completion date

- Working-Program, time schedule (max. 4 pages)Detailed information about your planned approach, especially a thorough explanation of the meth-odology, that you will apply in the completion phase of your PhD. A time schedule (e. g. in graphic or tabular form) for the period of funding should clearly demonstrate the steps in your research project that are planned, have already started or are completed. If your PhD includes experiments, please indicate the experiments that have already been conducted and that will still be conducted. The quality of the research approach and the characterization of the accomplished and planned steps are of utmost importance.
- Please specify your intended completion date.

D. Literature

References

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[5] A. Bodrova, D. Levchenko, and N. Brilliantov. Universality of temperature distribution in granular gas mixtures with a steep particle size distribution. *Epl*, 106(1), 2014.

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