## Physics of Planetary Systems — Exercises — Set 7

## Problem 7.1

(2 points)

Consider vertical settling and grain growth in a protoplanetary disk. Given a mass coagulation rate  $\dot{m} \propto \sigma \rho_{gas} \dot{z}$  (where  $m = 4/3 \times \pi \rho s^3$  and  $\sigma \propto s^2$ ), show that a grain's final radius (as it arrives in the disk's mid-plane) is independent from its (small) initial radius. *Hint: How can you calculate the gas column density*  $\Sigma_{gas}$  from the gas density  $\rho_{gas}$ ?

## Bonus problem 7.2

(2 extra points)

Perform a direct estimate of the final radius in Problem 7.1.

## Problem 7.3

(1 point)

Estimate the altitude from which you should drop an object (on Earth) so that it hits the ground at 1 cm/s, a velocity typical for grain–grain collisions in protoplanetary disks.



**Figure 1:** Snapshot of a cloud of fragments produced in a (high-velocity) collision experiment set up in a laboratory at Braunschweig University. (Blum, IGeP/TU Braunschweig)