Smoothed Particle Hydrodynamics Simulations for Asteroid Deflection

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Abstract

Fragen:
- Gliederung, SPH zu Theorie oder Numerics?
- Reihenfolge/Parallelität der Lösung von Mass/Momentum/Energy Conservation
- An wen ist eine Masterthesis gerichtet?

Contents

1 Introduction

2 Asteroid Deflection Missions

A number of research groups [2]

3 Numerical Simulations

3.1 Smoothed Particle Hydrodynamics

3.2 Miluphcuda SPH code

Miluphcuda is a GPU accelerated smoothed particle hydrodynamics code that has been developed over several years at the University of Tuebingen by Christoph Schaefer and others. Its general use is well documented in [1].

3.2.1 Porosity model

The model used is based upon the

3.2.2 Strength model

3.2.3 Variable smoothing length

3.2.4 Time Integration

1) Timestep algorithm for velocity update (RungeKutta 2) 2) Update particle positions from velocity and acceleration (accel from Navier Stokes) 3) Error criterium for timestep (what is used? RK45?)

- how are the equations from Theory section used to get the development over time - final form of Equation we used: .... - Neighborhoudsearch instead of computing Kernel over all particles is faster - Upper limit to maximum neighbor particles

3.3 Initial conditions

- resolution bound to variable smoothing length - SPH needs uniform macro structure but random micro structure

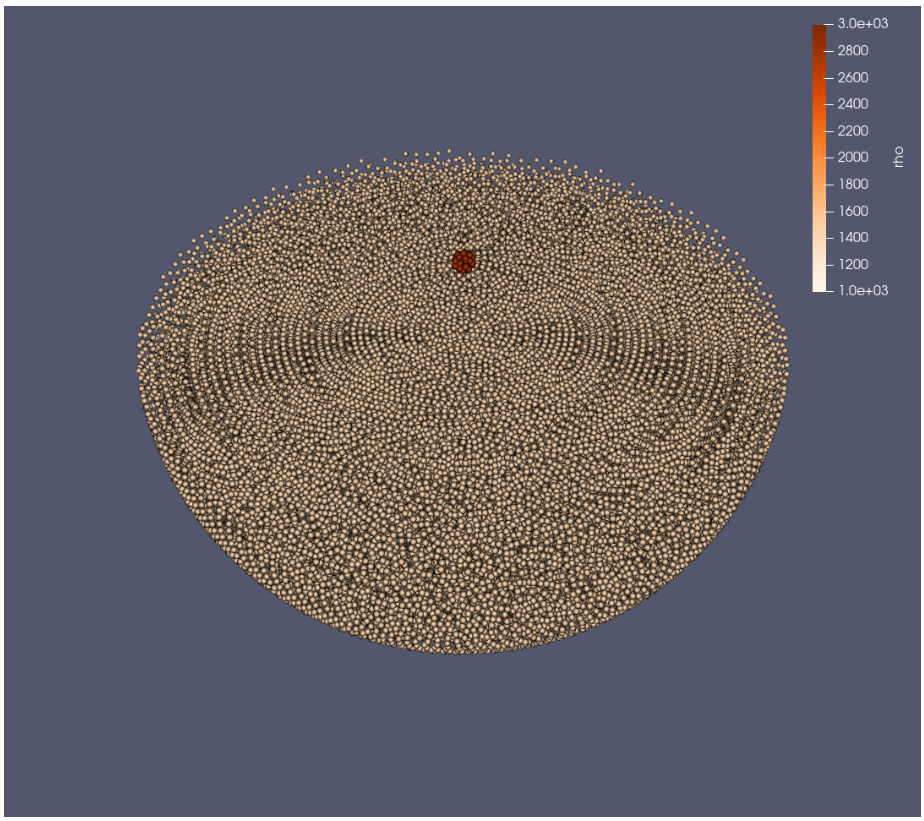

Figure 1: initial conditions

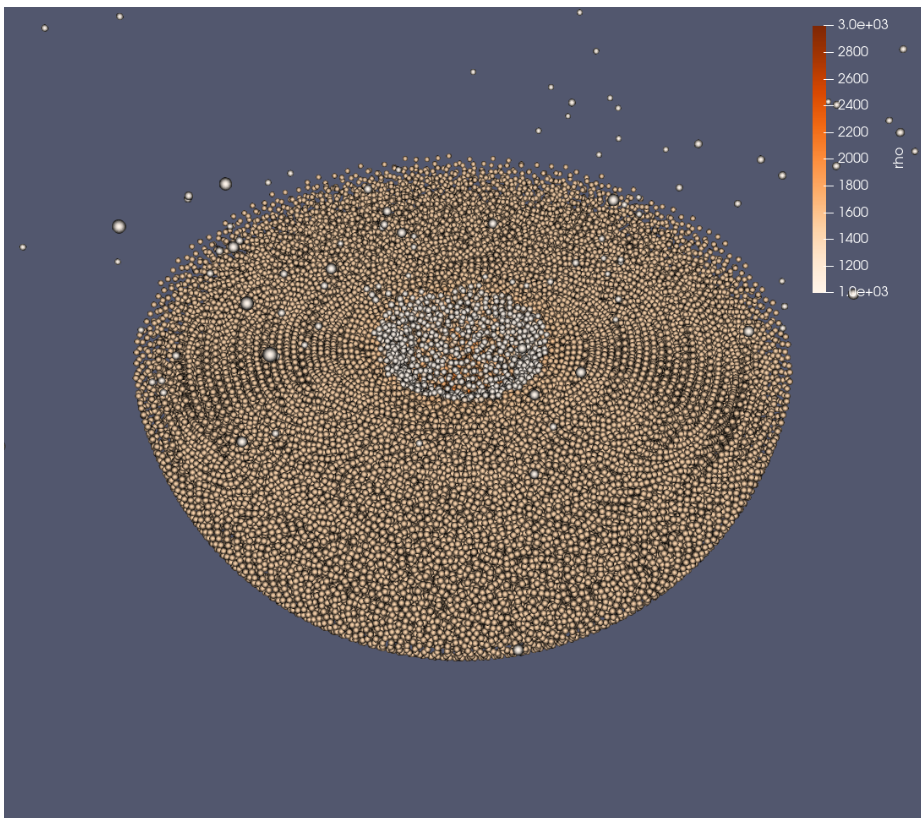

Figure 2: cratering of half sphere

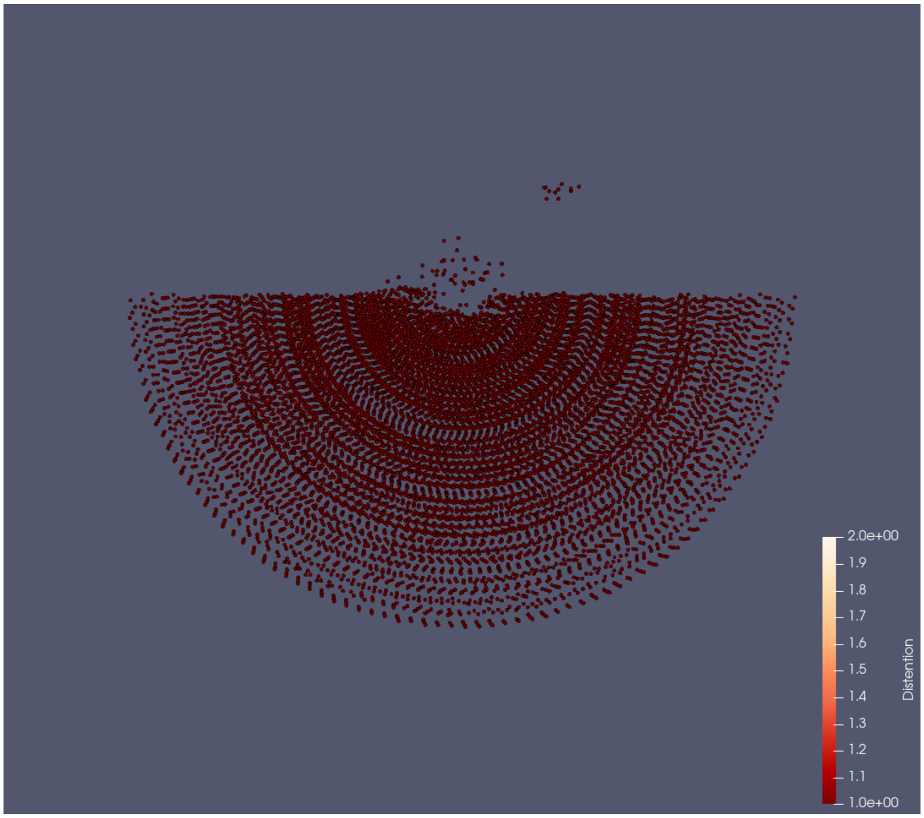

Figure 3: No porosity (0%), high strength (Y=1MPa)

4 Results

The simulations were run with porosities of 0%, 17%, 33% and 50% and cohesive strengths of 1kPa, 10kPa, 100kPa and 1MPa under impact angles of 0 and 45 degrees. This yields 32 simulations in total.

4.1 Cratering

Figures 3 through 6 show the effects of porosity and strength on the crater formation. The higher the porosity and the lower the porosity become, the wider and deeper the crater gets.

4.2 Beta factor

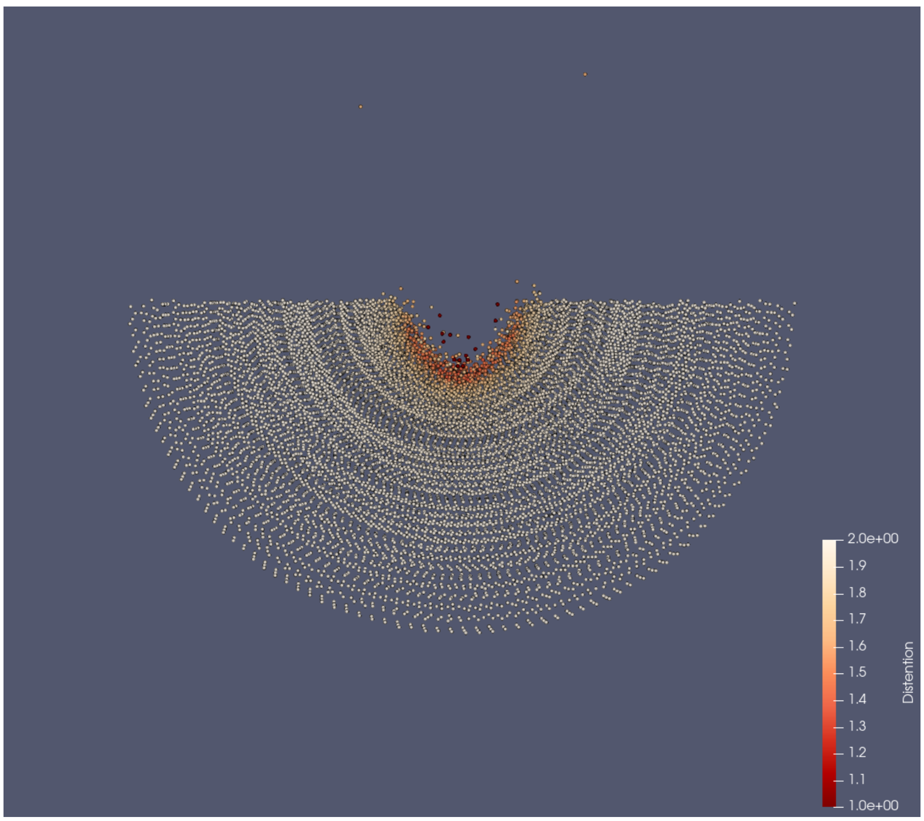

Figure 4: High porosity (50%), high strength (Y=1MPa)

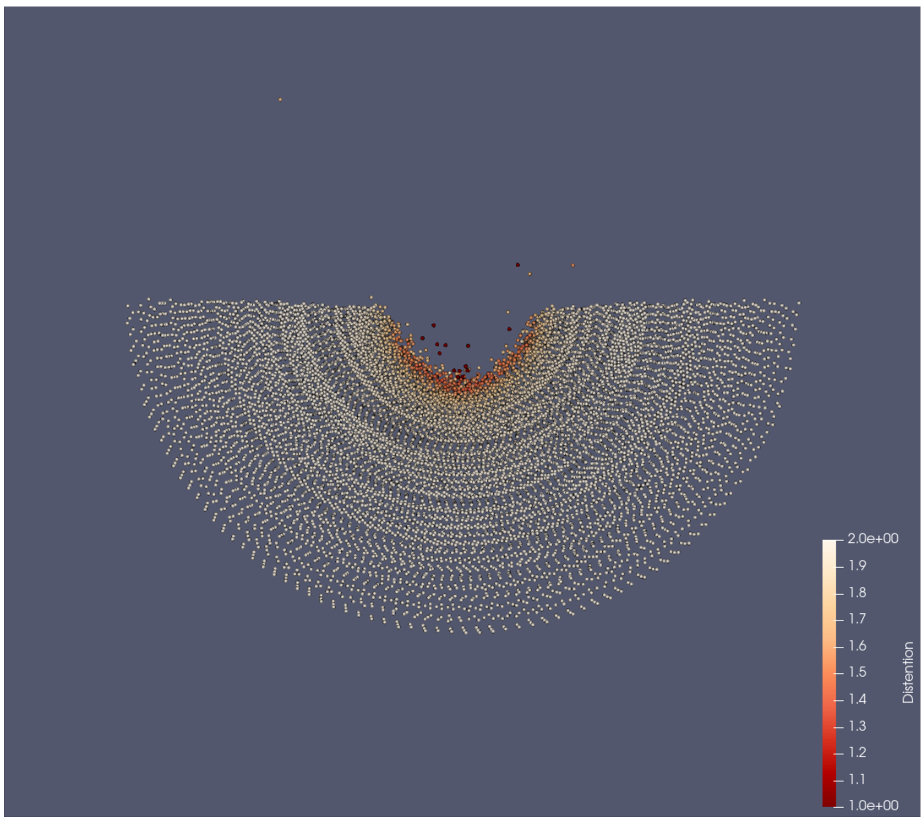

Figure 5: High porosity (50%), low strength (Y=1kPa)

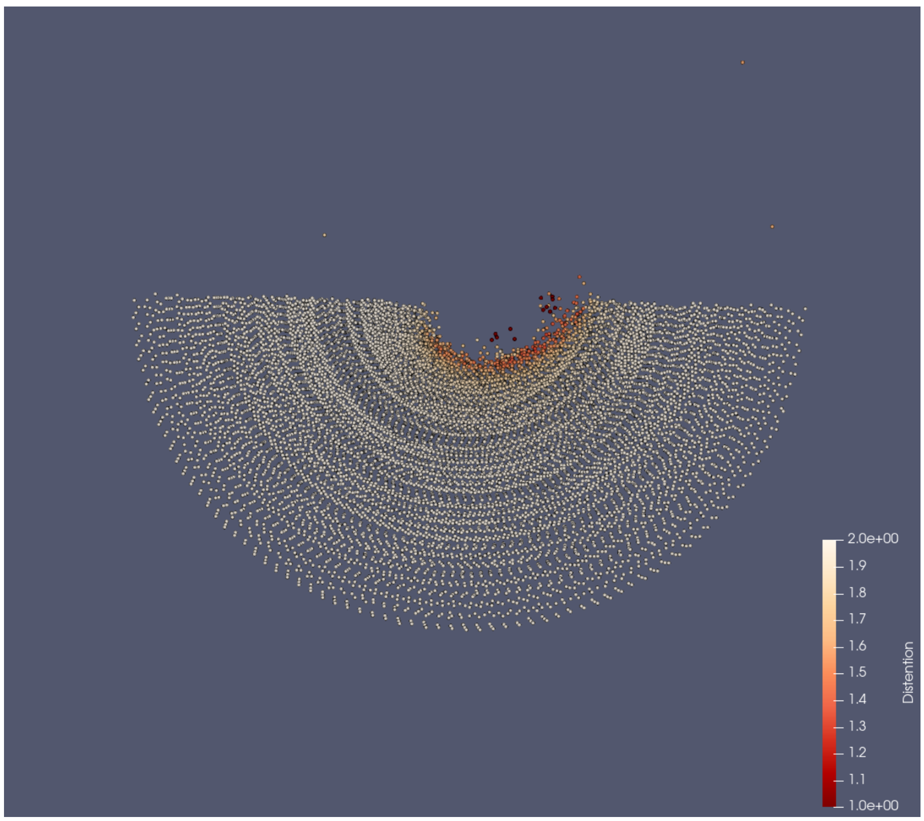

Figure 6: High porosity (50%), low strength (Y=1kPa), 45 deg angle

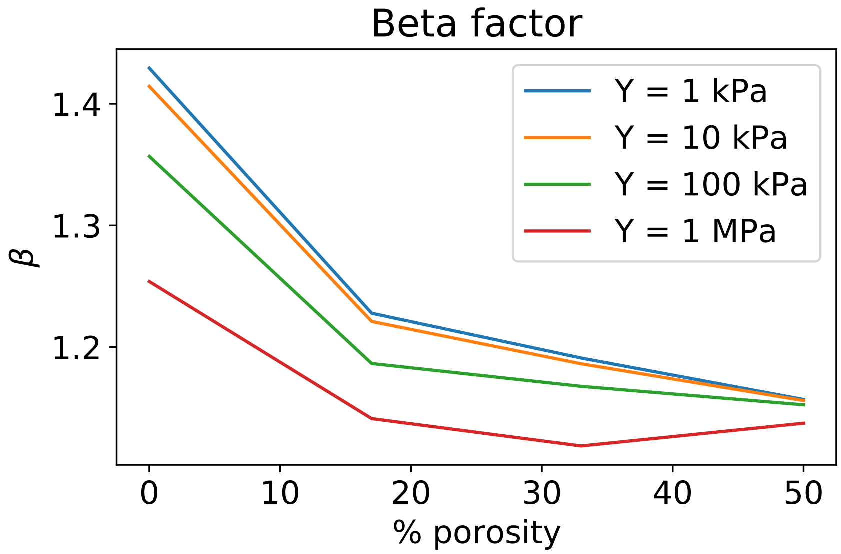

Figure 7: beta factor

5 Discussion

- beta factor on the lower end - upper limit beta ¡ 2 because of momentum conservation??

References

[1] C. Schaefer et al. "A smooth particle hydrodynamics code to model collisions between solid, self-gravitating objects". In: *Astronomy and Astrophysics* 590 (Apr. 2016), A19. ISSN: 1432-0746. DOI: 10.1051/0004-6361/201528060. URL: http://dx.doi.org/10.1051/0004-6361/201528060.

[2] Sabina Raducan et al. "The role of asteroid strength, porosity and internal friction in impact momentum transfer". In: *Icarus* 329 (Apr. 2019), pp. 282–295. DOI: 10.1016/j.icarus.2019.03.040.