A PROTOPLANETESIMAL DUST COLLISION MODEL BASED ON EXPERIMENTS

S. Kothe[1], C.Güttler[1], J.Blum[1], E.Beitz[1], R. Weidling[1]. [1]Institut für Geophysik und extraterrestrische Physik, TU Braunschweig. E-mail: s.kothe@tu-bs.de

Introduction: The formation of solid bodies in the early solar system, like e.g. planets, meteorites or asteroids started with the growth of small aggregates out of (sub-)micrometer sized dust grains. At distances of 1 AU from the young Sun, most of the particles are silicates. Collisions between those dust grains have initially low velocities and lead to sticking and hence to the growth of larger, at first fractal, aggregates. Further impacts are supposed to compact these agglomerates to non-fractal but still highly porous particles. Due to the interaction with the surrounding gas, these agglomerates collide at higher velocities. Therefore these collisions do not necessarily lead to sticking.

However, none of these processes is directly accessible by observations so that we depend on theories, simulations and experiments to develop a picture of these processes.

The collision behavior of two dust agglomerates has been studied in different experiments (e.g. reviewed in [1]) with typically micrometer sized dust particles and aggregates thereof. To reach low collision velocities, which are realistic in a protoplanetary disk, most of the experiments were performed under microgravity conditions on parabolic flights or in the drop tower in Bremen.

The experiments showed a variety of outcomes: while small particles at low collision velocities are still likely to stick, an increase in the impact energy leads to rebound of the particles, or, for even higher velocities of the order of 1 m s^{-1}, even to fragmentation. Both of these processes can restrain the growth of larger bodies.

Collision Model: To make the diversity of possible outcomes in these experiments accessible for theoretical approaches, we compiled them in a dust collision model (c.f. [2]). Depending on the particle masses, velocities, and porosities, the model predicts the outcome of collisions and distinguishes between different types of collisional outcomes, which are based on our experiments and extrapolations of these. For each type of collision, the model returns the particles porosities and size distribution after the collision.

Improvements: Since the original publication, several new experiments were conducted to improve the model. We found that there is a transition between the sticking and the bouncing regime and growth is still possible at velocities where we expect rebound [3]. Moreover, under certain circumstances fragmentation, which at first appears to constrain further growth, can actually lead to growth due to a small mass transfer [4,5].

This talk will give an introduction to our model and new experiments which were used to improve it.

References: [1] Blum, J. and Wurm, G. 2008. Annual Review of Astronomy & Astrophysics, 46, 21-56. [2] Güttler, C. et al. 2010. Astronomy and Astrophysics, 513, A56. [3] Weidling et al., arXiv:1105.3909. [4] Beitz et al. 2011. arXiv:1102.4441 [5] Kothe et al. 2010. The Astrophysical Journal, 725, 1242-1251.