THREE DIMENSIONAL MICRO-STRUCTURES OF DUST AGGREGATE BY RANDOM BALLISTIC DEPOSITION USING MICRO-TOMOGRAPHY

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Introduction: In a formation scenario of planetary system, it is widely accepted that planetesimals form due to collisions and aggregation of sub-micron solid particles (dust). In recent years, several studies have been made on the dust aggregation process. Blum et al. (2006) [1] describe the dust aggregation by annalistic theoretical approach. Wada et al., (2008) [2] determined an equation of state of dust aggregates by three dimensional numerical simulations of dust aggregate collisions. In terms of experimental studies, Blum J. & Wurm (2008) [3] reviewed a series of their studies of experiments about dust aggregation, and clarified macroscopic picture of dust aggregation. However, three dimensional (3D) structure of the dust aggregate has not been determined experimentally yet. In order to reveal dust aggregation in protoplanetary disk, it is necessary to clarify 3D structure of the dust aggregates experimentally.

Experiments: Dust aggregate analogs were made in a laboratory as simulation of random ballistic deposition process in the early solar system. Single silica sphere grains of 1.5 microns in diameter were dropped down by cogwheel [3] with a feasible low-velocity in a vacuum chamber evacuated at 100 Pa. During the falling, the grains were aggregated with each other, and finally deposited on a glass fiber of 40 microns in diameter. 3-D structures of the deposited aggregates were obtained by nanotomography using phase contrast at beamline BL47XU in SPring-8 with monochromatic X-ray beams of 8 keV. Successional slice images with the voxel size of 48 x 48 x 48 nm were reconstructed.

Results and Discussion: We succeed to recognize individual gains of the aggregates, and found that the aggregates are mainly composed of chains of grains with some branching. Positions of the center of gravity of individual grains were obtained using image analysis after binarization of the grains. The coordination numbers of the grains vary mainly from 2 to 3, and the fractal dimension of the aggregates ranges from 1.8 to 2.4. The numerical simulation of dust aggregation [2] showed that the fractal dimension of the aggregates does not exceed 2.5 in ballistic cluster-cluster aggregation process. The result of the numerical simulation is consistent with the result of the present study. However, some aggregates of the experiment have higher coordination numbers than those of the numerical simulation, although the fractal dimension of the experimental and numerical simulation aggregates are almost the same. We found that angles between neighboring grains in the experimental aggregates concentrate in 60 degree. In contrast, the aggregates of the numerical simulation do not have such feature. This suggests that there is difference of 3D structure between the aggregates of experimental and numerical simulations, and the aggregates may have difference physical properties such as, strength and collisional sticking probability.

References: [1] Blum J., et al, 2006. *Astrophysical Journal*, 652:1768. [2] Wada et al., 2008 *Astrophysical Journal*, 677:1296-1308. [3]Blum J. & Wurm G. 2008, *Annual Review of Astronomy and Astrophysics*, 46:21-56.