Comet formation

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There has been vast progress in our understanding of planetesimal formation over the past decades, owing to a number of laboratory experiments as well as to refined models of dust and ice agglomeration in protoplanetary disks. Coagulation rapidly forms cm-sized "pebbles" by direct sticking in collisions at low velocities (Güttler et al. 2010; Zsom et al. 2010). For the further growth, two model approaches are currently being discussed: (1) Local concentration of pebbles in nebular instabilities until gravitational instability occurs (Johansen et al. 2007). (2) A competition between fragmentation and mass transfer in collisions among the dusty bodies, in which a few "lucky winners" make it to planetesimal sizes (Windmark et al. 2012a,b; Garaud et al. 2013).

Predictions of the physical properties of the resulting bodies in both models allow a distinction of the two formation scenarios of planetesimals. In particular, the tensile strength (i.e, the inner cohesion) of the planetesimals differ widely between the two models (Skorov & Blum 2012; Blum et al. 2014). While model (1) predicts tensile strengths on the order of ~ 1 Pa, model (2) results in rather compactified dusty bodies with tensile strengths in the kPa regime.

If comets are km-sized survivors of the planetesimal-formation era, they should in principle hold the secret of their formation process. Water ice is the prime volatile responsible for the activity of comets. Thermophysical models of the heat and mass transport close to the comet-nucleus surface predict water-ice sublimation temperatures that relate to maximum sublimation pressures well below the kPa regime predicted for formation scenario (2). Model (1), however, is in agreement with the observed dust and gas activity of comets. Thus, a formation scenario for cometesimals involving gravitational instability is favored (Blum et al. 2014).

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