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The Bulk Density of Cometary Nuclei

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The properties of bodies formed in the early Solar System were a direct consequence of the physical and chemical conditions prevailing in the solar nebula, and the processes which governed its evolution. Whereas the subsequent development of planets, their satellites, and asteroids largely have erased traces of their original composition and structure, comets are believed to have undergone a rather insignificant evolution since their time of formation. The primitive and fairly primordial comet nuclei therefore constitute important sources of observational constraints on solar nebula properties, although these by no means are easy to obtain. Assumptions made in solar nebula evolution models, e.g., regarding dust number density, gas-dust drag forces, gas turbulence, dust-dust relative velocities, sticking efficiencies, effects of cometesimal collisions, and importance of collisional coagulation versus gravitational instability, have consequences for comets formed in such circumstances, i.e., may favor either dense or highly porous objects. One observationally derivable property of comet nuclei which therefore has cosmogonic significance, is the bulk density.
In this review, comprising both a historical retrospect and recent results from numerical simulations and laboratory experiments, various comet formation scenarios are summarized, focusing on predictions of the porosity and bulk density of comet nuclei. A number of methods for estimating comet bulk densities are presented (e.g., tidal or rotational breakup, and non-gravitational force modeling), and existing density estimates are summarized. The consensus between theory and observations is discussed.