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Modelling of the thermal evolution and differentiation of early Ceres

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The asteroid 1 Ceres is one of the remaining examples of the intermediate stages of planetary accretion. Studies of such protoplanetary objects provide insight into the history of the formation of Earth and other planets. One of Ceres' remarkable properties is the relatively low average bulk density of 2077 ± 36 kg m^{-3}[1]. Assuming a nearly chondritic composition, this low value can be explained either by the presence of a low density phase[2,3] (possibly water ice or hydrated silicates) that could have differentiated forming an icy mantle over a rocky core[2,3], or by a relatively high average porosity[4]. The shape and the moment of inertia of Ceres are consistent with both a homogeneous and a differentiated structure. In the first case Ceres would be just a large version of a common asteroid. In the second case this body could exhibit properties characteristic for a planet rather than an asteroid: presence of a core, mantle and crust, as well as a liquid ocean in the past and maybe still a thin basal ocean today.

We study the evolution of a Ceres-like body via numerical modelling in order to draw conclusions about the thermal metamorphism of the interior and its present-day structure. A numerical model of an ice-silicate planetesimal, considering both water-rock and metal-silicate differentiation of Ceres is being developed. In particular, accretion from a km-sized porous seed to a Ceres-sized asteroid is considered. Further relevant processes, such as transition from amorphous to crystalline ice, melting of ice, hydrothermal convection, as well as melting and percolation of metal and silicates are included in the model. The model is suited to prioritise between the two possible structures mentioned above and to constrain the present-day state of Ceres' interior. The necessary conditions for the differentiation as well as the influence of the vital parameters, such as the accretion duration, will be discussed.

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