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The Inner Structure of Enceladus – Physical Conditions at the Bottom of its Potential Subsurface Water Reservoir

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Abstract

Here we present a model of the inner structure of Enceladus, which is an advanced version of the model presented in [6]. This conception is based on a three layer model, also used in the uncompressed density model by [3], that allows us to determine the radial gradients of mass, gravity, and pressure. We give estimations on the physical conditions at the sea floor of the potential subsurface water reservoir of Enceladus.

1. Introduction

In our model, we assume a rocky silicate core surrounded by a thin global water layer. The outermost layer consists of water-ice with some other constituents, such as CO_2 (e.g., [4]). We vary the density of the liquid water/water-ice layer between 940 and 1050 $\mathrm{kg\,m^{-3}}$, depending on the chemical composition, but the major factor in this model is the variation of the silicate core density. In the following section we will present five different scenarios.

2. Scenarios

We have computed five different scenarios, which differ in the assumptions on the composition of the rocky core. In the first scenario (S1), we use the assumption that the mean density of Titan's rocky core should be similar to Enceladus' core because these moons were formed in the same region of the Solar System. The second scenario (S2) deals with a core density similar to the density of the uppermost part of the Earth's mantle primarily made up of olivine-rich rocks such as peridotite. The next scenario (S3) conveys the idea of [5] that Enceladus' core density is similar to Io's bulk density. According to [5] this number indicates the highest possible value for a rock-metal core because Enceladus' core is likely to be less dense than Io's bulk density due to inclusions of e.g. low-density hydrated silicates. For scenario S4 we assume a silicate core with the same density as the soil below the Arctic Sea. The last scenario (S5) assumes a density similar to the grain density of typical hydrated carbonaceous CI chondrites, which might be the building blocks of icy moons like Enceladus.

Due to Enceladus' small mean radius of only 252.1 ± 0.2 km [7], the densities of the different layers can be assumed to be nearly constant. Therefore, the uncompressed density [2] of the satellite is almost equal to its bulk density.

3. Summary

Our model will yield estimations about the inner structure of Enceladus and it can also be applied to other icy moons. It will give us a rough overview about the physical conditions at the bottom of the potential subsurface water reservoir to evaluate its astrobiological potential. To verify the model, we extend it to a 5- and 12-layer model applied to the different layers of the Earth. The results of these adapted models are in good agreement with the Preliminary Reference Earth Model (PREM, [1]).

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