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Interior Structure and Bulk Composition of the CoRoT-7b Exoplanet

F. Wagner (1,2), F. Sohl (1), H. Rauer (1,3), H. Hussmann (1) and M. Grott (1)

(1) Institute of Planetary Research, German Aerospace Center (DLR), Berlin-Adlershof, Germany, (2) University of Muenster, Muenster, Germany, (3) Technical University of Berlin, Berlin, Germany.

Abstract

The prospects of detecting low-mass (< $15M_{\mathrm{Earth}}$) exoplanets are rapidly growing using both ground- and space-based observational efforts. Modeling the interior structures of these exoplanets becomes increasingly important and a major task to understand the origin and evolution of planets. Those exoplanets can be classified as (a) terrestrial planets like our Earth or (b) ocean planets [1] with a composition similar to the icy satellites of the outer solar system. Therefore, their bulk composition can either be completely dominated by silicate rock and metal or they may harbor extensive water oceans and/or ices, overlying rock-metal cores.

Here we present a model approach used to calculate the internal structure and properties of low-mass exoplanets. Upon combining with a lithospheric model, we are able to better constrain the radial temperature distribution and to study its effects on the interior structure of the model planets. In order to estimate the impact of an equation of state (EOS) on the radial distribution of density, total mass, and surface radius of the model planets, different EOS were implemented, e.g. Birch-Murnaghan [2], Vinet [3,4], and reciprocal *K*-primed [5]. From these model calculations, mass-radius relationships for terrestrial and ocean planets are obtained and applied to the recently discovered CoRoT-7b [6]. From those possible bulk compositions, corresponding the observed mass range from 5.7-$11M_{\mathrm{Earth}}$ [7], are inferred.

Figure 1 shows internal density distributions of CoRoT-7b for a radius fixed at $1.72R_{\mathrm{Earth}}$ [6] and with an iron core mass fraction of 6 or 32 wt.%, respectively. For comparison, it also shows the model calculation for a one-Earth-mass model planet and the Preliminary Earth Reference Model (PREM) [8] based on seismological observations.

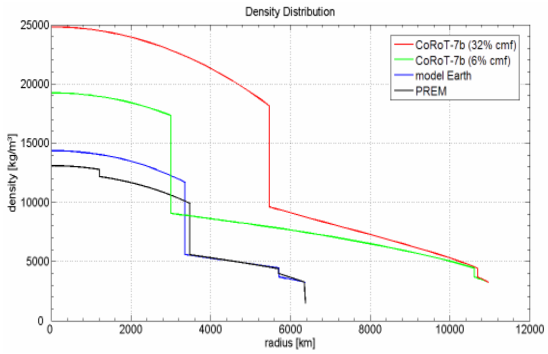

Fig. 1: Comparison of radial density distributions for CoRoT-7b (core mass fraction (cmf) 6% and 32%) and the Earth (model and PREM). The gap between the model Earth and the PREM is due to the presence of an element lighter than iron in the Earth's core.

Even for the upper mass limit of $11M_{\mathrm{Earth}}$, CoRoT-7b would have a much smaller iron core than a Mercury-like (~ 70 wt.%) planet of the same size. For the lower mass limit of $5.7M_{\mathrm{Earth}}$, CoRoT-7b would have a substantially lower mean density than an Earth-like (32.6 wt.%) planet of the same size (see topmost curve in Fig. 1). In that case, the bulk composition of CoRoT-7b rather may resemble that of a left-over rock-metal core of a former ocean planet or even a coreless silicate body [e.g.,9]. Thus, CoRoT-7b might be the remnant of a former ocean planet which originally formed in an iron-depleted region beyond the snowline and lost much of its volatile content when subsequently moving towards its primary.

References

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