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High-pressure equations of state for iron and the interior structure of super-Earths

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1 Introduction

With more than 800 exoplanets confirmed in early 2014, about 1800 exoplanets are now known. Over the last decade, these discoveries revealed a new class of rocky exoplanets known as super-Earths. They have radii typically between 1.25 and 2 times the radius of Earth and have relatively high internal pressures and temperatures. These exoplanets could possess an atmosphere, which would favor habitability.

2 High pressure equations of state

In order to better understand the nature of these exoplanets, including their dynamics and surface conditions, we study their interior structure and bulk composition. We extend our method developed to model the interior of terrestrial planets of the Solar System e.g. [1] to super-Earths by using suitable equations of state (EOS) for the very high pressure regime in the iron-rich core. Most EOS for iron used in the modeling of super-Earths tend to be uncertain beyond the pressures in the core of the Earth (few hundred GPa). As the internal pressures of super-Earths are expected to reach several TPa, see e.g. [2], there is a need for reliable EOS in this range.

In the considered pressure regime, the hcp phase of iron is the most stable phase [3] and we here only consider this phase for the iron core. We have performed ab initio calculations of the density of iron at high pressures in the TPa range and compared the results with predictions from various existing EOS for hcp iron. Several EOS previously used in the modeling of the core of super-Earths show substantial deviations from the ab initio results. We use the new data to model super-Earths and assess the influence of using different EOS on the interior structure of super-Earths and on the mass-radius relations.

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