Unveiling the Interior of Jupiter

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Introduction

More than **300 times the mass of the Earth**, Jupiter is mainly made of **hydrogen** and **helium**.

The internal structure of Jupiter is the direct outcome of its formation and evolution.

Understanding the interior of Jupiter will lead to a **better knowledge** of the **formation of our solar system** but also of the **composition of exoplanets**.

The Juno Mission

Since 2016, the Juno spacecraft is orbiting Jupiter, measuring the **gravity field** of the planet with unprecedented accuracy.

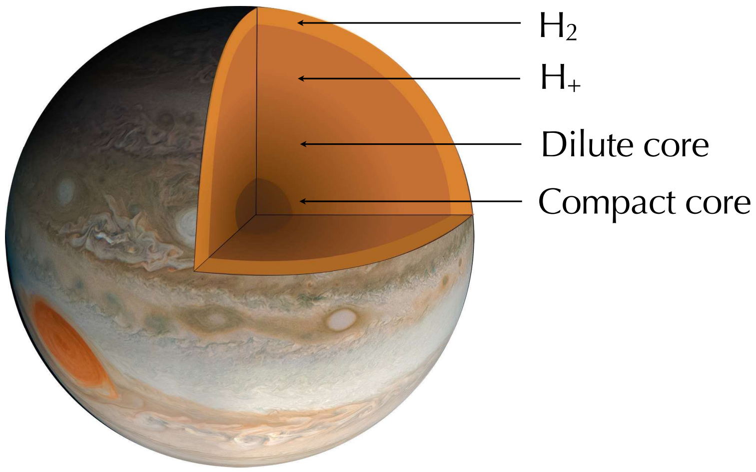
The internal structure of Jupiter can be inferred from the measurements of the **gravitational moments** :

$$J_{2n} = -\frac{1}{MR_{eq}^{2n}} \int \rho(r')^{2n} P_{2n}(cos\theta) d^3 r'$$

Using a Bayesian statistical approach (**MCMC**), we explore a large set of interior models, to understand which ones reproduce Juno's observations and represent best the internal structure of Jupiter.

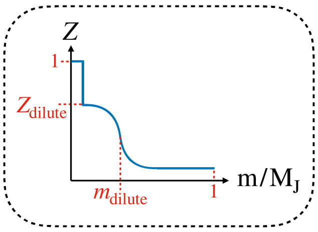
A dilute core inside Jupiter

Instead of a pure heavy-element (ices & rocks) core and a sharp discontinuity with the envelope of hydrogen and helium, Jupiter could harbour a dilute core where **the heavy elements are gradually distributed outwards**.

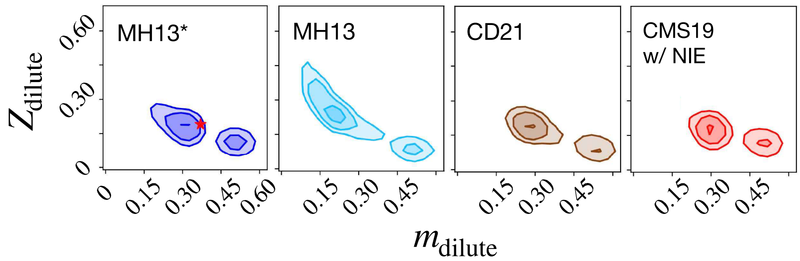


How extended is Jupiter's dilute core ?

Formation models (Müller et al. 2020) predict a dilute core which can extend up to **20% of Jupiter's mass** (within the inner ~60 $M_\oplus$), in agreement with a fraction of our interior models.



Heavy element mass fraction as a function of mass in Jupiter



Interior models results for several H-He equations of state.

H-He equations of state :

MH13 from Militzer & Hubbard 2013*

MH13 from Miguel et al. 2016

CD21 from Chabrier & Debras 2021

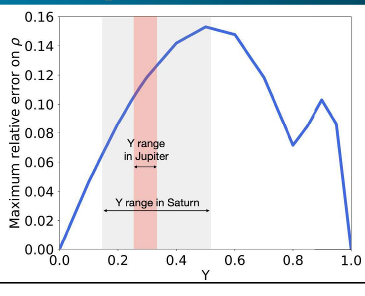
CMS19 from Chabrier et al. 2019

(NIE stands for Non-Ideal Effects)

Importance of the H-He equation of state

Interior models require an appropriate H-He EOS and rely on the additive volume law to calculate the EOS of a mixture :

$$\frac{1}{\rho_{H-He}} = \frac{X}{\rho_H} + \frac{Y}{\rho_{He}} + XYV_{mix}$$



Density discrepancy between CMS19 w/ NIE (including H-He interactions) and CMS19 (not including them)

Perspectives

Results from Juno and Cassini indicate that the interior of giant planets is complex. Constraining the size of their core is important for understanding the formation and evolution of planets in and out of our solar system.

Precise measurements of atmospheric composition (e.g. with JWST) will help to understand their structure and origin.