Empirical Structure Models of Uranus and Neptune

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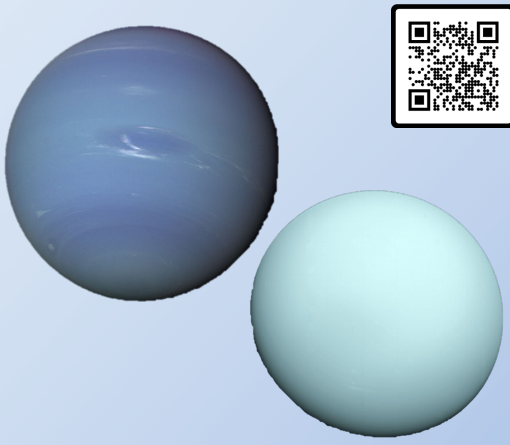
Motivation

- Uranus and Neptune are the least explored planets in the Solar System (only visited by Voyager II fly-by in 1986/1989)
- Knowledge of the interior is crucial to understand a planet's formation and evolution path
- Many Neptune-like exoplanets found in Milky Way
  - Apply knowledge gained of Uranus and Neptune
- Natural laboratory to study material under high pressure & temp.
- Unbiased approach to produce internal structure models



Method

- Generate various structure models of Uranus and Neptune that fit the measured **gravity field**, **mass**, equatorial **radius** and **rotation period**
- Generate three-layer models based on piece-wise arranged polytropes:

$$P = K\rho^{1+\frac{1}{n}},$$

where ρ is the density, P the rotation period, and K & n are free parameters

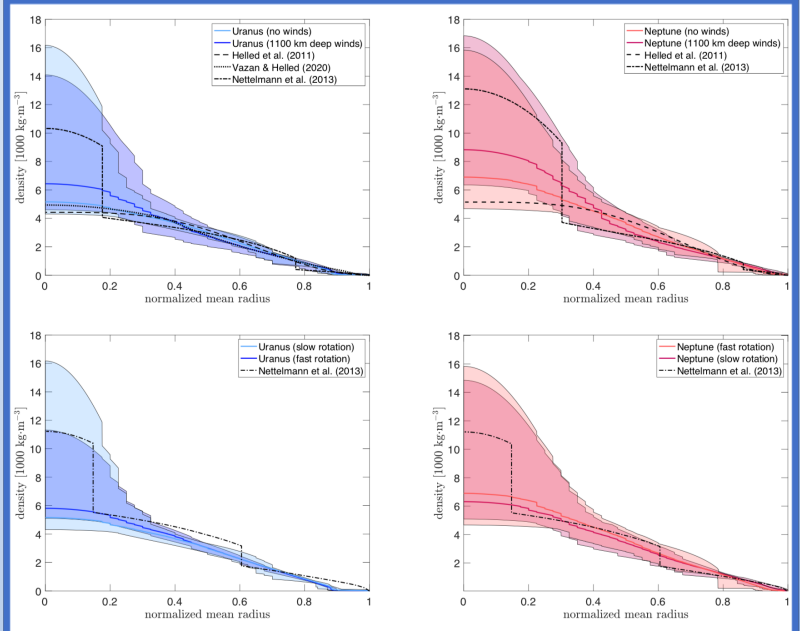
Predicted Gravity Field & MoI

Uranus	Neptune	
$46.1 < J_6 < 69.0$	$45.0 < J_6 < 80.8$	$[\times 10^{-8}]$
$-17.8 < J_8 < -8.4$	$-20.2 < J_8 < -7.9$	$[\times 10^{-9}]$
$0.218 < \text{MoI} < 0.227$	$0.235 < \text{MoI} < 0.254$	

- More accurate J_2 & J_4 constrain the predicted J_6 and J_8 range
- J_6 & J_8 predictions strongly depend on the wind depths
- The MoI value depend strongly on the rotation period and wind depths

"MoI" = Normalized Moment of Inertia

Density Profile Solution Spaces



- Models with deep winds generate mean core densities that are ~25% more dense
- Mean core densities based on fast rotation are ~13% more dense than those based on slow rotation

=> Lack of precise knowledge of the rotation period or wind depth lead to large degeneracy in core region

Conclusions

- ρ_{core} depends strongly on the rotation period and wind depth
- Precise measurement of J_6 and J_8 can constrain wind depths
- Precise estimation of MoI can constrain wind depths & rotation periods
- Generally used shape of Uranus and Neptune does no agree with broadly used rotation periods
- Provide a priori estimates of MoI, J_6 & J_8 that help design future space mission

https://doi.org/10.1093/mnras/stac628

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