University of Zurich[UZH]

Electrical Conductivity, Magnetic Fields, and Zonal winds in Uranus and Neptune

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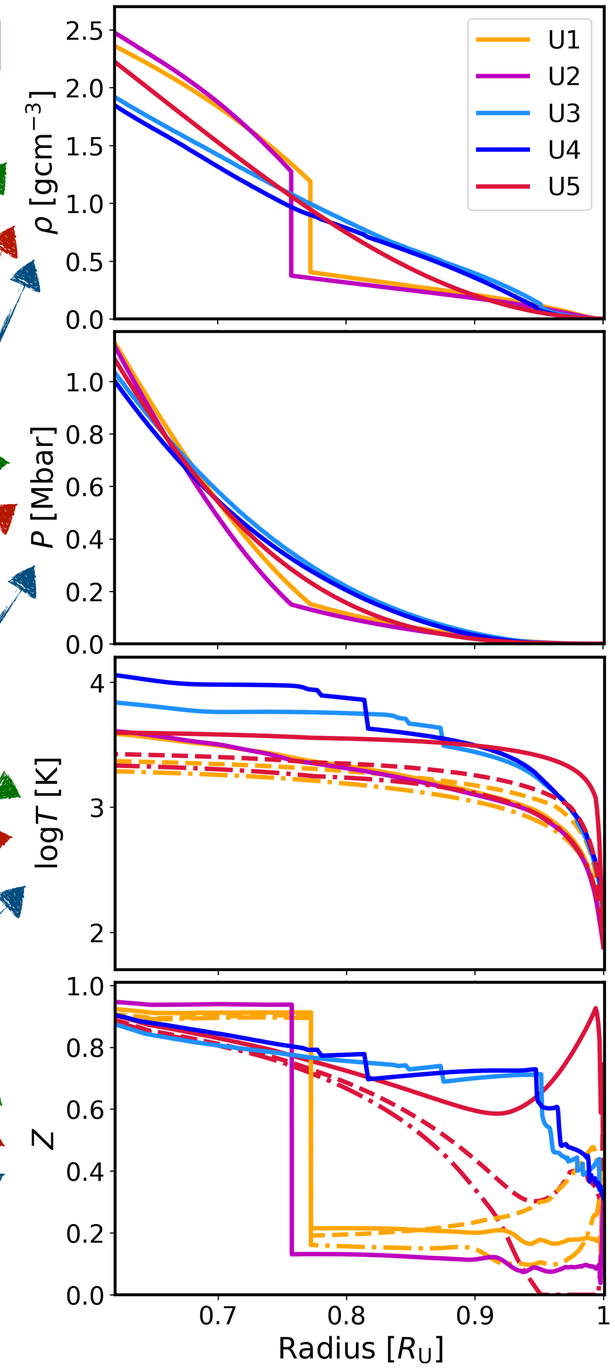
Background: Interior Modelling

Uncertainties in **interiors structure**

Unknown **heat transfer** mechanisms

Unknown **composition**



Electrical Conductivity

Uncertainties in **interiors structure**

Unknown **heat transfer** mechanisms

Unknown **composition**

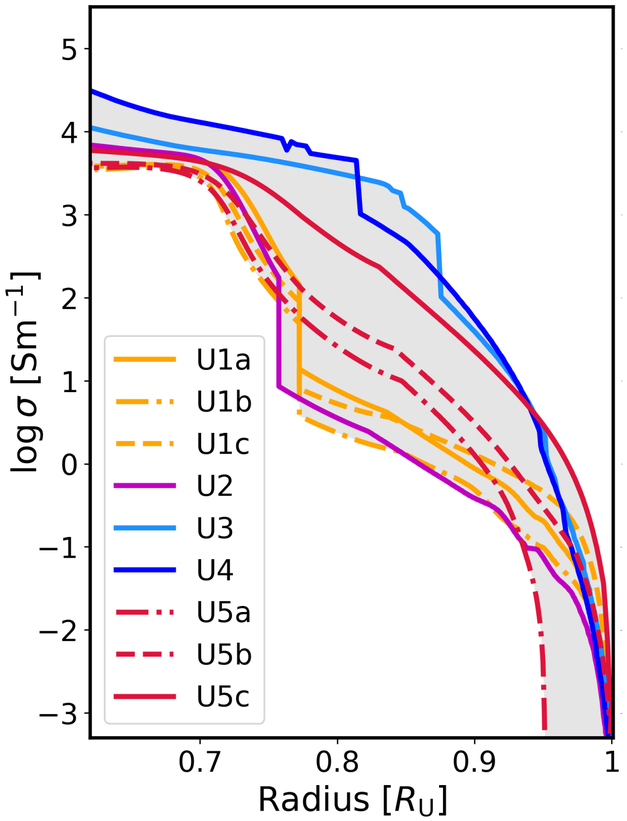
Unknown **behaviour of volatiles** under **planetary conditions**

Electrical conductivity profiles????

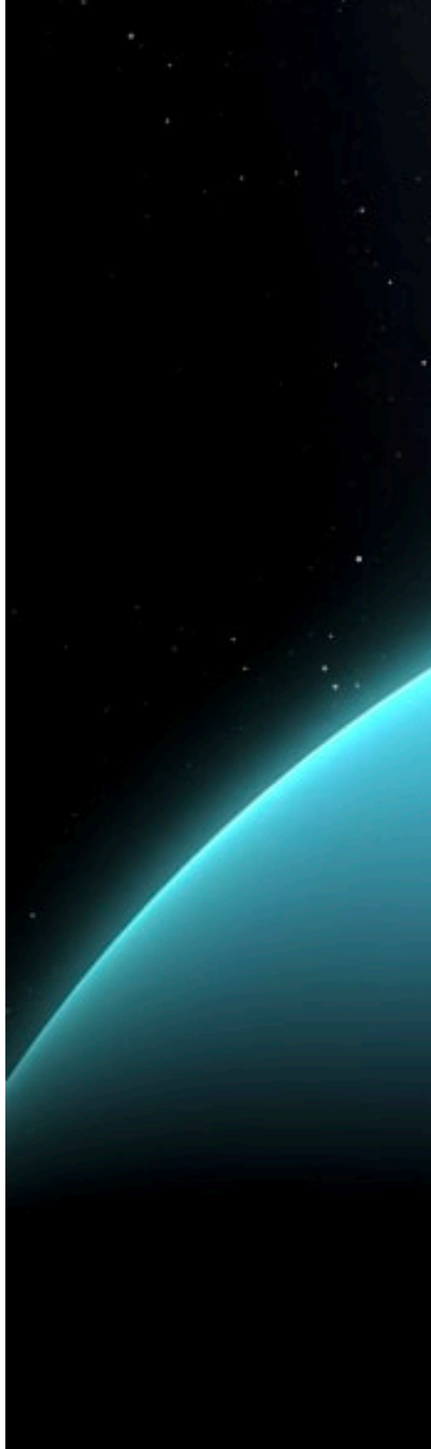
Let's model them!

- *Ab initio* simulation data for hydrogen and oxygen diffusion
- Simuluation data for water dissociation
- Bunch of theory…
- Many assumptions….

Mystery box
too long to explain in this presentation



Soyuer et al. 2020, MNRAS

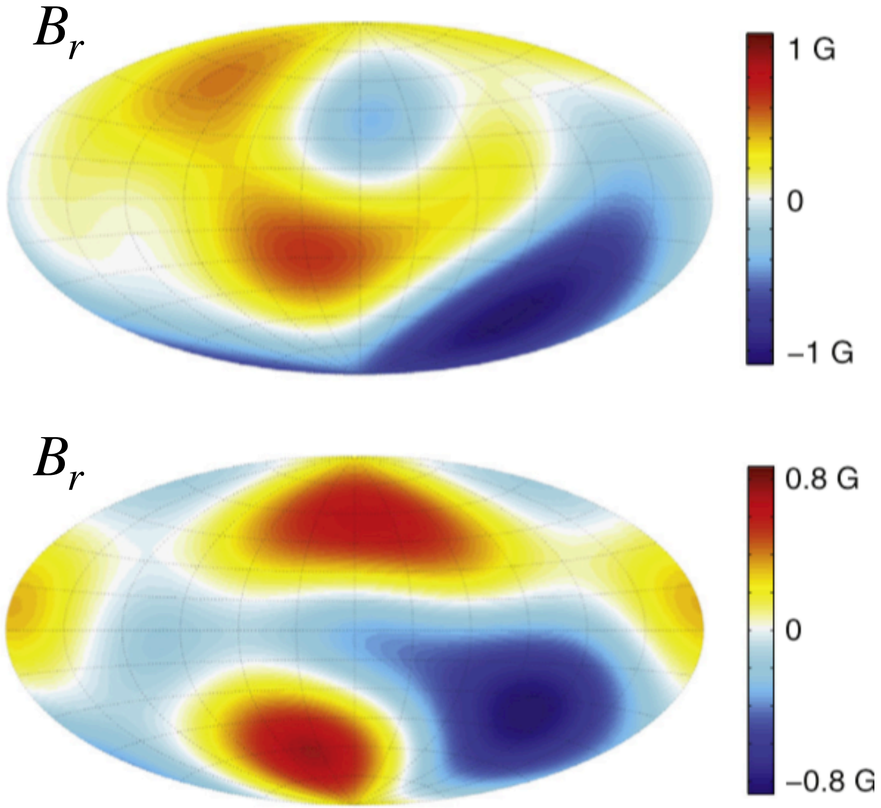


Background: Magnetic Fields and Zonal Winds

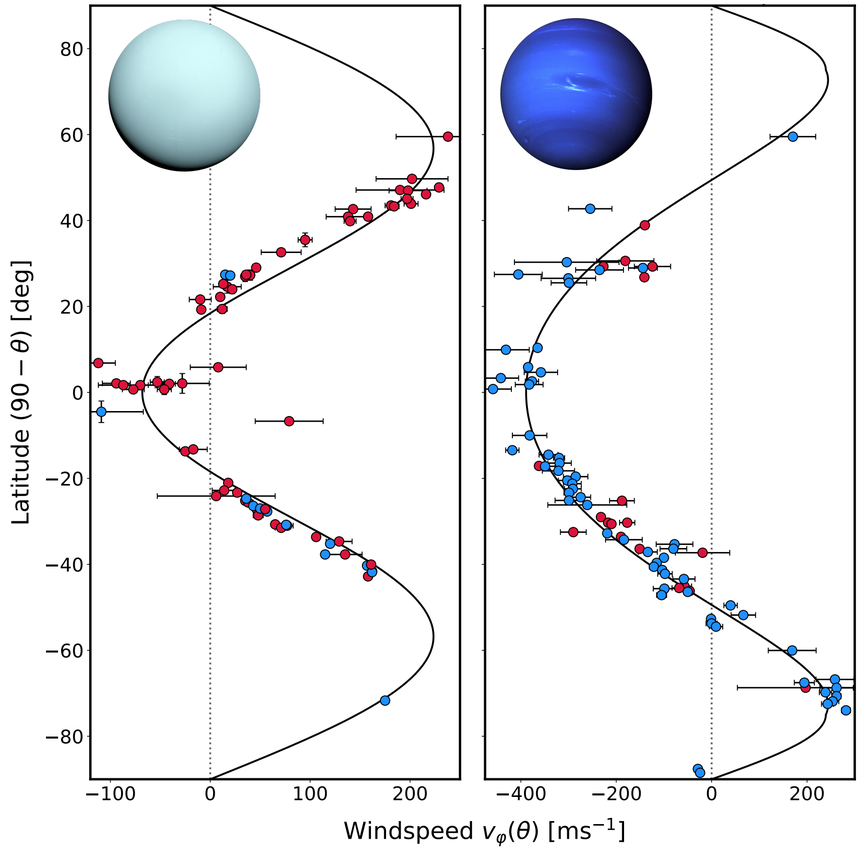
Strong, multipolar, non-axisymmetric magnetic fields

Fast, symmetric surface zonal winds

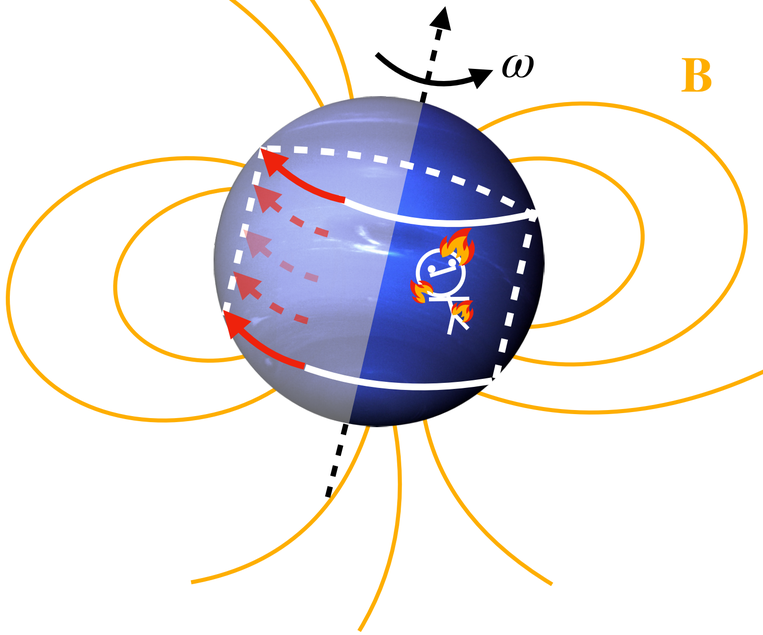
Uncertainty in dynamo generation region



Uncertainty in the decay profile



Zonal Wind—Magnetic Field Coupling



Rapidly increasing **electrical conductivity** with **depth**

Zonal flows start **coupling** to the magnetic field

Induction of currents! $\mathbf{j} \propto \sigma \mathbf{U} \times \mathbf{B}$

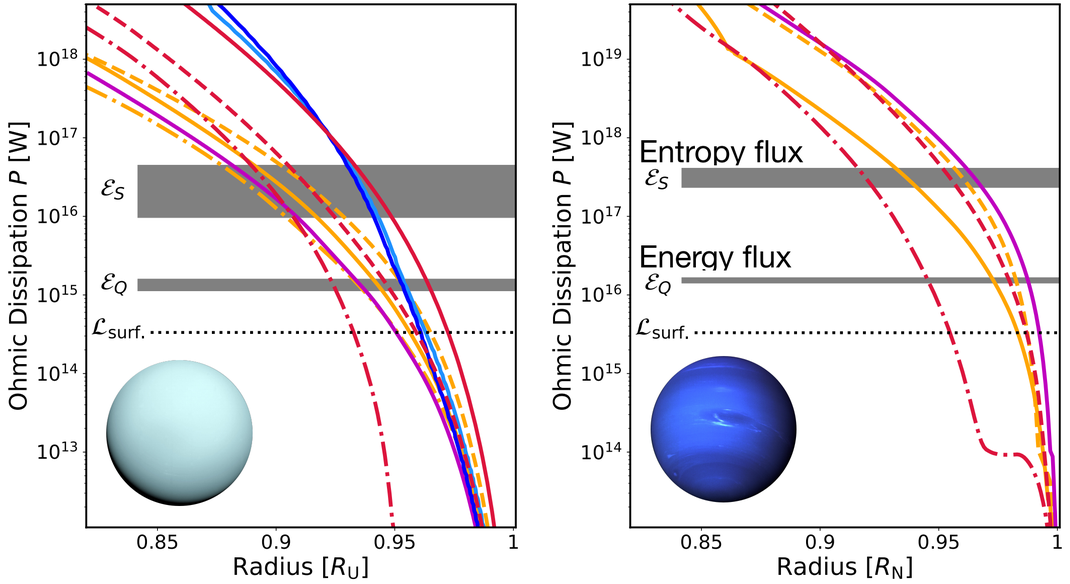
Flows coupled to fields induce mag. perturbations

Fields should be spatially correlated with the zonal flows

In the most extreme case, can reach strengths of $\frac{B_{\text{pert.}}}{B_{\text{backg.}}} \sim \mathcal{O}(0.1)$

Currents lead to **Ohmic dissipation!**

Constrain zonal wind decay via the **energy/ entropy budget** throughout the planet!



Takeaway

Electrical conductivity within Uranus and Neptune increases rapidly enough to…

- **couple** fast **zonal winds** to the background **magnetic field**,
- induce secondary magnetic fields **spatially correlated with the zonal flows**.

This can be used to…

- **constrain zonal wind decay** via the **Ohmic dissipation** mechanism,
- **compositionally/thermally interpret** interior structure models,

Soyuer et al. 2020

Soyuer et al. 2021