THE IMPLICATIONS OF ELECTRICAL CONDUCTIVITY MODELS OF URANUS AND NEPTUNE.

Deniz Soyuer[1], François Soubiran[2] and Ravit Helled[1], [1]Institute for Computational Science, University of Zurich (soyuerd@ics.uzh.ch, rhelled@physik.uzh.ch), [2]DAM-DIF, CEA (francois.SOUBIRAN@cea.fr).

Background: Recent studies show that planetary ices such as water and ammonia become ionically conducting under conditions present in the ice giants. [1][2]. Moreover, within the ionic liquid regime of water present in the outer layers of Uranus and Neptune, dissociation of hydrogen in H_2-H_2O mixtures has a significant ionic contribution to electrical conductivity [3]. On the other hand, the interiors of Uranus and Neptune can be fitted with varying amount of ice-to-rock ratios [4], challenging the view of Uranus and Neptune being “ice giants”. Understanding the behaviour of electrical conductivity within Uranus and Neptune has a direct implication on understanding their observed multipolar and non-axisymmetric magnetic fields, the extents of their dynamo generation region, their composition, and the complex secondary fields due to the background magnetic field—zonal flow coupling [5].

With rapidly increasing electrical conductivity, zonal flows inevitably couple to the background magnetic field, inducing electrical currents and magnetic field perturbations spatially correlated with zonal flows. Induced currents generate Ohmic dissipation, which can be used to constrain the depth of the zonal winds via considering the energy/entropy flux budget throughout the planetary interior [3]. Constraining the zonal wind decay in turn helps estimate the strength of magnetic field perturbations. The poloidal component of these perturbations can reach $\mathcal{O}(0.1)$ of the background magnetic field in strength in the most extreme case, depending on the temperature profile of the planets [5].

Aforementioned phenomena naturally depend on the electrical conductivity profiles within Uranus and Neptune, which in turn depend on the assumed interior structure and the implied composition. Limited gravity data available from *Voyager II* and ground based observations allow for a wide range of density distributions, lack of prior entry probes limit our capability of interpreting atmospheric compositions, and the surface temperature dichotomy between Uranus and Neptune present another puzzle for the thermal properties of the planets. Thus, modelling the electrical conductivity of Uranus and Neptune provide an additional approach for constraining their interiors and explaining their differences.

Panel shows various published interior structure models of Uranus, their assumed composition for an ideally mixed H_2-He-H_2O mixture, their electrical conductivity profiles [3], and the electrical conductivity assumed in various publications regarding Uranus’ dynamo [6][7][8].

Aims: (i) Modelling the electrical conductivity of H-He-H_2O mixtures under conditions in ice giants, (ii) exploring the zonal wind-magnetic field coupling due to rapidly increasing electrical conductivity with depth, (iii) investigating the effect of rocks on the electrical conductivity profiles of Uranus and Neptune.

References: [1] M. Millot et al. (2018) *Nature Physics 14*, 297–302.[2] A. Ravasio et al. (2021) *Phys. Rev. Lett., 126,* 025003. [3] D. Soyuer et al. (2020) *MNRAS, 498*, 621–638. [4] R. Helled et al. (2011) *ApJ, 726,* 15. [5] D. Soyuer & R. Helled (2021) *MNRAS, 507,* 1485–1490. [6] R. Holme & J. Bloxham (1996) *JGR, 101,* 2177–2200. [7] S. Stanley & J. Bloxham (2006) *Icarus, 184-2,* 556–573.[8] K. M. Soderlund (2013) *Icarus, 224-1,* 97-113.