THE DEEP O/H RATIO IN URANUS AND NEPTUNE FROM CO SPECTROSCOPY AND THERMOCHEMICAL MODELING. T. Cavalié[1], O. Venot[2], F. Selsis[3,4], F. Hersant[3,4], and P. Hartogh[1], [1]Max Planck Institute for Solar System Research (Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany ; cavalie@mps.mpg.de), [2] Instituut voor Sterrenkunde (Katholieke Universiteit Leuven, Leuven, Belgium), [3]Univ. Bordeaux (LAB, UMR 5804, F-33270, Floirac, France), [4]CNRS (LAB, UMR 5804, F-33270, Floirac, France).

One of the great mysteries in the Solar System is how Giant Planets formed. Several formation scenarios have been proposed: disk gravitational instability [1] and core accretion [2]. These scenarios differ not only in the time required to form planets, but also in the final composition of the planets' interiors. While gravitational instability should result in solar abundances of heavy elements, core accretion formation should lead to enriched composition in heavy elements. The level of enrichment then would depend on how the ices of the planetesimal that formed the cores of these planets condensed (amorphous [3] or crystalline [4]).

The Galileo probe has observed an enrichment factor of ~4±2 compared to the solar value in C, N, S, Ar, Kr and Xe in Jupiter's troposphere [5,6]. At Saturn, the C, N, P and S are also found enriched [7,8]. At Uranus and Neptune, only the C abundance has been measured [9,10]. Enrichment factors of heavy elements seem to increase with heliocentric distance.

The key measurement that would enable differentiating the condensation processes of the planetesimal ices is the deep water abundance. Indeed, clathration needs a larger amount of water than the amorphous ice scenario. While Galileo probably failed to measure the Jovian deep water abundance below the water cloud, Juno should shed light on this long lasting question. However, there is no such mission planned in the near future to measure the deep water abundance in the ice giants and it is difficult to probe remotely below the water cloud in these planets with microwaves. A few mission concepts are being developed for Saturn [11] and the ice giants [12,13], but these challenging missions require probes that would have to survive high pressures to reach below the water cloud (up to several tens of bars in the ice giants). Therefore, it is important to find other ways to constrain the deep water abundance. One interesting way is to use disequilibrium species like CO and link their tropospheric abundances to the deep water abundance and thus to the deep atmospheric O/H ratio using thermochemical modeling.

A first model developed for Jupiter by [14] was based on the approximation that the tropospheric mole fraction of CO is fixed at a so-called "quench" level, where the chemical timescale of the conversion of CO into H_2O becomes longer than the timescale for its vertical transport. This quench level approximation model was then used to constrain the atmospheric O/H ratio in all giant planets [15]. However, [16] showed that the assumptions of previous modelers on diffusion timescales were incorrect. His work was applied to Jupiter [17], to Saturn [18,19], and to Neptune [20]. But all these models relied on uncertain kinetic data.

A first comprehensive thermochemical and diffusion model was applied to Jupiter [21] to constrain its deep water abundance. An enrichment of 0.3-7.3 times the protosolar abundance was derived.

In this paper, we apply this methodology to the ice giants with a new thermochemical and diffusion model [22] and the most recent solar abundances [23]. We review the observations of equilibrium and disequilibrium species useful to constrain the O/H ratio in the interior of the ice giants. The model of [22] has the advantage of being based on a chemical scheme validated intensively by the combustion industry [24]. In such models, the results depend also on the adopted deep thermal structure. We have thus computed a series of thermal profiles based on dry/wet adiabats and that account for the mean molecular weight gradient. We will present the deep O/H ratios we infer from our models for the ice giants.

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