What is Neptune's D/H ratio really telling us about its water abundance ?

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Abstract

We investigate the deep water abundance of Neptune using a simple 2 layers core-envelope toy model. The model's free parameters are the total mass of heavy elements in the planet Z, the mass fraction of Z in the envelope (f_env), and the D/H ratio of the accreted building blocks D/H build . We constrain the parameters space using Neptune's carbon abundance, D/H ratio, and interior structure measurements. Assuming solar C/O and cometary D/H for the accreted building blocks, we can fit all of the constraints if on average only 10% of Z is in the envelope (f_env $\sim$ 10%), and the rest is in the core. This model predicts a maximal oxygen abundance in Neptune of 65$\times$ solar value. If we assume a C/O of 0.17, corresponding to clathrates building blocks, we find mean f_env $\sim$ 17%, and a maximal allowed oxygen abundance of 120$\times$ solar value. Both cases however thus to an oxygen abundance significantly lower than the preferred value of Cavalié et al. (2017) ($\sim$ 540 $\times$ solar), inferred from model dependent deep CO observations. Such very high water abundance are hence excluded by our simple but robust model. We attribute this discrepancy to our imperfect understanding of either the interior structure of the planet or the chemistry of the protosolar nebula. Only in situ measurements of the bulk water content of Neptune can resolve this mystery.
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