Key atmospheric signatures for deciphering the formation conditions of Uranus and Neptune in the protosolar nebula

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Abstract

The ice giant planets Uranus and Neptune represent a largely unexplored class of planetary objects, which fills the gap in size between the larger gas giants and the smaller terrestrial worlds. Uranus and Neptune's great distances have made exploration challenging, being limited to flybys by the Voyager 2 mission in 1986 and 1989, respectively. Uranus and Neptune are fundamentally different from the better-known gas giants Jupiter and Saturn. Interior models generally predict a small rocky core, a deep interior of 70% of heavy elements surrounded by a more diluted outer envelope with a transition at _˜70% in radius for both planets. Uranus and Neptune's envelopes display substantial carbon enrichments, ranging from 20 to 120 times the protosolar value, suggesting global metallicities much higher than those of Jupiter and Saturn. To derive some hints on their formation conditions, we investigate the possible reservoirs of volatiles that may have contributed to the compositions of Uranus and Neptune's atmospheres in both solid (amorphous ice, pure condensates, clathrates) and gas forms. We then discuss the atmospheric signatures that would be representative of each of these reservoirs, and that are potentially accessible to in situ measurements by an entry probe.

Keywords: Ice Giants, origin, building blocks, protosolar nebula

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