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Formation of Jupiter's envelope from supersolar gas in the protoplanetary disk

Artyom Aguichine[1], Olivier Mousis[2], and Jonathan Lunine[3]
[1]Aix Marseille Univ, CNRS, CNES, LAM, Marseille, France (artem.aguichine@lam.fr)
[2]Aix Marseille Univ, CNRS, CNES, LAM, Marseille, France
[3]Department of Astronomy, Cornell University, Ithaca, NY 14853, USA

The formation mechanism of Jupiter is still uncertain, as multiple volatile accretion scenarios can reproduce its metallicity [1-4]. The Galileo mission allowed in situ measurements of the abundances of several elements (Ar, Kr, Xe, C, N, S and P), which exhibit a uniform enrichment of 2 to 5 times the protosolar abundance, and a subsolar abundance has been measured for O. Recent measurements for N and O by the Juno mission confirmed the supersolar abundance of N, but indicated that the abundance of O may also be supersolar [5]. Elemental abundances measured in the Jupiter's atmosphere are key ingredients to trace the origin of various species.
Here, we investigate the possible timescale and location of Jupiter's formation using measurements of molecular and elemental abundances in its envelope. To do so, we use a 1D accretion disk model to compute the properties of the protosolar nebula (PSN) that includes radial transport of trace species, present in the form of refractory dust, a mixture of ices and their vapors, to compute the composition of the PSN [6]. We focus on the radial transport of volatile species by advection-diffusion combined with the effect of icelines, computed as sublimation/condensation rates. Initialy, the disk is uniformly filled with H_2O, PH_3, CO, CO_2, CH_4, CH_3OH, NH_3, N_2, H_2S, Ar, Kr and Xe [6,7], corresponding to the main bearers of C, N, O, P, S, Ar, Kr and Xe.
As the PSN evolves, solid particles drift inward due to gas drag. Volatile species are thus efficiently transported to their respective icelines, where they sublimate. This results in supersolar abundances of volatile elements in the inner part of the PSN. We find that the composition of Jupiter’s envelope can be achieved by accretion of enriched gas only, or a mixture of gas and solids, depending on the viscosity of the PSN. In both cases, the composition of the PSN matches the one measured in Jupiter’s envelope in timescale that are compatible with a formation by core accretion or gravitational collapse.

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