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Formation of Jupiter and Saturn and their atmospheres: Clues from composition and thermochemistry

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Comparative planetology of Jupiter and Saturn is key to an understanding of the formation of the gas giants, and by extension the extrasolar giant planets. According to conventional models, grains of dust, ice, metals and refractory material first formed a core. Once the core reached a critical mass, 10-15 Earth Mass for Jupiter, gravitational capture of the most volatile of gases (H, He, Ne) occurred, leading to the collapse of the surrounding protoplanetary nebula. The atmospheres resulted from these gases and those released from the core during accretionary heating. This formation scenario is constrained by the Galileo probe measurements. However, the composition data from the probe, especially those on the heavy elements, requires that the planet forming planetesimals be cold enough to trap nitrogen and argon, i.e. 30-35 Kelvin. The origin of such cold planetesimals – icy, or clathrates – is unknown. One key piece of information that could help but is still missing is the abundance of water in the well-mixed atmosphere of Jupiter. An analysis of the Galileo and Cassini imaging of storms with thermochemical models indicates that the water is perhaps also enriched, so that O/H is at least solar at Jupiter. Microwave radiometry observations from the 2011 Juno mission are expected to determine the well-mixed water abundance. At Saturn, carbon and phosphorus are the only heavy elements that have been measured by remote sensing. C/H and P/H are both found to be ten times solar. Whereas P/H may not be an ideal predictor of the heavy element enrichment, as phosphine is a disequilibrium species, the trend in C/H (from methane) is consistent with the prediction of the above formation model. Measurements of the other the heavy elements – N, S, O, Ar, Kr,

Xe – together with He, noble gas isotopes, D/H, and 15N/14N are required to constrain the models of the formation of Saturn and its atmosphere. Such measurements are possible to do in the near term from a Saturn flyby with probes mission. pdf's of relevant papers can be downloaded from <http://www.umich.edu/∼atreya>