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Compositional Constraints on Giant Planet Formation

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Except for neon, elements with masses heavier than helium appear to be enriched by a factor 3 $\pm$ 1 (relative to hydrogen) in Jupiter's atmosphere, compared to solar abundances This enrichment can be simply explained by a model in which the atmosphere is a mixture of volatiles released from the original core that accreted to initiate the planet-forming process and the solar-composition gases that collapsed from the surrounding solar nebula. This process predicts an enrichment of 7 $\pm$ 1 times solar values for Saturn, which Cassini CIRS has just confirmed in the case of carbon (as methane). The prediction for Uranus and Neptune is 30 to 40 times solar, consistent with ground-based observations of CH$_4$ in these planet's atmospheres. Atmospheric probes are essential to test this model further, by measuring abundances and isotope ratios of more consitituents–especially nitrogen and the noble gases–in the atmospheres of Saturn, Uranus and Neptune.