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To See the Inside of a Planet in a Drop of Deuterium[1]

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Despite their proximity, the giant planets of the solar system, Jupiter and Saturn, still present a number of fundamental puzzles. The discovery of nearly 300 planets around other stars in all manners of orbital and physical parameters has further complicated the picture. Giant planets are primarily composed of hydrogen and helium but also contain higher Z elements. The global abundances and the radial variation of the composition of a giant planet represents the end state of its formation process. Observations that pertain to the present-day internal structure of giant planets are the primary thread to the physical mechanisms that where at play when they formed several billion years ago. The interior structure is inferred from observations and is not uniquely determined. The modeled structures of Jupiter and Saturn are quite sensitive to the equation of state (EOS) of hydrogen/helium mixtures in the regime of warm dense matter. Unresolved EOS questions of great importance to planetary science include: Is there a first order metallization transition in hydrogen? What is the EOS of H/He mixtures? Is there a phase separation in H/He mixtures that could provide an additional energy source to slow down the cooling of giant planets, as suggested by observations of Saturn? Can a better EOS provide an explanation for the large radii of several extrasolar giant planets? The last decade has seen a tremendous experimental effort focused on shocked deuterium EOS measurements complemented by a renewed interest in ab initio simulations of H and very recently, He. Those experiments have been crucial in improving EOS models that had been mostly unencumbered by data. New experimental techniques, such as isentropic compression, will reproduce conditions closer to planetary interiors than current data EOS data. When combined with ab initio simulations of H/He mixtures, a much clearer understanding of the interiors of giant planets and of their formation should emerge.

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