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Interior structure of solar and extrasolar giant planets¹

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Molecular dynamics simulations combined with finite-temperature density functional theory (FT-DFT-MD) represent a powerful novel tool to calculate accurate equation of state (EOS) data. Comparison with shock wave experiments yields good agreement for the Hugoniot curve, the reflectivity, and the electrical conductivity for the most abundant materials in giant planets such as hydrogen, helium, and water, especially in the warm dense matter region. Based on this new ab initio data we discuss the nonmetal-to-metal transition in hydrogen, the demixing of hydrogen and helium at megabar pressures, the location of the superionic phase in water, and the respective high-pressure phase diagrams. Most importantly, the availability of more data will lead to modified or completely new interior structure models for solar as well as extrasolar giant planets. Key issues are in this context the core mass, the metallicity, and the cooling curve. We present recent results for the interior structure of solar giant planets. First predictions for the structure and composition of selected extrasolar giant planets such as GJ 436b are also given based on ab initio EOS data.

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