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Matter at high energy densities: planetary interiors and inertial confinement fusion

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We apply large-scale molecular dynamics simulations based on density functional theory (DFT-MD) to infer the high-pressure phase diagram of hydrogen-helium and H-C-N-O mixtures. Of particular interest is the nonmetal-to-metal transition in dense fluid hydrogen that occurs at few megabars (metallization). Furthermore, demixing of hydrogen and helium is predicted at about the same extreme conditions which leads to helium rain in the deep interior of gas giant planets like Jupiter and Saturn. We calculate the corresponding equation of state data and transport properties like electrical and thermal conductivity and discuss the impact of our results on the interior, evolution, and magnetic field of giant planets like Jupiter and Saturn (H-He), Uranus and Neptune (H-C-N-O mixtures). Furthermore, we consider higher temperatures relevant for stellar astrophysics and inertial confinement fusion scenarios. We calculate EOS data and construct conductivity models that are applicable for a wide range of densities and temperatures.

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