SHOCK07-2007-000267

Abstract for an Invited Paper
for the SHOCK07 Meeting of
the American Physical Society

Simulations of Shocked Hydrogen and Helium and Implications for Giant Planet Interiors

BURKHARD MILITZER, Carnegie Instition of Washington

In 1996 the NOVA laser shock wave experiments at LLNL probed the properties of deuterium at megabar pressure for the first time. These measurements have triggered a large number of theoretical and experimental studies. Recently the combination of static and dynamic compression techniques allowed one to reach even higher densities. In this talk, path integral Monte Carlo and density functional molecular dynamics simulations have been applied to predict the shock states of precompressed hydrogen and helium samples. It will be explained why the precompression leads to a reduction in the compression ratio for both materials [1]. It will also be demonstrated that electronic excitations lead to a much higher compression ratio of 5.24 for shocked helium compared to 4.3 that our simulations predicted for deuterium. Combining our equation of state (EOS) results for shock samples with further first-principles simulation for hydrogen-helium mixtures [2] allowed us to build a model for the interiors of giant planets. Included were corrections to the commonly used linear mixing approximation as well as the increased stability of hydrogen molecules that arises from the presence of helium. Our interior models update the suite of models that were based on the widely used Saumon-Chabrier-Van Horn (SCVH) EOS. Deviations from SCVH are up to about 5 percent depending on the pressure, and thus affect interior models at the same level. Unlike SCVH, the computed DFT-EOS does not predict any first-order thermodynamic discontinuities associated with pressure-dissociation and metallization of hydrogen [2]. We conclude by discussing constraints for the size of Jupiter's rocky core and whether the planet was formed by core accretion.

[1] B. Militzer, "First Principles Calculations of Shock Compressed Fluid Helium," Phys. Rev. Lett. 97 (2006) 175501.
[2] J. Vorberger, I. Tamblyn, B. Militzer, S.A. Bonev, "Hydrogen-Helium Mixtures in the Interiors of Giant Planets," Phys. Rev. B 75 (2006) 024206.