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P1.4010 Laser-driven shock compression of water ammonia and water-ethanol-ammonia mixtures to probe the interiors of icy giant planets

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Water, methane, and ammonia are amongst the key components of Uranus and Neptune. Knowing their equation of state, conductivity, and transport properties at planetary interiors conditions (pressures of several megabar and temperatures of a few thousand Kelvin) is required for developing precise models of the two planets, with the aim of explaining their puzzling structures, magnetic fields, and luminosities [1]. The physical and chemical behaviour of such mixtures at extreme pressures and temperatures is not only important for planetology but also interesting on its own, since those conditions are characterised by the coexistence of dissociated atoms, atomic clusters and chains. This regime is very difficult to study via ab initio simulations and experimental verifications are thus required.
Using laser-driven shocks, we compressed up to 3 Mbar pure water, pure liquid ammonia, and a C:H:N:O mixture composed by water, ethanol, and ammonia. Their principal Hugoniot curves have been explored using the decaying shock technique. Moreover, off-Hugoniot states have been reached via a double-shock technique and through the coupling of dynamic and static compression in diamond anvil cells. The experiments were performed at the LULI2000 laser facility employing standard rear-side optical diagnostics (Doppler velocimetry, optical pyrometry). The equation of state and the shock-front reflectivity have been measured, allowing an estimation of the electrical conductivity.
Our results show that water and the C:H:N:O mixture share similar Hugoniot curves with a trivial density scaling, while the reflectivity behaves differently in both the onset pressure and the saturation value. The experimental study of the structural and optical properties of shockcompressed ammonia essentially confirms the predictions of recent ab initio simulations [2]. The consequences for the modelling of the interiors of the icy giant planets will be discussed.

References
[1] T. Guillot, Annu. Rev. Earth Planet. Sci. 33, 493 (2005)
[2] D. Li, P. Zang, and J. Yan, The Journal of Chemical Physics 139, 134505 (2013)

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