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Exploring the deep interior of ice giants with shock-compression experiments and ab initio simulations: The case of metallic ammonia

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Ammonia is predicted to be one of the major components in the depths of the ice giant planets Uranus and Neptune. Their dynamics, evolution, and interior structure are insufficiently understood and models rely imperatively on data for equation of state and transport properties [1,2]. Despite its great significance, the experimentally accessed region of the ammonia phase diagram today is still very limited in pressure and temperature [3, 4].

We investigate the equation of state, the optical properties and the electrical conductivity of warm dense ammonia by combining laser-driven shock experiments and state-of-the-art density functional theory molecular dynamics (DFT-MD) simulations [5]. The equation of state is probed along the Hugoniot of liquid NH_3 up to 350 GPa and 40000 K and in very good agreement with earlier DFT-MD results [6]. Our temperature measurements show a subtle slope change at 7000 K and 90 GPa, which coincides with the gradual transition from a liquid dominated by molecules to a plasma state in our new ab initio simulations. The reflectivity data furnish the first experimental evidence of electronic conduction in high pressure ammonia and are in excellent agreement with the reflectivity computed from atomistic simulations. Corresponding electrical conductivity values are found up to one order of magnitude higher than in water in the 100 GPa regime, with possible implications on the generation of magnetic dynamos in large icy planets' interiors.

[1] Scheibe, Nettelmann, Redmer, Astronomy & Astrophysics **632**, A70 (2019).

[2] Vazan & Helled, Astronomy & Astrophysics **633**, A50 (2020).

[3] Nellis, Hamilton, Holmes, Radousky, Ree, Mitchell, Nicol, Science **240**, 779 (1988).

[4] Radousky, Mitchell, Nellis, Journal of Chemical Physics **93**, 8235 (1990).

[5] Ravasio, Bethkenhagen, Hernandez, Benuzzi-Mounaix, Datchi, French, Guarguaglini, Lefevre, Ninet, Redmer, Vinci, Physical Review Letters **126**, 025003 (2021).

[6] Bethkenhagen, French, Redmer, Journal of Chemical Physics **138**, 234504 (2013).