Observation of metallic helium: Equation of state and transport measurements under astrophysical conditions.

J. Eggert[1], P.Loubeyre[2], S.Brygoo[2], R.S.McWilliams[3], P.M. Celliers[3], D.G.Hicks[1], T.R. Boehly[4], R. Jeanloz[3], G.W. Collins[1].

1) Lawrence Livermore Laboratory, CA, USA. 2) CEA, France. 3) University of California, Berkeley, CA, USA. 4) LLE, University of Rochester, NY, USA.

eggert1@llnl.gov

The equation of state and opacity of warm dense helium ($1 < \rho < 10$ g/cm^3, $0.5 < T < 5$ eV) is essential for addressing a variety of astrophysical problems, such as the cooling rate of white dwarfs or the miscibility of H/He in the interior of giant planets. High-pressure experimental data on dense helium are sparse, and in particular none exist in the region of direct astrophysical relevance: models used by the astrophysical community have been calibrated on a small number of gas-gun measurements much below 1 g/cm^3 [1]. It has recently been shown that by coupling static- and dynamic-compression techniques, it is becoming feasible to recreate the conditions of giant planetary interiors in laboratory [2]. We present accurate pressure, temperature, density, and reflectivity measurements of helium using quartz as a reference material for impedance matching. We compressed helium to over 1.2 g/cm^3, and reflectivity data at these conditions show that helium is not a clear dielectric fluid but reflects like a metal. The pressure for this transition is almost independent of temperature, as would be expected for pressure-induced ionisation, but it occurs at pressures 1-2 orders of magnitude lower than theoretically expected for the T = 0 K solid or fluid [3]. These measurements also have implications for the phase diagram of helium, including the presence of a maximum on the melting line or the existence of a plasma phase transition.

[1] D. Saumon, G. Chabrier and H.M. VanHorn, Astrophys. J. Suppl. , 1995, **99**, 713.

[2] P.Loubeyre et al, High Press. Res., 2004, **24**, 25.

[3] O. Pfaffenzeller, D. Hohl and P.Ballone, Phys. Rev. Lett., 1995, **74**, 2599.