Refraction Index of Shock Compressed Water in the Megabar Pressure Range

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The interest related to behavior of water is largely justified by planetological research and it has been the subject of several works [1, 2]. Together with ammonia and methane, water is one of the main elements of the mantles of giant planets like Uranus and Neptune. The observation of a large and asymmetric magnetic field in those planets [3, 4] has prompted the idea that the field is originated in the mantle. Since the dynamo effect requires the presence of a conductive material, a phase transition to the metallic state has been suggested [5]. Such phase transition has been evidenced in molecular dynamics simulations.

The study of the optical properties of compressed water, of its refraction index n and its reflectivity R can allow getting information related to the microscopic structure of water and its transition towards a metallic state (i.e. how the energy gap is approaching closure).

Experimentally by increasing the pressure we observed an increase in water absorption (driven by larger value of n_i, the imaginary part of the refraction index) followed by a large increase of R when a conductive state is achieved.

In this contribution, we present the results of experiments performed at the LULI and RAL laboratories. A water sample was compressed to Mbar pressure by a laser-driven shock. We used shock chronometry and VISAR diagnostics to measure the shock and fluid velocities. This allowed obtaining experimental points on the equation of state (EOS) of water, which were in fair agreements with the SESAME tables. Also, VISAR allows to measure water reflectivity or, in a regime of pressures for which water is still transparent or weakly absorbing, its refraction index n (indeed in this case the probe beam crosses the layer of compressed water before being reflected from an Al pusher layer).

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