Shock Hugoniot data for Water up to 5 Mbar obtained with quartz standard at high-energy laser facilities

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Equation-of-State (EOS) of matter at extreme thermodynamic conditions is of a great interest of several areas of physics. Water is predicted to be abundant in the outer planets of the Solar System, as well in many of the recent discovered exo-planets. In particular, it is one of the principal constituents of the mantles of planets like Uranus and Neptune. The experiment was conducted on the HiPER (High Intensity Plasma Experimental Research) laser facility, a uni axial irradiation chamber of the GEKKO XII (GXII) at the Institute of Laser Engineering (ILE), Osaka University and the PHELIX at GSI to lunch a planar shock into multi-layered water samples. The experiment used up to 12 beams with energy $E_L \sim 1\ kJ$, at wavelength of 351 nm third harmonic of Nd:yttrium aluminium garnet (YAG) laser. The temporal profile of the laser pulse was square shape in time with FWHM 2.5 ns. The focal-spot diameter was 600 μm flat top and 350 μm respectively for PHELIX laser. A typical target assembly consist of 10 μm CH / 200 nm Au / 100 μm Quartz (with AR@1054&532&527 both sides) nominally ~500 μm water / 100 μm Quartz (with AR@1054&532&527 both sides). As diagnostics, we had two VISAR (velocity interferometer system for any reflector [1]), using a seeded probe laser at 532 - 660nm, synchronized with the main beam. VISARs allow to measure the shock transit time in the various materials trough the jumps in reflectivity and fringe jumps, from which we get the average shock velocity in each material. The impedance-matching method was used to determine the shock state in the water after passing the quartz/water interface. In our experiment, we generated pressures up to 5 Mbar. Results from preliminary analysis are compatible with the predictions of hydrodynamics simulations performed using MULTI 1D radiative hydrodynamic code [2] with known EOS table SESAME 7154 for Water and SESAME 7385 for Quartz.

References

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