Diamond rain in the interior of large planets

N. J. Hartley[1,2*], J. Vorberger[1], A. Pak[3], T. Döppner[3], L.B. Fletcher[4], S. Frydrych[5], E. Galtier[4], E.J. Gamboa[4], D.O. Gericke[6], S. H. Glenzer[4], E. Granados[4], M. J. MacDonald[4,7], A.J. MacKinnon[4], E.E. McBride[4,8], I. Nam[4], P. Neumayer[9], K. Rohatsch[1], M. Roth[5], A.M. Saunders[10], A. Schuster[1], P. Sun[4], T. van Driel[4], R.W. Falcone[10,11] and D. Kraus[1,10]

[1]HZDR, Dresden, Germany
[2]OTRI, Osaka University, Osaka, Japan
[3]Lawrence Livermore National Laboratory, Livermore, USA
[4]SLAC National Accelerator Laboratory, Stanford, USA
[5]Technische Universität Darmstadt, Darmstadt, Germany
[6]CFSA, University of Warwick, Coventry, UK
[7]University of Michigan, Ann Arbor, USA
[8]European XFEL GmbH, Schenefeld, Germany
[9]GSI Darmstadt, Darmstadt, Germany
[10]Department of Physics, UC Berkeley, Berkeley, USA
[11]Lawrence Berkeley National Laboratory, Berkeley, USA
*E-mail address: n.hartley@hzdr.de

Light element ‘ices’ (water, ammonia and hydrocarbons) are the primary constituent of icy giant planets such as Uranus and Neptune, and increasing numbers of extrasolar planets. Within such bodies, materials are compressed to many times ambient density, with thermal energies high enough to break apart chemical bonds, leading to a complex mix of molecular and ionic species. Under such conditions, demixing of carbon and hydrogen, and the subsequent formation of diamond, had previously been predicted.

On experiments at LCLS, plastic samples were shock-compressed to pressures and temperatures comparable to those expected within Uranus, with the evolution of the target structure observed by angularly and spectrally resolved X-ray scattering. In the case of polystyrene targets (CH), strong peaks characteristic of a diamond structure were observed. Other samples do not show such clear results, and suggest that liquid-liquid demixing may not be viable in hydrocarbon samples. The results are compared to *ab initio* simulations, with their relevance to planetary evolution and possibilities for future work discussed.