Contribution ID: **8** Type: **Talk**

Diamond formation kinetics in shock-compressed C-H-O samples via small angle X-ray scattering and X-ray diffraction

Friday 5 November 2021 10:35 (25 minutes)

Icy giant planets such as Neptune and Uranus are abundant in our galaxy. The interiors of these celestial objects are thought to be mainly composed of a dense fluid mixture of water, methane and ammonia[1]. Due to the high pressure and high temperature conditions deep inside the planet, this material mixture will likely undergo chemical reactions and structural transitions[2]. An example of these reactions is the possible dissociation of hydrocarbons, and subsequent phase separation, allowing the formation of diamonds. Laser shock experiments in combination with an XFEL allowed us to address these questions.[3-5] Due to the presence of water and therefore large amounts of oxygen inside the ice giants, ínvestigating C-H-O samples provides a more realistic scenario than studying pure hydrocarbon systems.

As an ultra-sensitive diagnostic technique, small angle X-ray scattering (SAXS)[6] can explore feature sizes in the order of nanometers by recording their scattering at small angles (typically 0.1-10°), allowing us to obtain deeper insights into the question how diamonds are formed, what grain sizes are achieved and how many grains are formed.

Experiments were carried out at the MEC end station of the LCLS XFEL in December 2020. Three oxygenated polymers with different carbon to H2O ratios, polyethylene terephthalate (PET, C10H8O4), polylactic acid (PLA, C3H4O2) and cellulose acetate (CA, C10H16O8) were compressed to planetary interior states ranging from 50 GPa to 150 GPa and 2000K to 7000K by laser-driven single shocks. The compressed samples were probed utilizing in situ X-ray diffraction (XRD) and SAXS.

The diamond formation kinetics in presence of oxygen in these three materials have been observed. SAXS shows more sensitive information than XRD, revealing that the diamond fraction first increases and then decreases with increasing of pressure and the growth of particles with time in the medium pressure regime (~110 GPa). The observed particle radius of diamond is between 1.5 nm and 3 nm. In addition, the proportion of carbon in the initial sample materials also shows a correlation with the observed diamond fraction. Ongoing simulations aim to explain these phenomena in order to improve the theory of planetary formation and evolution.

[1]T. Guillot, Annu. Rev. Earth Planet. Sci. 33, (2005).
[2]M. Ross, Nature 292, (1981).
[3]D. Kraus, J. Vorberger, A. Pak, et al., Nature Astronomy 1, (2017).
[4]D. Kraus, N. Hartley, S. Frydrych, et al., Phys. Plasmas 25, (2018).
[5]A. Schuster, N. Hartley, J. Vorberger, et al., Phys. Rev. B 101, (2020).
[6]O. Glatter, O. Kratky and H. Kratky, Small angle X-ray scattering (Academic press, 1982).

Primary authors: HE, Zhiyu (Helmholtz-Zentrum Dresden-Rossendorf); Mr LUTGERT, Julian (Helmholtz-Zentrum Dresden-Rossendorf); Dr VORBERGER, Jan (Helmholtz-Zentrum Dresden-Rossendorf, Dresden); Prof. KRAUS, Dominik (Universität Rostock, Rostock, Germany)

Presenter: HE, Zhiyu (Helmholtz-Zentrum Dresden-Rossendorf)

Session Classification: Talks