Integration of quantum beam measurements, modelling, and mathematics to unravel disordered matter: towards a collaboration with microgravity in space

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The structure of glassy, liquid, and amorphous materials is still not well understood, due to the lack of experimental information which, in turn, is the result of “disorder”. To overcome this situation, we will adopt comprehensive integration of quantum beam measurements at SPring-8 and J-PARC, data-driven modelling employing advanced supercomputing, and modern mathematics [1] to unravel hidden ordering in disordered matter by understanding relatively sharp peaks appearing in diffraction patterns. Figure 1 shows diffraction data for amorphous Si and silica (SiO_2) glass. As indicated by the arrow, silica glass shows a very sharp diffraction peak, but not amorphous Si, although both materials have a tetrahedral network structure. The origin of the difference in the diffraction patterns will be revealed on the basis of topology. We introduce recent activities on this topic [2], too.

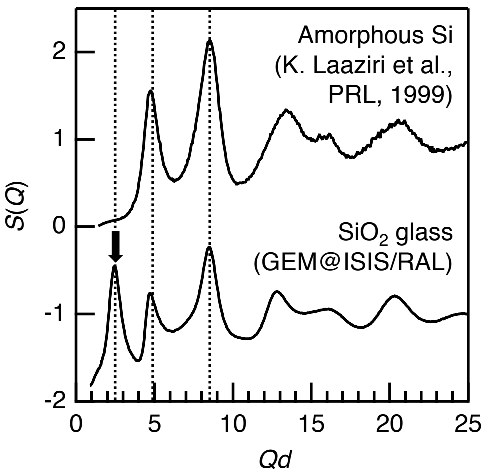

Fig. 1 Diffraction patterns for amorphous Si and SiO_2 glass.

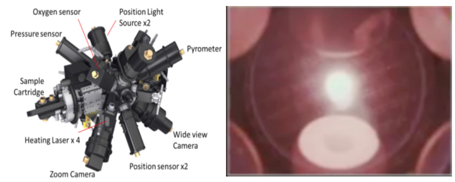

Fig. 2 Schematic illustration of ELF (left) and a levitated droplet of high-temperature melt (right).

By utilizing this technique, we will try to uncover the relationship between viscosity and the structure of high-temperature oxide melts. The nature of viscosity is not so well understood, due to the difficulty of viscosity measurements at high temperature (> 2,000 ˚C). To overcome this situation, JAXA has developed an electrostatic levitation furnace (ELF) at the international space station (ISS) (see Fig. 2). We can measure viscosity from the decay time of droplet vibration generated by ELF. Simultaneously, we will also take diffraction data of melts at quantum beam facilities. Then we will try to unravel the relationship between viscosity and the atomic structure of liquids on the basis of topology of melts.

Bibliography

[1] Y. Hiraoka et al.; PNAS, **113**, 7035 (2016).

[2] Y. Onodera et al.; Nat. Commun., **8**, 15449 (2017).

External links

http://ishikawa.isas.jaxa.jp/index.html