Understanding the glass transition phenomenon is encountered to the greatest challenges of 21[st] century science [Kennedy, D. *125 outstanding problems in all of science: what is the nature of the glassy state*. Science 309, 83 (2005)]. The practical significance of the problem extends from material sciences, pharmacy industry, food industry to geophysics. Then , reaching the ultimate insight into this problem can have a great impact on the nowadays society life. One of the most striking features of this phenomenon are far previtreous effects of dynamic properties occurring already 200 K above the glass temperature (T_g), despite the fact the it cannot be treated as a phase transition. Notwithstanding, this indicate that studies of previtreous effects can be the key for revealing the nature of the glass transition, Unfortunately, although these phenomena are studied since decades no ultimately conclusive results have been reached so far – regarding both experiment and theory.

The key research hypothesis of this Project is that the *breakthrough* in the glass transition physics can approached via:

- **(i)** studies in experimental model-systems "extracting" key artifacts related to the vitrification process. Thus then can create an 'experimental model system' for which a theoretical-model parallel can be designed
- **(ii)** experimental implementation beyond the current state-of-the-art
- **(iii)** innovative way of analysis, revealing fundamental features "hidden" so far.

This Project addresses above questions via:

(i) **The selection of the experimental model-System:** Studies are planned in liquid crystals (LCs) plastic crystals (*orientationally disordered crystals*: ODICs) where the vitrification process is limited solely to translational or orientational processes. *For "canonical glassformers" (supercooled liquids and polymers) the complex interplay of translational and orientational degrees of freedom takes place.*

(ii) **Experiment:** Coherent insight in the pressure – temperature (*P*-*T*) plane well beyond the current experimental limitations for glass formers.
It bases on new facilities in IHPP PAS (PressLab in the Innovation and Technology Park in Celestynow) for pressures up to even 10 GPa, matched with temperatures from – 60 °C up to even 1 600 °C, additionally with large pressurized volumes facilitating *in situ* (under pressure) monitoring. In situ monitoring via broad band dielectric spectroscopy (BDS), supported by nonlinear dielectric spectroscopy (NDS), and thermodynamic (DTA/DSC and density) and structural (X-ray) insight. Supplementary structural analysis of supercooled/superpressed samples (XRD, silver line) are planned. *Extreme pressures are essential for plastic crystals, which are less compressible than liquids or polymers*.
Only monitoring of properties in the P-T space can yield ultimate picture of various phenomena, can enable the construction of unequivocal equations of state, reveal hidden phenomena and phases. Finally, the analysis of relevant process temperatures (as the glass temperature) vs. pressure can become possible.

(iii) **Data analysis and modelling:** the innovative *model-free route* will be *implemented & developed* as the key analytic tool. It has been introduced by the authors of the Project in refs. [Nature Communications 4, 1823 (2013); Scientific Reports 4, 5160 (2014) and 5, 8314 (2015).
Instead of analyzing of 'direct' experimental properties as relaxation time or viscosity the transformation to the apparent activation energy index is carried out. This is associated with the non-biased calculation of the apparent activation energy in prior.
Results enable the 'new level' of verification and development of theoretical model. The particular attention will be paid to issue related to the impact of symmetry of the system on the vitrification and the new general dependence for the structural entropy.
The '*feedback analysis' experiment – modelling* is the essential feature of the Project.