Structure and Dynamics of Isotropic Order

Jun Yamamoto
Department of Physics, Graduate School of Science, Kyoto University　Japan

Liquid state has highest symmetry, so the X-ray diffraction pattern is completely uniform and symmetric in the space. Thus, space has complete spherical isotropic symmetry in liquid state. On the contrary, if temperature goes down to the solid phase or liquid crystalline phase, special regularity of the "order" breaks the symmetry of the space. So, both the "Ordering" and "Spherical isotropic symmetry" never coexist simultaneously. However, we have found the novel isotropic smectic blue phase ($SmBP_{Iso}$), which show the appearance of the "Ordering" does not break the macroscopic "symmetry" of the space[1]. We call this is "Isotropic order". Soft condensed matter system can form the huge length scale order. $SmBP_{Iso}$ is characterized by the simultaneous presence of the local order parameter of an helix and of a smectic layer, while being spontaneously isotropic without any characteristic discontinuity on a mesoscopic length scale. It is great advantage for the optical devices that the spectrum of the iridescent color of $SmBP_{Iso}$ is completely equivalent by the changing the viewing angle because of the special isotropic symmetry and its wavelength can be successively controlled by changing temperature.

Recently, we found the color can be tuned by shining the strong pulsed laser light. Then we can artificially design the special pattern of the "structural color" by scanning and on/off the laser light beam. Response time of the color shift is not so fast but not so slow (~200msec) in spite of the existence of the complicated inter-connected multi-lamellar structure. We also confirms experimentally that the existence of the collective fluctuation mode just around the sub second by the dynamic light scattering measurement. Relaxation time can be assigned as reorientation motion of the helical pitch, which must be correlated to the dynamics of the shrinkage/elongation of the inter-connected multi-lamellar structure through the coupling between two types of the liquid crystalline orders. Furthermore, we found that cubic SmBP reenter the $SmBP_{Iso}$ at super cooling temperature (T_{sc}) in the twin poor region. Since Smectic A phase appear by applying the heating shock and is stable until T_{sc} where cubic SmBP reappear. So we can conclude that the re-entrant $SmBP_{Iso}$ is super-cooled state. We also found the power law slow dynamics in the director orientation fluctuation as similar to the conventional liquid-glass transition. However, it should be noted that smectic-A phase, which is hidden by the super cooling of $SmBP_{Iso}$, is not solid state! So, translational and rotational diffusion motion of molecules is never frozen. Thus, we found the novel topological glass state which shows the slow dynamics of the fluctuation on the internal degree of freedom as same as conventional glass material, nevertheless microscopic molecular motion is completely free as similar to the liquid phase.

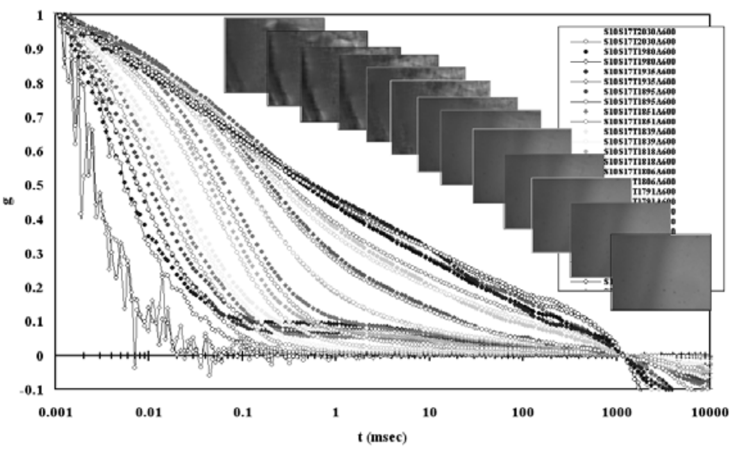

Fig.1 Glassy Slow Dynamics of Super-Cooled $SmBP_{Iso}$

REFERENCES

1. Yamamoto, J., Nishiyama, I., Inoue, M., & Yokoyama, H.　Nature 437, 525-528(2005).