Hiroyuki Shima (University of Yamanashi, JAPAN)

Geometry - Property Relation in Condensed Matter Physics

The phrases of “geometry” and “curvature”, originally used in the mathematics community alone, are becoming commonplace in a realm of condensed matter physics. Profound effects of geometric curvature have manifested not only in Einstein’s gravity theory, but also in diverse low-dimensional materials such as nano-carbon layers, liquid crystal membranes, and mono-layered aqueous foam. The body of research on the subjects has relied on differential geometry. On one hand, it allows to formulate an effective Hamiltonian of quantum excitations confined in curved surfaces. On the other hand, it enables us to appreciate beautiful interplay between surface curvature and topological defect configuration in two-dimensional ordered systems. Furthermore, geometry-property relations become salient in soft matters that are mechanically deformable.

In this lecture, I give a bird’s-eye review on the theoretical progresses on the geometry-property relations in low-dimensional materials endowed with nonzero surface curvature. Special focus is placed on the following three issues: (i) quantum transport in curved nanostructure [1,2,3], (ii) orientational order/disorder transition on curved surfaces [4,5], and (iii) time-evolution of aqueous foam confined between curved substrates [6]. Theoretical approaches based on differential geometry, which facilitates quantitative description of the curvature effects, are also explained.

[1] H. Shima et al., Phys. Rev. B 79 (2009) 201401(R).
[2] J. Onoe et al., EPL 98 (2012) 27001.
[3] H. Shima, Phys. Rev. B 86 (2012) 035415.
[4] H. Shima & Y. Sakaniwa, J. Phys. A: Math. Gen. 39 (2006) 4921.
[5] S. K. Baek et al., Phys. Rev. E 79 (2009) 060106(R).
[6] H. Shima, J. Phys. Soc. Jpn. 79 (2010) 074601.