UNIVERSITÉ DU LUXEMBOURG

Physics Colloquium

3 October 2019 at 10:00 am
Coffee at 9.45 am

Campus Limpertsberg
Bâtiment des Sciences – room 1.03

Talk by Professor Gerd Schröder Turk
Murdoch University in Perth, Australia
Invited by Prof. Ludger Wirtz

Nature's amazing labyrinths: Bicontinuous phases in biology and material

Bicontinuous geometries are fascinating structures that are characterised by spatially extended highly-ordered arrangements on the nanoscale. Alan Schoen's Gyroid surface is in many ways the archetype of these geometries, being a surface that divides space into two identical domains, each of which is an ordered maze-like infinite labyrinth.

For the Gyroid and all other bicontinuous forms, the characteristic defining feature is that all components (which may be lipid membranes, copolymer moieties, membranes, biopolymeric materials) all 'percolate' throughout space. Because of this geometric characteristic, they allow e.g. macroscopic and fast transport or diffusion; simultaneous mechanical stiffness and permeability; and other functional material properties including photonics.

Bicontinuous phases (and related phases) have by now become nearly house-hold names and occur in many synthetic soft matter systems, particularly those that are self-assembled [1]. There are many instances where these phases occur in biological tissues, yet, their role in these biological systems remains less well understood.

In this talk, I will first discuss how several different species of green butterflies use the Gyroid nanostructure as a biophotonic crystal that causes the green coloration. I will further discuss how we can draw inspiration from this biological photonic material for man-made photonic structures and how Gyroid-related photonic properties can be investigated geometrically [2,3].

I will then discuss the occurrence of Gyroid-like phases and structures in biology, in particular in intracellular membrane structures. I will discuss why I consider that understanding why and how these structures form in nature is a useful future step – both for material design and for understanding their function in nature – and why progress in this area is likely in the next few decades [4].

References

[1] R. Mezzenga, J.M. Seddon, C.J. Drummond, B.J. Boyd, G.E. Schröder-Turk, and L. Sagalowicz, "Nature-inspired design and application of lipidic lyotropic liquid crystals", Advanced Materials, 2019

[2] M.D. Turner, M. Saba, Q.M. Zhang, B.P. Cumming, G.E. Schröder-Turk, M. Gu, "Miniature chiral beamsplitter based on gyroid photonic crystals", Nature Photonics 7(10), 801-805 (2013)

[3] M. Saba, M. Thiel, M.D. Turner, S.T. Hyde, M. Gu, K. Grosse-Brauckmann, D.N. Neshev, G.E. Schröder-Turk, "Circular dichroism in biological photonic crystals and cubic chiral nets", Phys. Rev. Lett. 106, 103902 (2011)

[4] B.D. Wilts, B. Apeleo Zubiri, M.A. Klatt, B. Butz, M.G. Fischer, S.T. Kelly, E. Spiecker, U. Steiner, G.E. Schröder-Turk, "Butterfly gyroid nanostructures as a time-frozen glimpse of intracellular membrane development", Science Advances 3, e1603119 (2017)

Biography: Dr Gerd E. Schröder-Turk is an Associate Professor at the School of Engineering and Information Technology at Murdoch University in Perth. He holds a PhD awarded by the Australian National University, for his research thesis "Skeletons in the Labyrinths" about geometric aspects of pattern formation in self-organised systems. He has held a academic positions at the Australian National University (postdoctoral research) and the Friedrich-Alexander University Erlangen-Nuremberg (teaching/research). In 2014, he was awarded the Friedrich-Alexander University Emmy-Noether Award for his habilitation work and in 2019 the Fellowship Awards of the Camurus Lipid Research Foundation. In 2019, he was selected as a fellow of the American Physical Society. He is the author of around 80 scientific articles and has been the chair or co-chair of numerous international scientific conferences, including "Shape Up: Exercises in Materials Geometry and Topology" in Berlin in 2015, the Australian Academy of Sciences 2016 Boden conference "Animal, Vegetal, Mineral" in Yallingup and the 2018 Australian Institute of Physics Bianniel Congress. He refers to his area of research as "Materials Geometry", that is, the materials science of nano- or microstructured materials and tissues, addressed through the goggles of advanced geometric methods. Aside from his scientific interests, he feels strongly about governance of the academic sector and the national and international scientific communities; as such he is a member of the Senate of Murdoch University and a member of the National Executive of the Australian Institute of Physics.