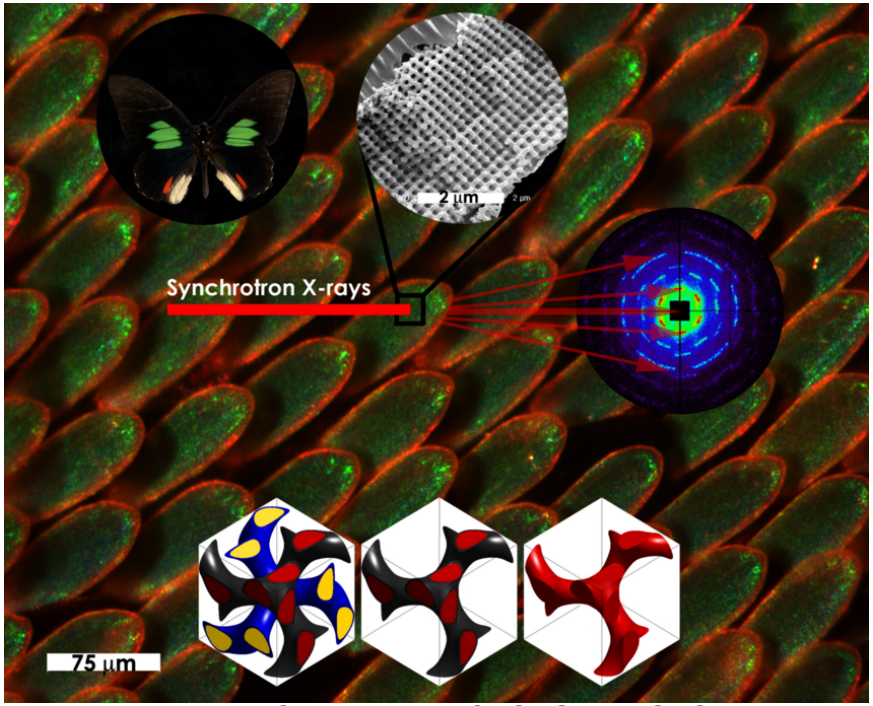
What has soft matter physics got to do with butterfly colors?

The vivid, angle-dependent structural colors of some butterfly wing-scales are produced by light scattering from complex three-dimensional nanoscale structures. With intricate structural knowledge from synchrotron small angle x-ray scattering (SAXS), we hypothesize that the butterfly nanostructures develop by the self-organizing kinetics of cellular membranes, as with soft matter systems such as a soap film spanning a wire contour. Half of the space so templated gets filled with the protein chitin, while the rest of the scale cell degenerates leaving behind a single crystalline network of chitin and air. Butterfly biophotonic nanostructures that evolved over millions of years not only offer a biomimetic template for novel engineering applications, but also serve as a platform to advance our understanding of the physical principles guiding biological soft matter assembly.



Scanning electron microscopy and SAXS of the vivid green forewing scales (background) of this Papilionid butterfly reveal single gyroid photonic crystal domains, with an unusually high degree of order for a biological soft matter system (top panel). The butterflies develop the thermodynamically-favored core-shell double gyroid precursors through membrane self-organization en route to the optically efficient single gyroid biophotonic nanostructures (bottom panel).

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