"Evolutionary Photonics: natural designs for manipulating the flow of light and colour"

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The study of structural colour in brightly coloured animals is an exciting interdisciplinary area of research[1]. Complex photonic bandgap (PBG) structures (which prevent the propagation of a band of wavelengths through them – causing strong coloured reflections) in Colepotera[2] and Lepidoptera[3] suggest broad innovation in nature's use of materials and its manipulation of light. In certain butterflies, ultra-long-range visibility of up to one half-mile is attributed to photonic structures that are formed by discrete multilayers of cuticle and air[3]. This contrasts, in other butterfly species, to photonic structures designed more for crypsis and which not only produce strong polarisation effects but can also create colour stimulus synthesis using highly adapted structures[4]. Optical systems also exist that employ remarkable 2D and 3D photonic crystals of cuticle to produce partial PBGs, with the effect that bright colour is reflected, or fluorescence emission is inhibited[5], over specific angle ranges. From the perspective of modern optical technology, these structures indicate a significant evolutionary step, since in principle, these 2D and 3D periodicities are potentially able to manipulate the flow of light in all directions.
This lecture will present an overview of this emerging field of study, as well as several of the exciting recent discoveries that reflect nature's optical design ingenuity, and the technological applications to which they are currently being applied.

1. P. Vukusic & J.R. Sambles, *Nature* **424**, 852-855 (2003).
2. P.Vukusic, B. Hallam and J. Noyes, *Science*, **315**, 348 (2007).
3. P. Vukusic, et al., *Proc Roy Soc B* **266**: 1403-1411 (1999).
4. P. Vukusic, J.R. Sambles, C.R. Lawrence *Nature* **404**, 457 (2000).
5. P. Vukusic and I. R. Hooper, *Science*, **310**, 1151, (2005).