COURSE TITLE:

PHYSICAL AND BIOLOGICAL APPLICATIONS OF POLARIZED LIGHT IN ENVIRONMENTAL OPTICS

COURSE DESCRIPTION:

This lecture is intended for anyone interested in environmental optics, animal and human vision, polarized light and polarization sensitivity, including biologists, physiologists, ecologists and physicists. In particular, the recent advances in imaging polarimetry, that translate the parameters of polarization into colour, allow the students to understand the information within the polarization patterns of the optical environment not directly accessible to the human visual system. Such instrumentation has also allowed polarization research to advance rapidly, as we can now glimpse this previously hidden world.

Part I of the lecture deals with the polarization vision/sensitivity in animals and humans. (I.1.) Overview on the historical perspective of polarization vision research. (I.2.) Polarization vision and orientation of ball-rolling dung beetles which is governed partly by sky polarization. (I.3.) Polarization vision in ants, bees and wasps. (I.4.) Polarization-based behaviour, polarization detectors and polarized-light processing in the brains of desert locusts, Monarch butterflies, crickets, houseflies and fruit flies. (I.5.) Polarization vision, polarization sun-dial, polarization-based water detection and positive polarotaxis (attraction to horizontally polarized light) in aquatic insects (non-biting midges, dragonflies, mayflies, tabanid flies, yellow fever mosquitoes) and negative polarotaxis (repellence by horizontally polarized light) in desert locusts governing the avoidance of larger water bodies. (I.6.) Circular polarization patterns and vision of scarab beetles. (I.7.) Polarization vision of crustaceans. (I.8.) Polarization sensitivity and its functions in cephalopods. (I.9.) Polarization sensitivity in fishes and its functions in object recognition, navigation and camouflage. (I.10.) Polarization sensitivity in amphibians. (I.11.) Polarization vision in reptiles (crocodiles, lizards and snakes). (I.12.) Polarization vision in birds and in avian celestial navigation and orientation. (I.13.) Interactions between colour vision and polarization vision: polarization-induced false colours. (I.14.) Human polarization sensitivity: Haidinger's and Boehm's brushes.

Part II of the lecture concerns descriptions of the physics of polarized light in nature with specific reference to animal polarization vision. (I.15.) Underwater polarization induced by scattering hydrosols. (I.16.) Polarization patterns of freshwater bodies and their role in guiding water detection in aquatic insects. (I.17.) Polarization characteristics of forest canopies: How the azimuth of the foliage-occluded sun can be determined from the pattern of the direction of polarization of sunlit foliage canopies. Why dusk-active cockchafers sense downwelling polarization in the green part of the spectrum is also explored. (I.18.) Polarization patterns of the sky under different meteorological conditions (foggy, partly cloudy, overcast, twilight, smoky and eclipsed skies, skylight polarization transmitted through Snell’s window on the flat water surface). (I.19.) Linearly and circularly polarized signals from terrestrial and aquatic animals (butterflies, beetles, flies, dragonflies, spiders, fiddler crabs, birds, stomatopods, cephalopods and fishes). (I.20.) Anthropogenic polarization patterns and polarized light pollution, which induces polarized ecological traps for polarotactic insects, such as water beetles, aquatic bugs, dragonflies, mayflies, caddis flies and stoneflies.

Part III of the lecture summarizes several practical applications of polarization vision and patterns. (I.21.) Polarization as a guiding cue for oviposition in non-biting midges (chironomids) and mosquitoes. (I.22.) Linearly polarized light and its use as a guiding cue for water detection and host finding in tabanid flies. Tabanid repellency of bright animal coats, zebra stripes and spotty fur patterns. It is shown that stripes and spots make ungulates unattractive to host-seeking female tabanid flies, and stripes disrupt the odour attractiveness of host animals to tabanids. (I.23.) Polarization-based insect traps: polarization traps of egg-laying chironomids, and tabanid traps as a new technique of horsefly control to capture host- and water-seeking tabanid flies. (I.24.) Polarization cloud detection with imaging polarimetry. (I.25.) Psychophysical study of the possibility and the atmospheric optical prerequisites of the hypothetical sky-polarimetric Viking navigation.

LITERATURE:

Gábor Horváth (editor) (2014) *Polarized Light and Polarization Vision in Animal Sciences* (2nd edition) Springer Series in Vision Research, volume 2 (series editors: Shaun P. Collin, Justin N. Marshall) Springer-Verlag: Heidelberg, Berlin, New York (printBook ISBN: 978-3-642-54717-1, eBook ISBN: 978-3-642-54718-8, doi: 10.1007/978-3-642-54718-8) p. 649

Gábor Horváth (2012) Chapter 9: Polarized Light Pollution. pp. 82-108. In: Máté Csanád, Ákos Horváth, Gábor Horváth, Gábor Veres (editors) (2012) *Environmental Physics Methods Laboratory Practices*. Electronic text-book (editor: Ákos Horváth), p. 206, ISBN 978-963-279-551-5, Typotex Kiadó, Budapest

Gábor Horváth, György Kriska, Péter Malik, Ramón Hegedüs, László Neumann, Susanne Åkesson, Bruce Robertson (2010) *Asphalt Surfaces as Ecological Traps for Water-Seeking Polarotactic Insects: How can the Polarized Light Pollution of Asphalt Surfaces be Reduced?* Series: Environmental Remediation Technologies, Regulations and Safety. Nova Science Publishers, Inc., Hauppauge, New York, USA, p. 47, ISBN 978-1-61668-863-9

Gábor Horváth, Dezső Varjú (2004) *Polarized Light in Animal Vision - Polarization Patterns in Nature*. Springer-Verlag: Heidelberg, Berlin, New York, p. 447, ISBN: 3-540-40457-0

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