Two-Photon Infrared Vision

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Abstract

Although human vision is confined to the visible spectrum, recent research has revealed that pulsed near-infrared (NIR) light can be perceived as visible through two-photon absorption (TPA) in the photoreceptors. This nonlinear optical process allows pairs of infrared photons to excite visual pigments in a manner analogous to conventional single-photon absorption of visible light. The discovery not only expands our understanding of retinal physiology but also opens new avenues for both fundamental and applied vision research. In this presentation, I will discuss our recent investigations into TPA-mediated vision, focusing on its effects on visual acuity and color perception. Our experiments show that visual resolution under TPA conditions is comparable to that achieved with normal visible-light vision, using a scanned pulsed NIR beam to project letter stimuli onto the retina. Psychophysical studies further reveal that perceived hue varies systematically with both NIR wavelength (880–1100 nm) and radiant power (10–30 µW), shifting from reddish-purple to blue, green, and yellow-green. These findings provide new insights into the intensity-dependent interplay between single-photon (1P) and two-photon (2P) absorption processes in the human eye. Beyond its fundamental implications, TPA vision offers promising clinical and technological applications. It may enable retinal diagnostics that bypass ocular opacities, and the development of TPA-based RGB displays could transform future display technologies. This presentation will summarize our key findings, methodologies, and the broader significance of two-photon infrared vision for both science and technology.

Biography

Pablo Artal is the Director of the Laboratorio de Óptica at the Universidad de Murcia where he researches the optics of eye and the retina and develops optical and electronic imaging techniques to be applied in Vision, Ophthalmology and Biomedicine. He has pioneered a number of highly innovative and significant advances in the methods for studying the optics of the eye and has contributed substantially to our understanding of the factors that limit human visual resolution. In addition, several of his results and ideas in the area of ophthalmic instrumentation over the last years have been introduced in instruments and devices currently in use in Vision and Ophthalmology.