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Applications of Two-Photon Absorption in Medicine and Biology Enabled by Specially Designed Biological Molecules

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We quantitatively study how the two-photon absorption (2PA) properties of biological molecules depend on their structure. 2PA is advantageous over regular one-photon absorption because of deeper penetration and more localized excitation in biological tissues. However, 2PA cross sections of biological chromophores are usually rather small to be useful in real life applications. Using quantum-mechanical few-level description of molecular electronic states, we interpret our data and predict new structures with considerably increased 2PA cross sections. These new materials either synthesized or genetically engineered make 2PA-based techniques applicable in medicine and biology. We show how our new porphyrin photosensitizers with drastically enhanced 2PA ($\sim$1000 times compared to regular porphyrins) can be used for in vivo two-photon-induced closing of blood vessels in Age-Related Macular Degeneration. The second example describes the application of fluorescent proteins in two-photon laser microscopy of biological cells. We demonstrate how the 2PA properties of fluorescent proteins can be considerably improved by smart mutations of the environment of chromophore inside the protein.