Pathways for super-depth optical imaging inside scattering media

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Multiple light scattering occurring in scattering media such as biological tissues hinders imaging objects embedded inside the medium and attenuates wave energy delivered to the targets. In this talk, I will introduce experimental methods to improve the working depth of high-resolution optical imaging in scattering media. In our proposed methods, we exploited both time-gated detection and spatial input-output correlation for identifying and eliminating sample-induced aberrations even in the presence of strong multiple light scattering. In doing so, we enhanced Strehl ratio by about 1,000 times, two orders of magnitude improvement over conventional adaptive optics, and demonstrated a spatial resolution of 600 nm up to the unprecedented imaging depth of 7 scattering mean free paths. We also developed methods to control time-gated multiple light scattering for efficiently delivering light energy to deeply embedded targets. For targets that are too deep to be visible by optical imaging, we demonstrated a more than 10-fold enhancement in light energy delivery in comparison with ordinary wave diffusion cases. We expect that all these studies will lead to advances in deep-tissue optical bio-imaging, bio-sensing, and light therapy.