IMAGING DEEP WITHIN SCTTERING MEDIUM BY THE SIMULTANEOUS SUPPRESSION OF SCATTERING AND ABERRATION

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Optical microscopy suffers from a loss of resolving power when target objects are embedded deep within scattering media such as biological tissues. The scattering media attenuate signal waves and generate speckle noise by means of multiple light scattering. Furthermore, they give rise to angle-dependent phase retardation of the unscattered signal waves, thereby distorting the point-spread-function. In this talk, I will present a label-free and high-resolution imaging method that can identify sample-induced aberrations in illumination and imaging paths separately without the need for guide stars and even in the presence of multiple light scattering. We use a time-gated optical coherence imaging to record the amplitude and phase maps of backscattered waves from the specimens for various illumination angles. In the image reconstruction process, we introduce separate angle-dependent phase factors for the incident and reflected waves, and identify phase corrections that preferentially accumulate signal waves over multiple- scattered ones for the forward and phase-conjugation processes. By applying these angle-dependent phase corrections to the initial data, we could not only optimize the accumulation of signal waves but also significantly reduce the effect of image distortion. Using this method, which we term ‘closed-loop accumulation of single scattering’ (CLASS) microscopy, we achieved a spatial resolution of 600 nm up to the imaging depth of seven scattering mean free paths. To demonstrate the applicability of CLASS microscopy to biological tissues, we conducted imaging of a rabbit’s cornea infected by the Aspergillus fumigatus, a type of fungi, and successfully visualized individual fungal filaments embedded within opaque fungal infection.