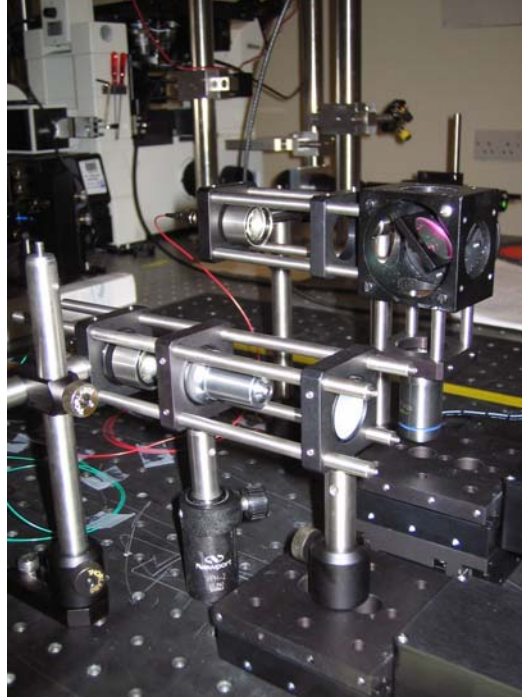


LOW COHERENCE OPTICAL INTERFEROMETRY



When the low coherence light source is coupled into a fiber optic Michelson interferometer (shown in the above image) and is divided at the 2 x 2 fiber coupler into reference and sample arms. The light retroreflected from the reference scanning reference mirror is interfered with light backscattered from the sample. The interference signal between the reference and sample beams is detected by a single photodiode followed by signal processing electronics and computer data acquisition.

Given the assumption that the photodiode captures all of the light from the reference arm and sample arm, the intensity that impinges on the photodiode is,

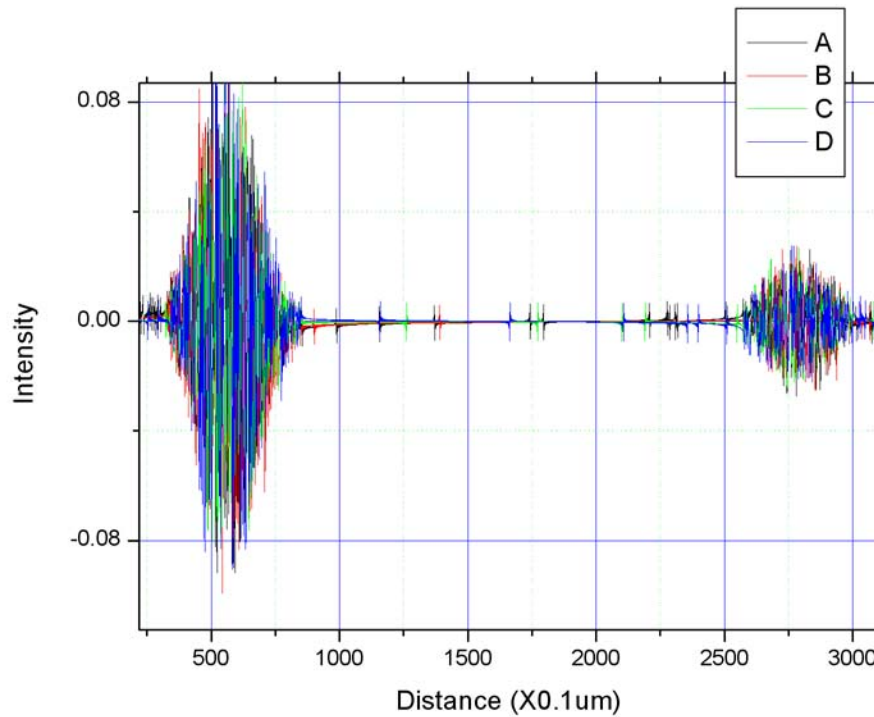
$$I_d = \langle |E_d|^2 \rangle = 0.5(I_r - I_s') + \text{Re} \left\{ \langle E_r^*(t + \tau) E_s'(t) \rangle \right\} \quad (1)$$

where I_r and I_s' are the mean (dc) intensities returning from the reference and sample arms of the interferometer. E_r and E_s' are the e-field from the reference and sample arms of the interferometer.

The second term of (1), which depends on the optical time delay τ set by the position of the reference mirror represents the amplitude of the interference fringes that carry information about the tissue structure. The nature of the interference fringes depends on the degree to which the temporal and spatial characteristics of the E_r and E_s' match. Thus the interferometer functions as a cross correlator and the amplitude of the interference signal generated after integration on the surface of the detector provides a measure of the cross-correlation amplitude. The second term of (1) can be expanded to

$$\text{Re}\left\{\left\langle E_r^*(t+\tau)E_s'(t) \right\rangle\right\} \propto \cos\left(2\pi\frac{\Delta l}{\lambda/2}\right) \quad (2)$$

where $\Delta l = l_s - l_r$ is the mismatch in distance between the reference and sample beam paths. Interference occurs when Δl matches that of the coherence length of the light source. The interference peaks from the two reflecting peaks of a coverslip are shown in the figure below



What determines the axial resolution of the OCT system is the choice of the linewidth and centre wavelength of the light source. The expression that governs the axial resolution is given by [6],

$$\Delta z = \frac{2 \ln 2}{\pi} \frac{\lambda^2}{\Delta \lambda} \quad (3)$$

where λ and $\Delta \lambda$ are the centre wavelength and spectral bandwidth of the light source. Eq. 3 shows that the axial resolution is inversely proportional to the spectral bandwidth of the light source used for imaging (assuming a Gaussian spectrum).

Several types of broadband light source have been used for OCT, namely SLD, Ti:Sapphire laser, supercontinuum light source and even quantum dot light source¹.

¹ <http://newsroom.spie.org/x2227.xml?highlight=x533>