Optical Coherence Tomography with Nonlinear Interferometers

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D Huang et al. [1] put forward the concept of Optical Coherence Tomography (OCT), a 3D non-invasive optical imaging technique that permits cross-sectional and axial high-resolution tomographic imaging of biological tissue. The very same year, X Y Zou et al. [2] introduced the concept of induced coherence. This effect should still be present even in the case of strong pumping [3,4].

Recently, G Barreto Lemos et al. [5] used the concept of induced coherence to demonstrate a 2D imaging system, where photons used to illuminate the object do not have to be detected at all, that enables the probe wavelength to be chosen in a range for which suitable detectors are not available. Here we go one step further and demonstrate in a proof-of-concept experiment [6] that a nonlinear interferometer based on the concept of induced coherence can be used to perform 3D imaging of a sample, i.e., in addition to obtaining information in the transverse plane (plane perpendicular to the beam), it can also provide optical sectioning of the sample (information in the axial direction, along the optical beam).

In doing this, we put forward a new type of OCT scheme based however on a different physical principle: the varying reflectivity of the sample along the direction of propagation of the optical beam translates into changes of the degree of first-order coherence between two beams. As practical advantage the scheme allows probing the sample with one wavelength and measuring light with another wavelength. In a bio-imaging scenario, this would result in a deeper penetration into the sample thanks to probing with longer wavelengths, while still using the optimum wavelength for detection. The scheme proposed here can achieve sub-micron axial resolution by making use of nonlinear parametric sources with broad spectral bandwidth emission.

There has been a growing interest in recent years in these so-called nonlinear interferometers [7], not only because of its importance to unveil the interplay between information and coherence in quantum theory, but also because of their applications in quantum metrology. For instance, D A Kalashnikov et al. [8] showed that a nonlinear interferometer allows performing spectral measurements in the infrared range using visible-spectral-range components. Recently, A V Paterova et al. [9] also demonstrated optical coherence tomography using induced coherence in a Michelson interferometer configuration.

References

