Harmonic optical tomography (HOT) of nonlinear structures

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Abstract: Second harmonic generation (SHG) microscopy is a powerful technique for high spatial resolution optical imaging of non-centrosymmetric molecules in cells and tissues [1]. Conventionally, this modality replies on the intrinsic optical sectioning capability afforded by the use of a tightly focused laser pulse that restricts the SHG scattering to a small region centered on the focal point of the incident light pulse, and 3D volumetric signal is obtained by scanning of the focal position. By contrast, holographic SHG microscopy is able to record the full field complex second harmonic scattering by the specimen in high speed [2]. However, to our knowledge, the holographic harmonic data has not been used to solve the inverse problem, i.e. to extract the 3D distribution of $\chi^{(2)}$. For its counterpart, the theory of linear scattering has been established for experimented tomographic reconstruction using various holographic methods.

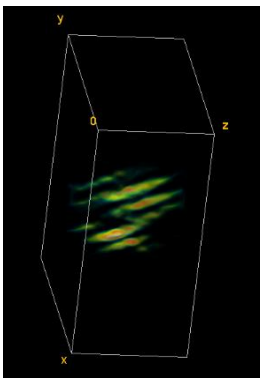

Fig.1 3D distribution of pumpkin stems

In this project, we develop a novel method, referred as harmonic optical tomography (HOT), to quantitatively reconstruct 3D $\chi^{(2)}$ distribution. We design a holographic SHG microscope and perform measurements on a range of fixed biological samples. One the other side, using the 1st order Born approximation, we come up a theoretical description of the SHG field propagation in weakly scattering media, which offers a physical foundation to solve the inverse problem. Figure 1 shows one example of a tomographic reconstruction on pumpkin stems. We expect HOT would open a new avenue to study biomaterials through nonlinear optical measurements.

References:

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