Causality Acoustic Attenuation in Thermo/Photo/Opto-Acoustic Imaging

Thermo/photo/opto-acoustic tomography (TPOAT) are non-ionizing imaging techniques combining the high contrast in electromagnetic (EM) absorption between healthy and cancerous tissue with the high-resolution of ultrasound(US). TPOAT deposits EM energy as impulsively in time and as uniformly as possible throughout the imaging object. The premise is that cancerous masses preferentially absorb EM energy, undergo more thermal expansion than neighboring healthy tissue, creating a pressure wave which is detected by transducers at the edge of the object.

TPOAT shares many similarities with xray CT and will require comparable scientific and engineering effort to come to fruition. We will tackle the TPOAT analog of xray ?beam hardening,? one of the most challenging sources of xray CT artifacts. It is widely accepted that US pulses ?soften? as they travel through tissue, attenuating according to $e^{-\alpha L|\omega|}$ where ω is frequency, L is distance traveled; $\alpha \sim 0.1??z^{-1}cm^{-1}$ and $b \sim 1$. Attenuation smoothes US pulses and limits depth penetration of standard US imaging. Attenuation anisotropically blurs TPOAT reconstuctions because high-frequencies in the measured data are heavily attenuated. Analysis of this attenuation model led to a more startling conclusion: US pulses are instantaneously smoothed by attenuation, resulting in very small pressure signals far from the source and challenging the finite soundspeed paradigm.

We will present results, both theoretical and measured, for the far simpler case of acoustic attenuation in homogeneous fluids, for which the frequency power law attenuation model is nearly Gaussian.