Western Science

DEPARTMENT OF PHYSICS AND ASTRONOMY

Physics Undergraduate Conference (PhUnC)
KEYNOTE TALK

Thursday, 12th March 2020 @ 1:30 p.m.
PAB Room 100

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A modern ceraunoscope: Probing different biological length scales using photoacoustic imaging

ABSTRACT

Photoacoustic imaging relies on the generation of ultrasound waves from optically absorbing structures. The interest in photoacoustic imaging has been steadily growing as optical absorption contrast can be probed deeper compared to conventional optical methods, resulting in possibly one of the most exciting new biomedical imaging techniques of the decade. Most imaging reconstruction algorithms use only on the intensity of the detected photoacoustic waves. However, the ultrasound waves produced by the absorption of light in tissue can be analyzed by methods similar to those developed to analyze ultrasound backscatter signals in the field known as ultrasound tissue characterization or quantitative ultrasound. In photoacoustic imaging, the interpretation of the signals detected by ultrasound transducers is guided by the physics of photoacoustic wave generation. In the absence of exogenous optical absorbers, hemoglobin in red blood cells is the primary endogenous chromophore in tissues (as melanin is predominantly confined to the skin). The spatial distribution of red blood cells, typically confined to the vasculature, determines the frequency content of the ultrasound signals produced. Analysis of the photoacoustic signals can reveal information related to the tissue vasculature. We have applied these principles to cancer treatment monitoring and other blood pathologies. Tumor blood vessels have a distinct organizational structure compared to healthy blood vessels: typical vessel networks are hierarchically organized, with vessels that are evenly distributed to ensure adequate oxygen and nutrient delivery. Tumor vessels are structurally different: they are torturous and typically hyperpermeable. Therapies that target the vasculature can induce changes in the vascular networks that, in principle, should be detected using photoacoustic imaging. In this presentation, we will review the techniques we have developed which depend on the analysis of the frequency content of the ultrasound photoacoustic waves. We will show how we can use this information to filter vessels according to size with high specificity (resulting in a technique we have termed F-mode) and for non-resolvable vessels, how the frequency content of the photoacoustic signals encodes information about the size, concentration and spatial distribution of blood vessels. We also show how these techniques can be used to assess treatment response.