SPECIAL SEMINAR

‘Hearing’ the Shape of a Drum: The Inverse Imaging Problem in Magnetic Resonance Diffusion Experiments

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ABSTRACT

The problem first posed by Kac in 1966 on ‘hearing’ the shape of a drum is equally applicable to imaging biological structures since vibrating membranes also obey the diffusion equation. Diffusion encoding thus requires an adequate sampling of the eigenspectrum of the restrictive media followed by an inverse transform to derive the underlying geometry. The sensitivity of MR to measuring diffusion has long been exploited as a method of investigating molecular motions in complex systems by measurement of the diffusion coefficient. The recognition that MR can be made sensitive to the details of anisotropic diffusion in structured materials led to the formulation of the problem as a tensor rather than a scalar. However, the existence of multiple-fiber orientations within an imaging voxel renders the diffusion tensor model inadequate. The practical limitations imposed by the requirement for delta function type diffusion sensitizing gradients to adequately sample q-space, can be relaxed if these impulse gradients are replaced with chirped oscillatory gradients. In this talk, chirped diffusion sensitizing gradients are shown to yield an efficient sampling of q space in a manner that asymptotically approaches that using delta function diffusion sensitizing gradient. The challenge is the consequent reduction in diffusion sensitivity as one probes higher frequency dynamics. This problem is addressed by the use of both UHF-MR systems (>4T) as well as restricting the gradient power to a spectral bandwidth corresponding to the diffusion spectral range of the underlying restrictive geometry. Simultaneous imaging of diffusion and flow at microscopic resolution and at temporally resolvable diffusion time scales thus becomes possible in-vivo.

BIO

Dr. Andrew Kiruluta graduated with PhD from Institute of Biomaterials and Biomedical Engineering at the University of Toronto in 1997 and subsequently pursued a post-doctorate in quasi-optical phased array processing at JILA Physics & NIST in Boulder Colorado. He holds a joint associate professorship in the Department of Biophysics, Harvard University and the Department of Radiology, Harvard Medical School where he is also the Director of clinical MR physics in the department of Radiology, Massachusetts General Hospital (MGH) since 2002. His research interests are in the areas of clinical applications of ultra-high field MR (UHF-MR at 7T and above), far field NMR phenomena, quasi-optical analogies and high resolution spectral domain diffusion encoding for neurological circuitry mapping. He is the author of over 50 publications in optics and NMR, 4 book chapters and has given over 30 national and international invited talks in the field of UHF-MR.