Engineering and Physical Sciences Research Council Doctoral Landscape Award

PROJECT TITLE: Sub-diffraction sensing of biomolecular organisation using structured light

Lead Supervisor: Dr. Ben Sherlock, B.Sherlock@exeter.ac.uk

Co-Supervisors: Prof. Dave Phillips, D.Phillips@exeter.ac.uk

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Project details: The connective tissues of our bodies play a crucial role in keeping us healthy and active. These tissues posses a wide range of mechanical properties, from the clear, flexible cornea in the eye to the tough, rope-like tendons that connect muscles to bones. Emerging research suggests that these properties are largely determined by how the molecules in the tissues are stacked together. For example, both corneas and tendons are made from the same molecule, type I collagen, but the way the collagen molecules are organised leads to these disparate properties. Deciphering the principles that govern how these molecules are organised, and how this organisation gives rise to the tissue's biomechanics will enable critical breakthroughs in burgeoning fields such as biomedical engineering and regenerative medicine. Detailed molecular structure could also provide crucial insights into why our tissues fail when they're affected by diseases, helping to develop better ways to diagnose and treat these conditions.

The gold standard for imaging collagen organisation is technique called Second Harmonic Generation (SHG) microscopy. This imaging method uses light to examine the collagen structures in biological tissues. SHG microscopy is fast, non-invasive, and doesn't require any dyes or labels, making it safe to use on living tissues. Whilst SHG microscopy is widely used to study the structure of collagenous materials, the resolution of the images is limited by the diffraction of light, which precludes this technique from being able to sense molecular scale structure in the sample. Dr. Sherlock is recognised as a leading figure in a more advanced version of SHG microscopy, known as polarisation-sensitive SHG microscopy. This approach uses serial illumination of the sample by light with carefully controlled polarisation states that enable it to sense the organisation of collagen at molecular length scales.

The goal of this project is to develop the world's most advanced polarisation-sensitive SHG microscope by combining it with the burgeoning field of structured light. In structured light, devices such a spatial light modulators and deformable mirrors are used to provide exquisite control over the spatial and polarisation properties of a laser beam. Prof Phillips is a global leader in the field of structured light with experience of developing optical systems that allow for creation of arbitrary polarisation states in a laser. Dr Sherlock and Prof Phillips have already collaborated to conduct an initial feasibility study showing how a spatial light modulator can be used for arbitrary polarisation control (paper in preparation). Building on these foundations, the proposed project will deliver new instrumentation that unites polarisation-sensitive SHG with structured light, creating an unprecedented platform for imaging collagen at the molecular scale.

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Ultimately, this innovation will open new windows into the organisation of connective tissues in health and disease, with the potential to transform both fundamental science and clinical applications.

Project specific entry requirements: Masters in Physics, Biomedical Engineering or Applied Mathematics

Potential PhD programme of study: PhD in Physics

Department: Physics and Astronomy

Location: Physics building, Streatham campus

Please direct project specific enquiries to: b.sherlock@exeter.ac.uk

Please ensure you read the entry requirements for the potential programme you are applying for.

To Apply for this project please click on the following link - **APPLY HERE**