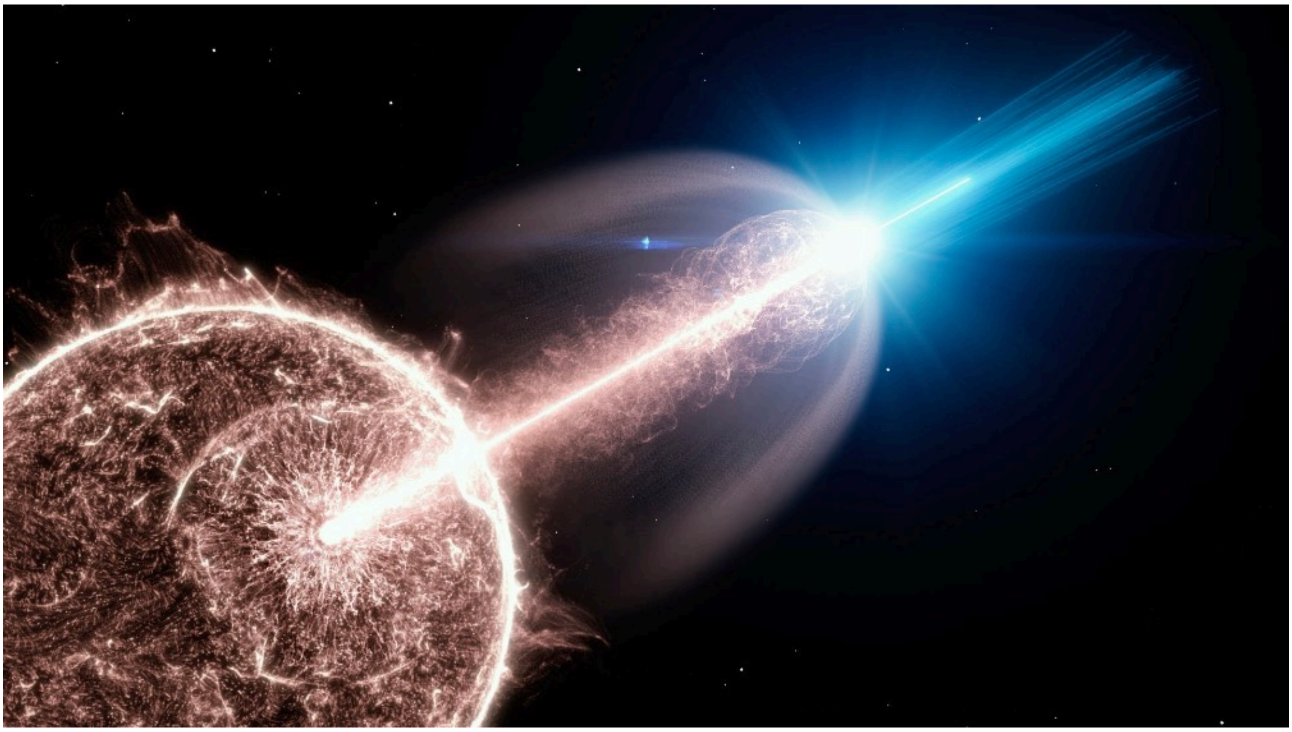
UCD Physics
Summer Research Studentships
2025

Project 1: The connection between Gamma-Ray Bursts and Supernovae

Assist. Prof. Antonio Martin-Carrillo

The aim of this project is to study through observations and simulations the connection of gamma-ray burst (GRB) and supernova (SN) emission at the UV energy range. The goal is to understand if some UV SN light curves could have an underlying component, currently ignored, that could be associated with the signature of off-axis GRBs. The study of off-axis GRBs can be potentially very beneficial since we are outside the main jet emission and we can learn about their jet structure. GRBs are among the most luminous explosions in the Universe, with central engines which drive the outbursts in highly relativistic jets. Because the emission is jetted, an observer can be outside the jet and miss the initial gamma-ray bright flash. However, their afterglow emission could still be visible outside the jet once the shock decelerates enough and becomes mildly relativistic. How bright the afterglow would be depends on several physical parameters of the jet, the viewing angle and the structure of the jet. The association of GRBs with a particular type of SN, makes it possible to search for this off-axis GRB emission. The student will acquire valuable knowledge on the areas such as scientific computation using Python, numerical simulations and multi-wavelength observational and theoretical astrophysics.



Project 2. Using ESO-VLT to peer into the accretion history of young stellar objects

Assist. Prof. Rebeca Garcia Lopez

Stars form by accreting material from their surrounding protoplanetary disks. Astronomers believe that accretion takes place as matter flowing through the disk is channeled onto the stellar surface by the stellar magnetic field shocking the stellar surface at free-fall velocity. This process is called magnetospheric accretion and it represents the theoretical framework of disk accretion, that is, how stellar embryos gather mass from its surrounding disk (i.e. accrete) to become a fully grown up star.

In this project, you will study how young stars gather mass using state-of-the-art data . You will learn how to reduce and analysed spectroscopic data, as well as how to use gas tracers present in the spectra to peer into the accretion and ejection history of these objects to find clues about how angular momentum is transported within the disk.

Project 3: Innovate & Illustrate: Co-Creating STEAM Futures

Dr. Sharon Shannon
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This internship is centred on a multimedia STEAM collaborative project that uses co-creation and co-design to engage students and educators in creative and meaningful ways. It focuses on developing educational content tailored to Ireland's primary and secondary school STEAM curricula. The project has an emphasis on promoting accessible and engaging approaches to STEAM education. Students will assist in the creation of supporting materials that encourage creativity, inclusivity, and collaboration in classrooms. These resources aim to reach students with diverse learning styles while empowering teachers to adopt contemporary and non-traditional educational practices. The internship also offers an opportunity to explore insights from global STEAM curricula, interconntivity and data analysis. This role involves collaboration with a creative and educational team offering a platform to contribute to impactful educational tools that inspire and engage young learners both locally and globally. Our work collaborates with STEAM colleagues, colleges and universities in Europe, UK, North and South America with a goal to create further academic and social connections. Outputs will build on earlier work *Harmonic* funded by Science Foundation Ireland, Department of Education and current research project *Chorus* by Research Ireland amongst other collaborative research activities.

Project 4: Beyond Size Limitations: Controlling Atmospheric Factors for Enhanced Ferroelectricity in Hafnia-Based Materials

Prof. Brian Rodriguez
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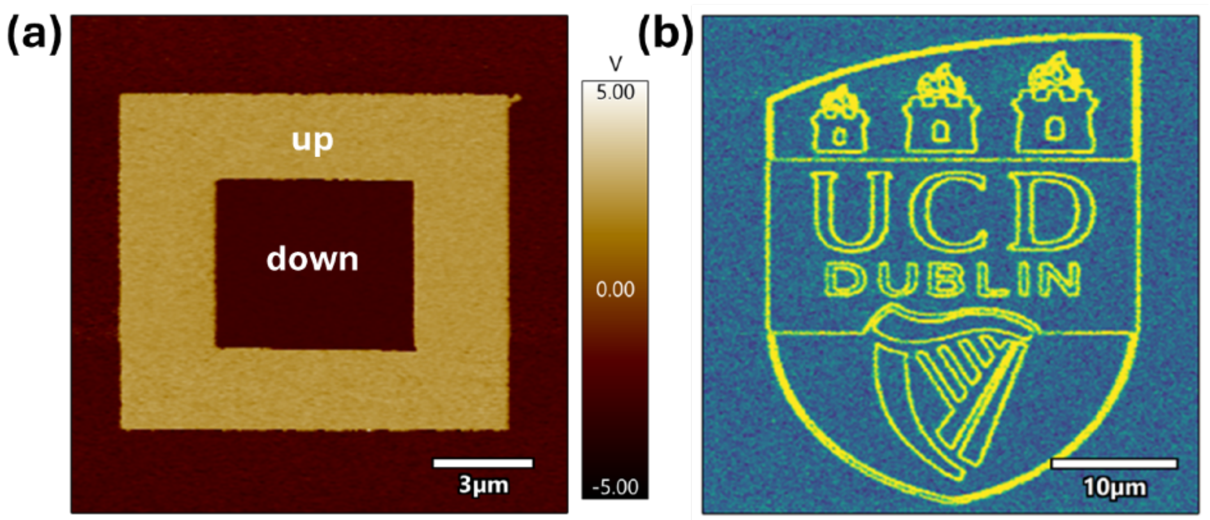
Ferroelectric materials have long been explored for non-volatile memory, but miniaturization faces challenges due to CMOS (complementary metal–oxide–semiconductor) compatibility and scaling effects. The discovery of ferroelectricity in hafnia (HfO_2) in 2011 has drawn significant interest, offering advantages like CMOS compatibility and unconventional ferroelectric behaviour. However, fundamental understanding remains challenging, leading to discrepancies in the literature. Our work focuses on improving ferroelectric response at the nanoscale using piezoelectric force microscopy (PFM). We have uncovered a transition from non-ferroelectric to ferroelectric behaviour accessible only under controlled environments (for example, (a) PFM phase image of up and down switched domains and (b) electrically written domain pattern on hafnia film in controlled environment). With the support of a summer intern, we aim to further explore the interplay of surface electrochemistry, oxygen vacancy dynamics, and environmental factors. You will gain hands-on experience with state-of-the-art atomic force microscopy techniques (and be able to make nanolithography portraits) and contribute to advancements in high-performance ferroelectric memory applications and fundamental condensed matter physics. The project can be tailored for experimental and computational interests and might support more than one intern.



Project 5: Using Electronically Controlled Active Optical Arrays to Correct for Wavefront Aberrations

Dr. Silas O'Toole

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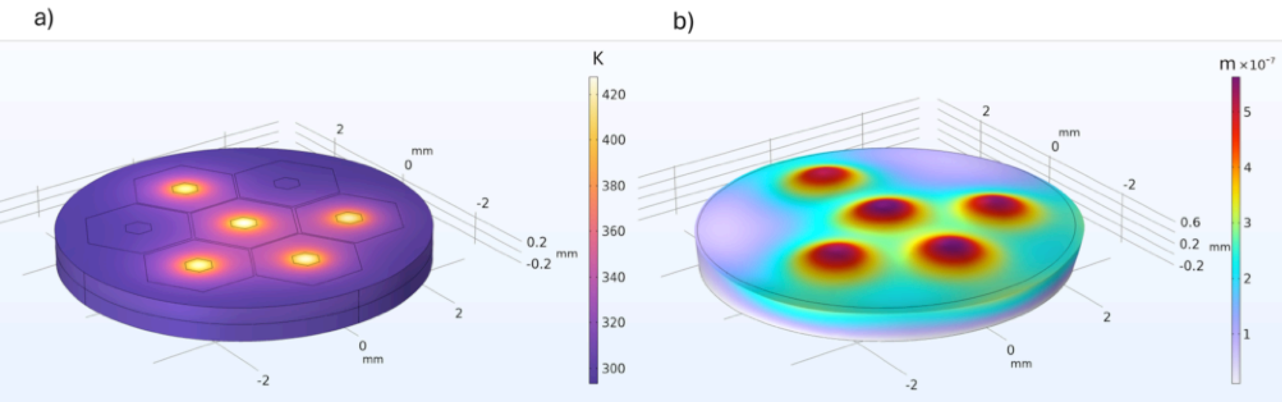
This project examines a new solid state lens and mirror array for its ability to actively correct for wavefront aberrations. The student will use a wavefront sensor and compare expected outcomes to distorted waves and then actively compensate using a self designed electronic control unit to correct for artificially induced aberrations. Active parts of the research will include interfacing with electronics using coding of your choice and interface with a wavefront sensor and device communication. The optical element has been developed within the research group, it uses a transparent conductive oxide to deliver a unique localised heating pattern to activate thermal expansion and create a lensing effect. It is currently part of several active funding projects and is of interest for industry applications making this a highly exciting project.



Project 6. Green photonic materials

Assoc. Prof. James Rice

Exploring the potential of sustainable organic materials for use in photonic device design. The project will centre on the development and study of the optical properties of green materials. The project involves materials processing and the experimental analysis of optical processes in the selected materials.

Project 7. Tuning the morphology and elasticity of amyloids and biomembranes by ionic liquids - An atomic force microscopy experimental study

Assist. Prof. Antonio Benedetto
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The morphology and elasticity of amyloids and cellular membranes are key in many processes relevant to life and diseases. For example, it is well-known that cancer cells are softer than their healthy counterparts, and abnormal amyloids are involved in neurodegenerative diseases. As a result, controlling the morphology and elasticity of amyloids and cell membranes can lead to breakthrough applications in medicine and pharmacology. In our NanoBioPhysics Lab, we are studying how the family of complex organic salts known as "ionic liquids" can control the morphology and mechanics of amyloids and biomembranes - our main technique is atomic force spectroscopy. During the internship, the intern will be trained in basic and advanced atomic force spectroscopy modes for both imaging and mechanical characterisation of amyloid fibrils and (model) cell membranes. The effects of two ionic liquids on amyloid morphology and membrane mechanics will be investigated. If time allows, fluidFM technology will also be used. For more info on our Lab visit www.antoniobenedetto.eu