High definition sub-diffraction limited imaging using non-linear structured illumination

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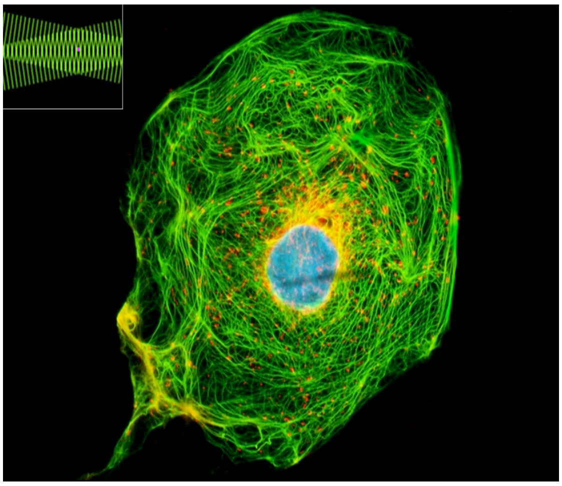

Fluorescence microscopy is one of the most important key technologies for imaging of molecules, sub-cellular structures, and bio-medical processes in cells. However, it is limited by the Abbe diffraction limit of optics, namely a lateral resolution of $\lambda/(2NA)$, where NA is the numerical aperture of the objective lens and λ is the wavelength of the emission light, limiting the attainable spatial resolution to ~200 nm for visible light.

Although this limit is a universal principle that cannot be broken directly, Structured Illumination Microscopy (SIM) is able to code high resolution information into the low resolution supported region of the microscope and thus circumvent the limit. The required additional information is generated in SIM by illuminating the object with a periodic pattern. The here described project is exploiting non-linear optical effects and surface bound evanescent waves to generate highly spatially confined illumination patterns in a precision interferometric device which will routinely yield super resolutions < 50 nm.

Design of optical system

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Experimental design of light scattering instrumentation and then application to plasmonic surfaces. The project aims to develop an optimum design based on combining a light source with optics and detection system. This will provide experience of optical design and instrumentation.

Multi-wavelength study of Gamma-ray Bursts afterglows

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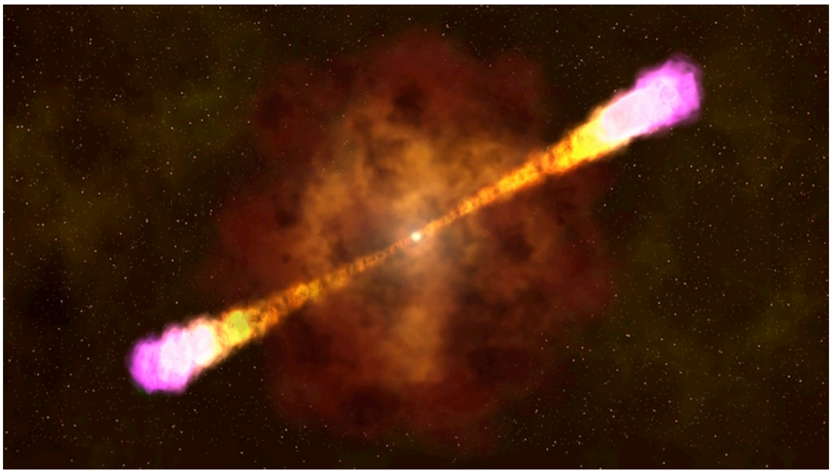

Gamma-ray bursts (GRBs) are the most luminous explosions in the Universe, with central engines which drive the outbursts in highly relativistic jets. Most of their energy is produced at high energy gamma-rays and last only a few seconds. However, about 10% is released as longer wavelength 'afterglow' emission which is detectable at X-ray, optical and radio wavelengths for days, weeks and even months after the main burst.

The aim of this project is to study the multi-wavelength afterglow from long GRBs (durations > 2 sec) which signals the death of massive stars. The student(s) will be using data from ground-based telescopes, such as UCD robotic telescope, Watcher, as well as space observatories such as Swift and XMM-Newton. The student(s) will acquire valuable knowledge on the physics of GRBs as well as skills on optical photometry and high-energy observational techniques such as spectroscopy.

Markov state models for protein folding and protein-protein interactions: applications to self-aggregating amyloid peptides

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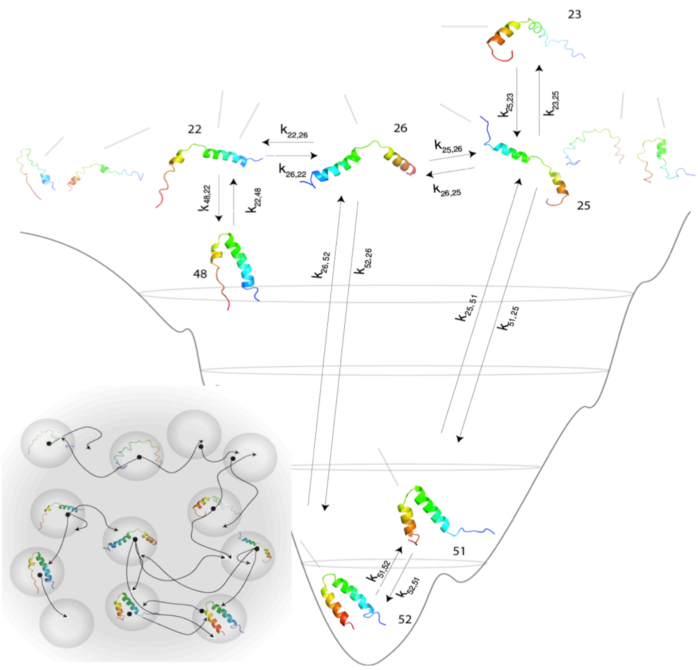

Computational molecular biophysics studies using modern high-performance computational physics (HPC) studies, including studies of protein-protein biophysics interactions have to overcome challenges due to the separation between the relevant physical time-scales (e.g., for protein folding or binding) and the accessible time-scales of simulation. We developed recently new algorithms based on Coarse Master Equations (CME), where the underlying configuration space is discretized into a network of Markovian states, such that the mean lifetime of each state is much larger than the transition time between the states.

This project (suitable to 1 or 2 students working separately, or as a team) will involve learning about modern Markov-based statistical methods, running simple Matlab codes for analysis, and/or designing and running simple molecular dynamics (MD) simulations using the CME-based formalism, using Linux workstations and supercomputing clusters, with the aim to improve the speedup of typical MD runs. Applications will study simple MD trajectories of diabetes or Alzheimer's diseases Abeta peptides for understanding their conformational dynamics and their propensities to form amyloid nanofibrils.

Science Communication

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Suite Science is in partnership with the Solas Project, An Cosán and 15 UCD linked DEIS (Delivering Equality of Opportunity in Schools) schools. The governmental DEIS action plan focuses on addressing and prioritising the educational needs of children and young people from disadvantaged communities. This project will involve a literature review of current science communication models, analysing data obtained from class surveys, experiment design and development, creation of lesson plans and worksheets and assisting with the delivery of outreach lab sessions.

Ion stage distributions in laser produced plasmas

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This project will introduce the student to atomic physics, specifically laser produced plasmas. Laser produced plasmas contain a range of ion charge states and the spectrum emitted from such a plasma can be modelled using simulated spectra for the ions in the plasma. The ion distributions in a laser produced plasma can be estimated from empirical models. The main aim of the project will be to develop a computer routine to use data-fitting to determine the optimum balance of charge states needed to mimic experimentally recorded spectra and compare this with the empirical predictions. The project will be hosted in the Atomic, Molecular and Plasma Physics (Spectroscopy) Group and give the student the chance to record some laser produced plasma spectra using the short pulse lasers in the Group.

http://www.ucd.ie/speclab/research/

Teaching Laboratory Development

Associate Prof. Emma Sokell / Prof. Padraig Dunne / Dr. Tom McCormack

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This project will involve upgrading and developing experiments for the 2nd, 3rd and 4th year laboratories. The work can be tuned to suit particular areas of interest but will require both experimental testing and documentation development. This year there will be a particular focus on experiments for the thermal physics module (PHYC20030) and the development/exploration of a new advanced laboratory experiment on water bridges.

Quantum Dynamics and Path Sampling

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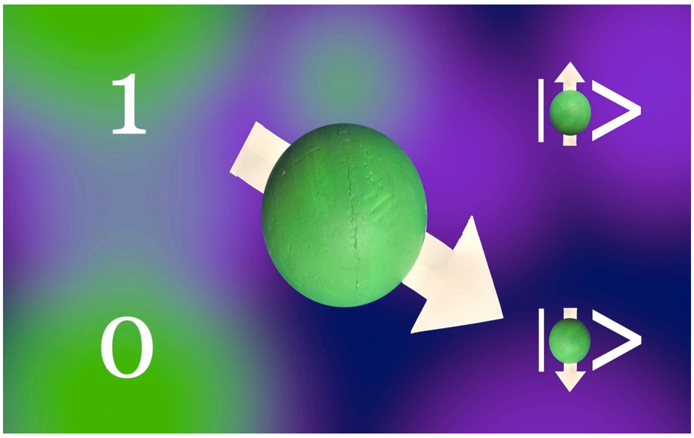

Quantum dynamics involves the motions, and energy and momentum exchanges of systems whose dynamical behavior is governed by the laws of quantum mechanics, and finds application in fields such as quantum computing. Surface hopping is a well-used algorithm in quantum dynamics in which classical paths are used to sample the quantum wavepacket by switching (or hopping) between electronic states. The interaction of the quantum subsystem with its environent can be dramatic. A key aspect of the algorithm and project is the efficient use of Super Computers to model these effects with a classical like description of the environment.

The project is suitable for students with a liking of mathematics and coding, and will involve European Partners, and ICHEC.

Development of undergrad experimental classes

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Experimental lab classes in the first year of undergrad study can benefit from the application of circular review. The student will be part of a team that will aim to advance the presentation of delivery of experimental classes aimed at first years. The placement student will lead this aiming at developing video based teaching and for clear review of learning outcomes for experiments.

This placement will provide experience of teaching development and review at an undergrad level. The use of modern teaching methods and circular development and review.

Design of molecular sensors

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The focus of the project is the design and optimization of fusion protein based molecular biosensors using advanced simulation methods and machine learning. Fusion protein based molecular biosensors proteins comprise sensing units which detect the presence of a target bio-marker, and units which perform an action if the target is detected, such as to fluorescene. Those interested in the project should have an interest in statistical physics, and High Performance Computing as the work will involve European Partners at CECAM (www.cecam.org) and the Irish Centre for High End Computing (www.ichec.ie).

Exploring the Low Frequency Radio Sky with LOFAR

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In summer 2017 a LOFAR radio telescope was installed in Birr, Co. Offaly. This station can operate independently, or as part of the international LOFAR telescope, where the data is combined with other stations throughout Europe. This project is for a student to become familiar with the analysis of LOFAR data and to explore the science capabilities of both the single-station and international LOFAR.

High-Energy studies of Blazars

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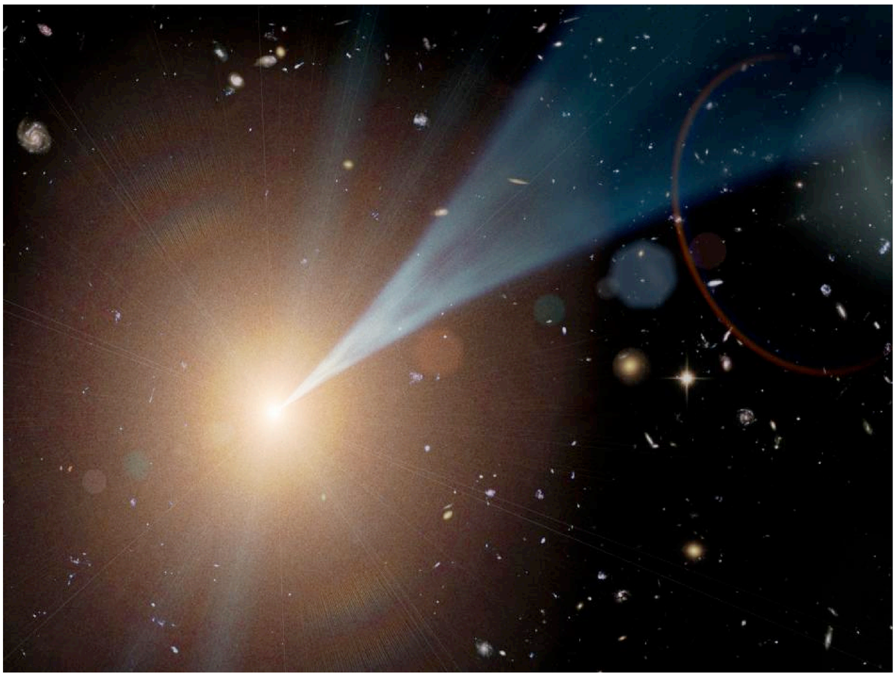

(image credit: NASA/JPL-Caltech)

Blazars are active galactic nuclei which produce powerful jets that happen by chance to be pointed towards the Earth. They emit radiation across the entire electromagnetic spectrum and dominate the extragalactic gamma-ray sky. This project will be to study the high-energy emission from Blazars using data from the VERITAS gamma-ray observatory in Arizona as well as data from satellites such as Fermi-LAT (gamma-ray) and Swift XRT (X-ray) to learn about the physical processes at work in the blazar jets. There is also the possibility to analyse simulations from the upcoming CTA (Cherenkov Telescope Array) gamma-ray observatory to explore its sensitivity for future blazar studies.