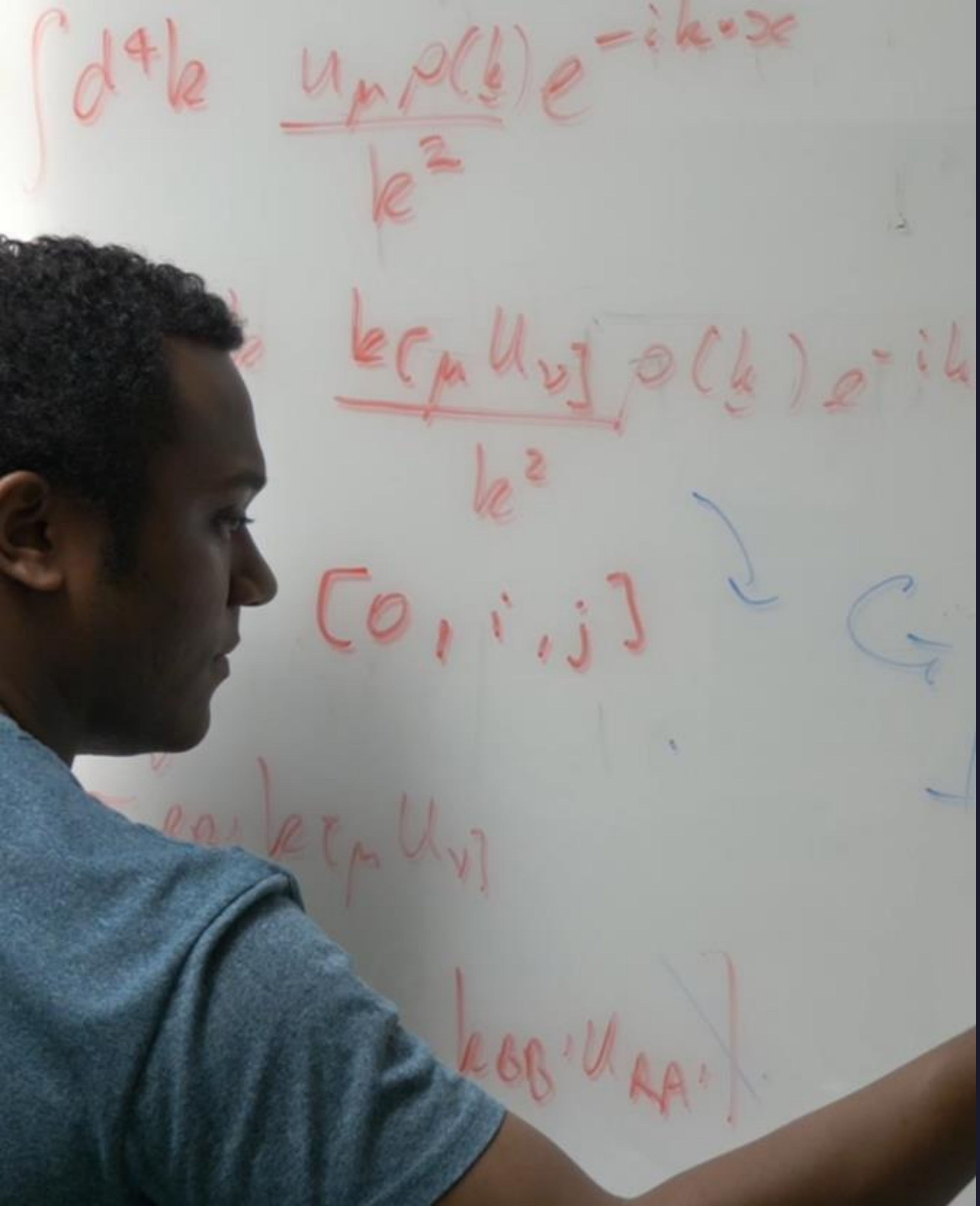
Euromasters

Queen Mary University of London

Dr David Vegh



MSc Euromasters

- Eight elective taught modules are offered, divided into four modules for the 1st semester and four for the 2nd semester.

- Research project: This component takes place during the second year of the programme. It entails conducting an in-depth and independent investigation into a topic directly aligned with your interests and career objectives.

  If you choose to leave the MSc at the end of your first year without completing a research project, you may be awarded a Physics (Euromasters) PGDip.

Timeline

4 modules

1st semester | 2nd semester

4 modules

Full year research project

Research supervised by QMUL academic

Research Excellence

In the Euromasters MSc programme, students have the opportunity to work with leaders in diverse fields, spanning from theoretical to experimental subjects, such as quantum computation, machine learning, and more formal aspects such as the AdS/CFT correspondence. In many instances, students will have the chance to publish and work at the forefront of research. Additionally, all students are assigned an academic advisor.

We are very proud that the attributes our graduates gain during their degree mean that they go on to a wide range of excellent careers, including in the areas of R&D in industry, software engineering, artificial intelligence and machine learning, finance, management and academic careers.

The modules

(a selection from a larger list)

Relativistic Waves & Quantum Fields

The module introduces quantum field theory, which explains the laws of Nature at the microscopic level.

The module starts by reviewing spacetime and its symmetries and the axioms of Einstein's special relativity. Lorentz transformations, generators of the Lorentz group and the Poincaré group are discussed in detail.

Klein-Gordon theory and its quantisation is discussed, along with symmetries and conservation laws via the example of the complex scalar field.

Further topics: Green's functions, propagators, T-products. Dirac equation and the quantisation of the Dirac field. Non-relativistic limit of the Dirac equation.

S-matrix, the Dyson expansion, and simple examples of Feynman diagrams.

$$iS_F(k) = i\frac{\not{k} + m}{k^2 - m^2 + i\varepsilon}$$

Advanced Quantum Field Theory

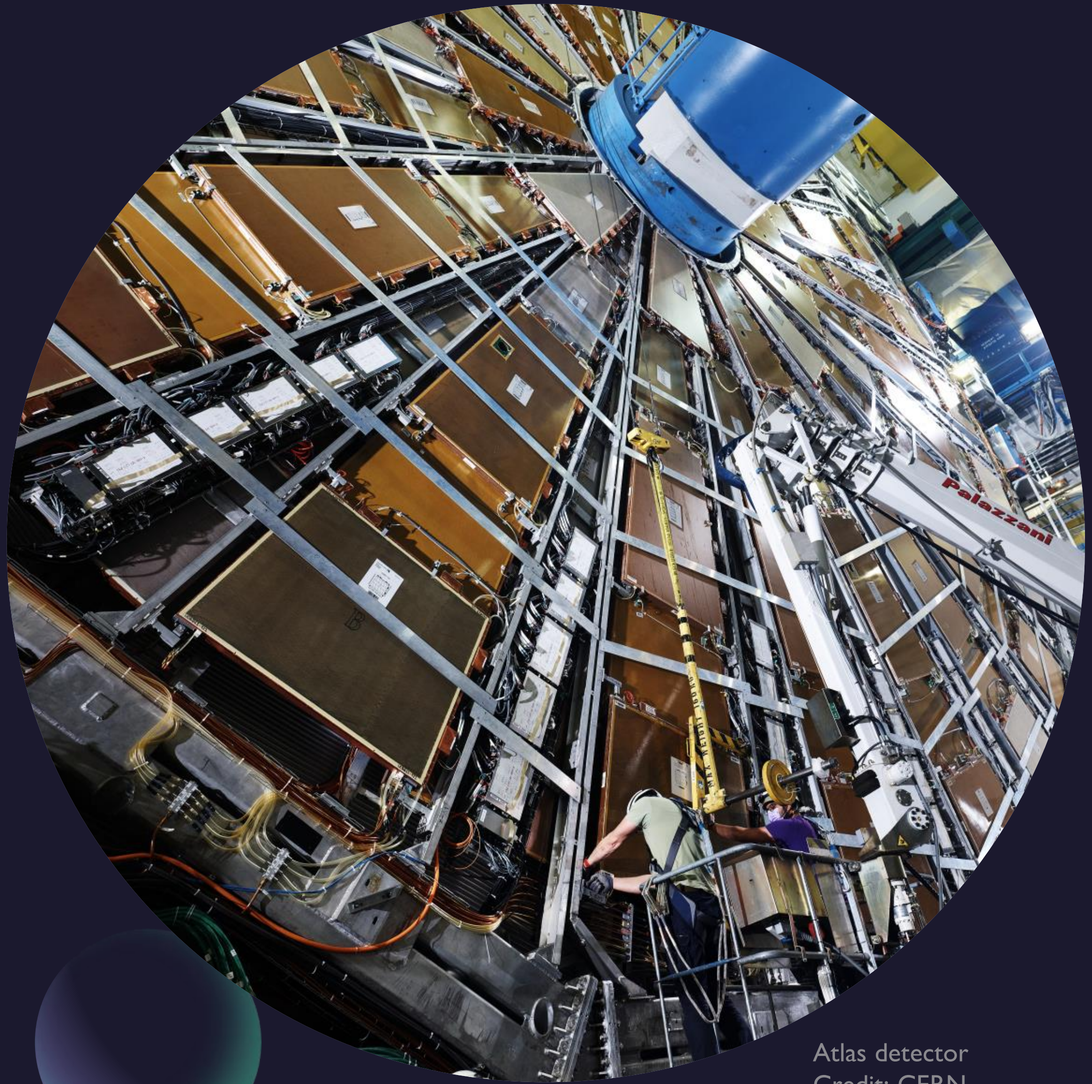
Building on the fundamental concepts of Quantum Field Theory introduced in Relativistic Waves and Quantum Fields, this course will cover the following topics:

Classical field theory and Noether's theorem, quantisation of free spin 0, 1/2 and 1 fields.

Perturbation Theory and Feynman diagrams:
Dyson formula and the S-matrix, in and out states, evaluation of S-matrix elements using Wick's theorem and LSZ reduction formula, formulation in terms of Feynman diagrams (part revision)

Quantum electrodynamics, Feynman diagrams for QED, simple scattering processes at tree level, cross sections, spin sums

Renormalisation of QED at one-loop level, regularisation (dimensional and Pauli-Villars), running coupling, corrections to electron anomalous moment.



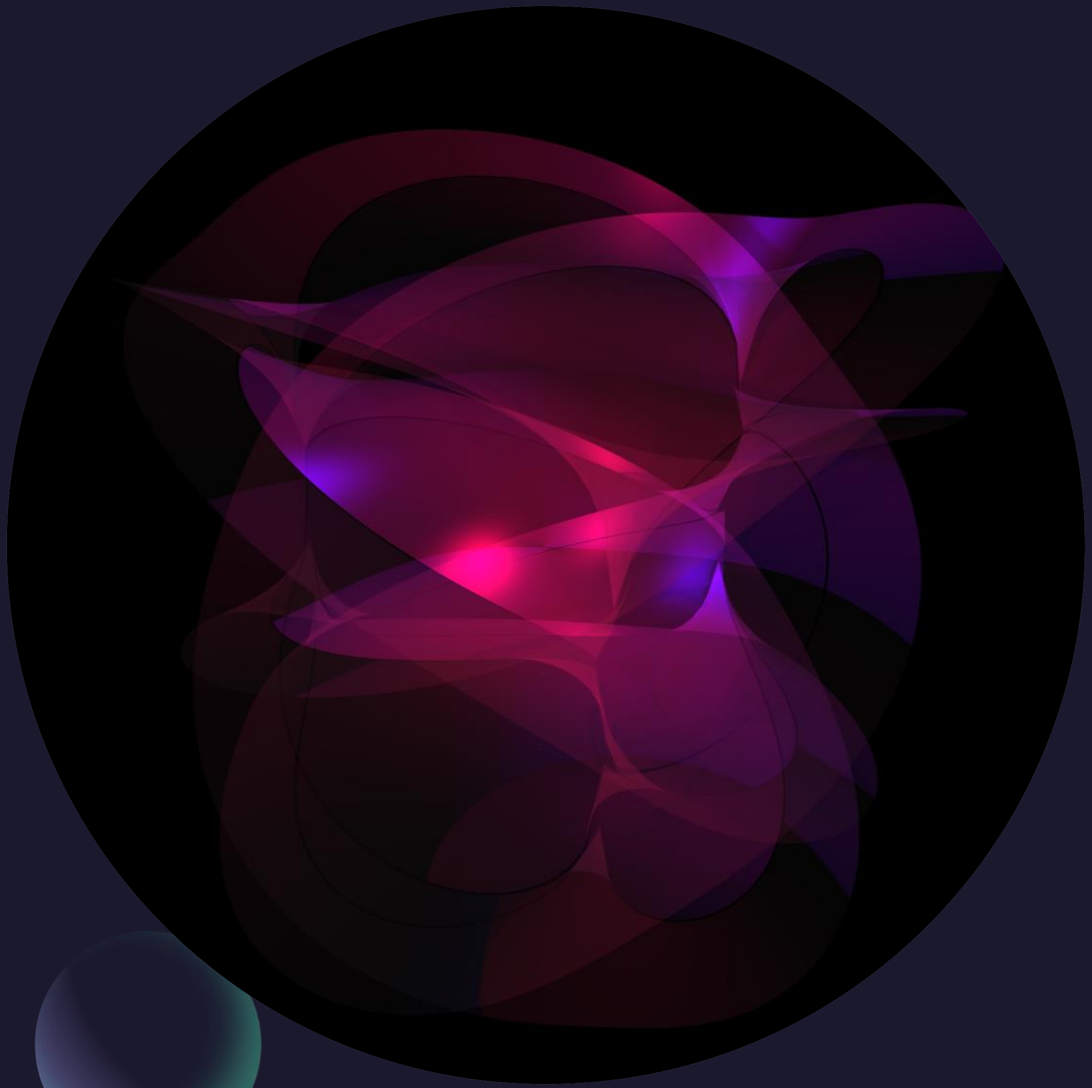
Atlas detector
Credit: CERN

Introduction to Strings & Branes

The module introduces the classical and quantum dynamics of point particles and strings in spacetime. It discusses bosonic string theory, the GSO projection, Type I and II superstrings. Higher dimensional objects e.g. D-branes are also described.

Important mathematics is introduced along the way, in addition to other tools, e.g. conformal field theories, which live on the worldsheet of the string and describe its embedding into spacetime.

Further topics include: bc ghosts, operator expansions and primary operators. String scattering amplitudes. T-duality.

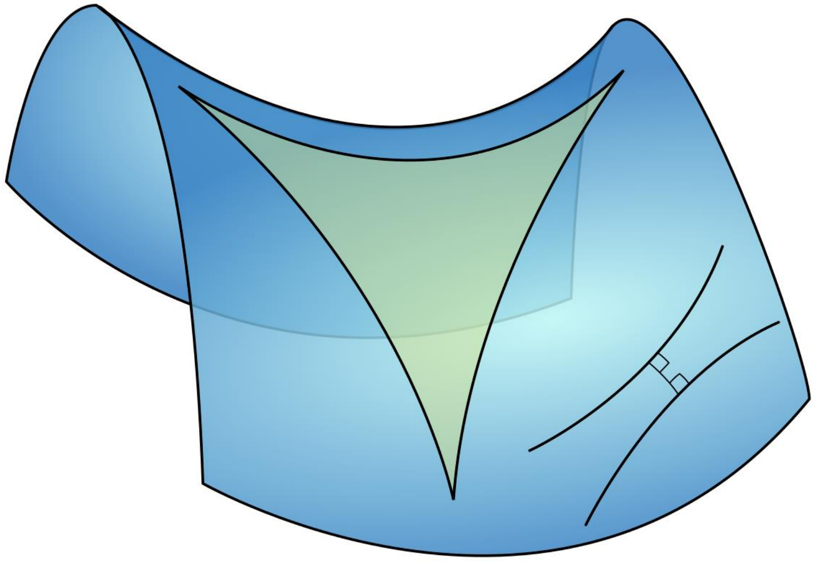


Differential Geometry

The aim of this course is to provide the student with a number of advanced mathematical tools from differential geometry, essential for research in modern Theoretical Physics, and apply them to certain physical contexts.

The notation of differential forms will be introduced and the geometric aspects of gauge theory will be explored. Gravity will be interpreted as a gauge theory in this geometric setting. Manifolds will be introduced and studied, leading to the definition of fibre bundles.

Finally, we will explore the Dirac and 't Hooft-Polyakov monopoles and the Yang-Mills instanton, as well as their associated understanding in fibre bundle language.



Relativity & Gravitation

Einstein's theory of relativity is one of the pillars of modern physics. This module begins with an introduction to differential geometry, before moving on to Einstein's gravitational field equations and their solutions. It will include the study of black hole and an introduction to the formalism used for studying perturbative relativistic gravity for calculating the gravitational wave signals from inspiralling binaries (LIGO).

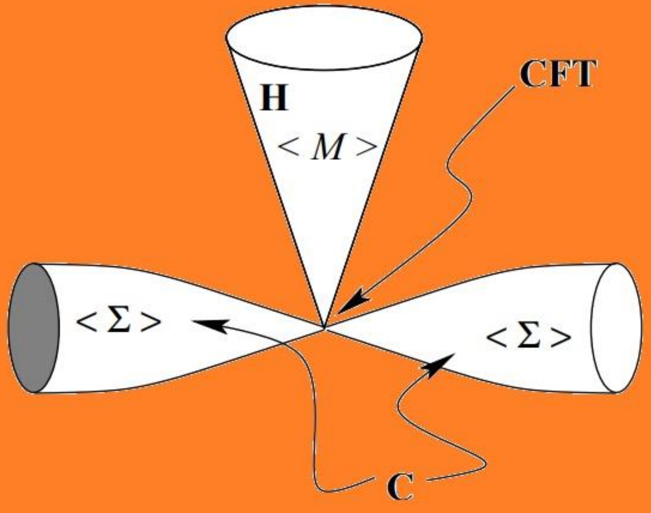
Supermassive black hole in galaxy M87
Credit: Event Horizon Telescope Collaboration 2019

Supersymmetric Methods

Starting with supersymmetric quantum mechanics as a toy model, the course covers the supersymmetry algebra, its representations, the Witten Index, and the resulting constraints on quantum dynamics.

We then move on to introduce supersymmetric field theories in three space-time dimensions consisting of scalars and fermions while giving a basic introduction to symmetry currents, the classical and quantum Wilsonian renormalisation group flow, moduli spaces, spurions, and non-renormalisation arguments.

The course is designed to culminate with a study of dualities in three-dimensional supersymmetric abelian gauge theories.



Contact me ☺

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