IQF 2018 SCHEDULE

	28/5 **MONDAY**	29/5 **TUESDAY**
09:00	Registration and Coffee	Coffee
09:30	**Invited Talk 1:** E. Winstanley (Sheffield)	**Invited Talk 4:** A. Castro (Amsterdam)
10:30	Contributed Talk 1: T. Morley (Sheffield)	Contributed Talk 8: M. Leitner (DIAS)
10:50	Contributed Talk 2: M. Casals (CBPF/UCD)	Contributed Talk 9: J. Brennan (Maynooth)
11:10	Coffee Break	Coffee Break
11:30	**Invited Talk 2:** E. Fort (ESPCI)	**Invited Talk 5:** L. Mason (Oxford)
12:30	Contributed Talk 3: S. Kovacik (DIAS)	Contributed Talk 10: E. Ó Colgáin (APCTP)
12:50	Contributed Talk 4: A. Rubeo (TCD)	Contributed Talk 11: B. Dolan (Maynooth)
13:10	Lunch	Lunch
14:30	**Invited Talk 3:** P. Coles (Maynooth/Cardiff)	**Invited Talk 6:** R. Monteiro (Queen Mary London)
15:30	Coffee Break	Coffee Break
16:00	Contributed Talk 5: M. Fremling (Maynooth)	**O'Rafeirteagh Lecture:** D. Haldane (Princeton)
16:20	Contributed Talk 6: R. McGuinness (Trinity)	
16:40	Contributed Talk 7: C. Pantelidou (Durham)	
17:00		Closing
18:30	**Public Lecture 1:** S. Hossenfelder (Frankfurt IAS)	
19:30	**Public Lecture 2:** D. Haldane (Princeton)	
20:30	Conference Dinner	

Abstracts for Invited Talks

Elizabeth Winstanley (Sheffield)	**Spinning thermal states:** Within the framework of canonical quantization, we consider the construction of rotating thermal states on Minkowski and black hole space-times. This process is fundamentally different for bosonic and fermionic fields. In particular, we are able to define rotating thermal states for a Dirac fermion field which have no counterpart for a scalar field.
Emmanuel Fort (ESPCI)	**Classical wave-particle duality based on wave memory:** We have recently discovered a macroscopic object composed of a droplet bouncing on a vertically vibrating liquid bath. Each time the droplet bounces, it creates a surface wave. These waves accumulate on the bath surface to form a wave packet. Above a certain excitation threshold, the droplet becomes dynamically coupled to these waves and becomes self-propelled piloted by the wave field it has created during its previous bounces. This symbiotic wave-particle object is designated as a “walker”. The wave packet encodes the memory of the droplet past trajectory since its structure depends on the previously visited spots where the droplet has bounced along its trajectory. This information is stored in the form of a wave field. Each elementary wave produced by each impact of the droplet interfere coherently to drive the droplet. We call this dynamics a path memory dynamics. The depth of memory can be tuned experimentally. The walker is thus a non-local entity in space and in time. Such a walker is dual in nature being composed of both, a wave and a particle. It exhibits several features previously thought to be specific to the quantum realm. The unexpected appearance of both uncertainty and quantization behaviors at the macroscopic scale lies in the essence of its “classical” duality and its wave memory. In this talk, I will discuss the role of this wave memory to explain the features of the walker’s dynamics. I will also introduce the concept of time mirrors to understand the characteristics of the pilot wave.
Peter Coles (Maynooth)	**Quantum Mechanics and Cosmic Structure:** The Standard Model of Cosmology involves the assumption that galaxies and large-scale cosmic structures form through the gravitational instability of a distribution of collisionless cold dark matter which is usually treated as classical particles. In this talk I will outline some of the problems with this picture and discuss the possibility that dark matter might behave quantum mechanically (e.g. if it comprises a very light axion-like particle). Following on from a seminal paper by Widrow & Kaiser (1992) I will further discuss why it can be advantageous for some purposes (e.g. reconstruction problems) to treat the growth of cosmic structure as a wave rather than particle phenomenon anyway.
Alejandra Castro (Amsterdam)	**Black Holes & Number Theory: how to bootstrap a black hole via modular forms:** In the language of statistical physics, an extremal black hole is a zero temperature system with a huge amount of residual entropy. Understanding which class of counting formulas can account for a large degeneracy will undoubtedly unveil interesting properties of quantum gravity. In this talk I will discuss the application of Siegel modular forms to black hole entropy counting. The role of the Igusa cusp form in the D1D5P system is well-known in string theory, and its transformation properties are what allow precision microstate counting in this case. We implement this counting for other Siegel modular and paramodular forms, and we show that they could serve as candidates for other gravitational systems.
Lionel Mason (Oxford)	**From null geodesic to gravitational scattering: how soft theorems link to asymptotic symmetries via ambitwistor strings:** It is well known that the scattering of null geodesics underpins the scattering of massless fields, at least at the level of wavefronts and singularities. Here I will describe a conformal approach to scattering from `null infinity', that, via a new kind of string theory, ambitwistor strings, makes the connection much more explicit at the level of detailed formulae for scattering amplitudes. As an application, I will discuss how the geometry underpins recently observed connections between asymptotic symmetries and soft theorems for amplitudes when particle energies become small.
Ricardo Monteiro (Queen Mary)	**Gravity as a double copy of gauge theory:** I will give an overview of the relations expressing perturbative gravity as a "double copy" of perturbative gauge theory. These relations appeared first in string theory, and have been used to compute scattering amplitudes in gravity theories and to study their ultraviolet divergences. At the level of scattering amplitudes, I will review current research topics such as the duality between colour and kinematics in gauge theory, which underlies the double copy to gravity. I will then discuss the extension of the double-copy procedure to classical solutions in general relativity, from gravitational waves to our best known black hole spacetimes.
Duncan Haldane (Princeton)	**Geometry of "flux attachment" in the fractional quantum Hall effect:** Most of our theoretical understanding of the topologically-ordered fractional quantum Hall (FQH) states derives from the remarkable model wavefunctions discovered by Laughlin, which explicitly exhibit "flux attachment". What has perhaps long been missing is a detailed understanding of why these wavefunctions work so well, and of the energetics that causes "flux attachment" to occur in a partially-filled Landau level. I will describe a simple physical and geometrical analogy between the incompressible quantum liquid FQH states and quantum solids, in which the "composite boson", that forms by "flux attachment” and condenses, is the analog of the unit cell of the quantum solid, and how the apparently-competing "composite boson" and "composite fermion" pictures are related. If time permits, I may also describe a new formaiism for states projected into a single Landau level on the torus.

Abstracts for Contributed Talks

Thomas Morley (Sheffield)	**Renormalised vacuum polarisation on anti-de Sitter black holes:** Anti-de Sitter spacetime is a solution of Einstein’s equations with a negative cosmological constant. This fact allows for unusual black hole solutions with non-spherical horizon topology. We consider massless quantum scalar fields in the Hartle-Hawking vacuum state. This state is regular at the event horizon and represents a black hole in thermal equilibrium. We calculate the renormalised vacuum polarisation for black holes with spherical, flat and hyperbolic event horizons, following the Breen + Taylor method, which uses a mode-sum representation for the Hadamard parametrix. Renormalisation counter terms are subtracted from the Green’s function mode-by-mode, leaving each individual term manifestly finite.
Marc Casals (CBPF/UCD)	**Spectroscopy of Extremal Kerr Black Holes :** Extremal (i.e., maximally-rotating) Kerr black holes play a special role within theories of gravity. From a theoretical point of view, they exhibit a near-horizon conformal symmetry, they are quantum-mechanically stable and they are the “last frontier” between rotating black holes and naked singularities. From an observational point of view, various highly-spinning astrophysical black holes have been identified and the gravitational waveform due to a particle inspiralling into such black holes possesses a distinct observational feature. In this talk we will present an investigation of field perturbations of extremal Kerr black holes throughout the complex-frequency domain. In particular, we will show: that the emergence of a branch cut in the extremal limit leads to an instability of the horizon of the black hole (which is associated with the near-horizon conformal symmetry); numerical evidence for the absence of frequency modes which grow exponentially with time; a calculation of the maximum amount of rotational energy that can be extracted from a black hole via the phenomenon of superradiance.
Samuel Kovacik (DIAS)	**(Magnetic Monopoles in) (Noncommutative) Quantum Mechanics:** We utilise the close relation between complex 2-dimensional space and real 3-dimensional space to reformulate quantum mechanics in a manner which allows to, either or both, describe magnetic monopoles and quantise the underlying space. A brief summary of our studies of noncommutative quantum mechanics will be provided.

Argia Rubeo (TCD)	**Gradient flow coupling and cutoff effects:** A very precise determination of the parameters of the Standard Model is essential in the search for new physics. Lattice QCD allows one to compute them in the strongly coupled regime, from first principles. The gradient flow (GF) is a tool recently introduced in lattice QCD and it is extremely useful as it provides a new class of renormalized observables. They can be measured with high precision by means of lattice simulations and have a number of interesting applications, such as the scale setting, a non-perturbative definition of the coupling constant, the so called GF coupling, which has technical properties that allow step-scaling studies to be performed with unprecedented precision. The drawback of such choice is that rather large cutoff effects have been found in many gradient flow observables. The Symanzik improvement programme has been introduced as a systematic approach in order to reduce the size of the lattice effects and accelerate the convergence to the continuum limit.
Mikael Fremling (Maynooth)	**Fermionic dynamics in the Lowest Landau Level:** We study the time evolution of fermions, moving on the surface of a sphere in strong radial magnetic field, subject to a center-off-mass preserving interaction. We find, that fermion configurations that initially are confined to the equator relax to cover the whole sphere, but that fermion configurations that start closer to the north and south poles can get trapped there. We also characterize the level-statistics of the system and comment on the connection with the presence of (or lack of) integrability.
Robert McGuinness (TCD)	**Optical Chern Insulators from Conical Refraction:** The topological classification of bandstructures plays an important role in understanding phenomena such as the quantum Hall effect. It was first applied to photonic materials by Raghu and Haldane, who showed that hexagonally patterned photonic crystals can have bandstructures with non-zero Chern numbers. In this contribution we outline another perspective on the topological classification of photonic materials, which is based on their refractive index surfaces, rather than their dispersion relations. Whereas most approaches involve exploiting particular lattice structures, our approach relies on optical spin-orbit coupling, i.e., the coupling between polarization and propagation direction, in birefringent materials.
Christiana Pantelidou (TCD)	**Holographic superconductor in magnetic fields:** Holography has been proven to be a very powerful tool for studying strongly coupled Condensed Matter systems. Within this framework, particular attention has been given to superconducting and spatially modulated phases. In this talk, I will discuss the behaviour of holographic superconductors in an external magnetic field. As we will see, a lattice of vortices will be spontaneously created at low temperatures. What are the properties of the system in this phase and how universal are they?
Marianne Leitner (DIAS)	**The modular forms of the simplest quantum field theory:** Much of the $(2,5)$ minimal model in conformal field theory is described by very classical mathematics: Schwarz' work on algebraic hypergeometric functions, Klein's work on the icosahedron, the Rogers-Ramanujan functions etc. Unexplored directions promise equally beautiful results.
John Brennan (Maynooth)	**The Kitaev Honeycomb Model on Surfaces of Genus $g\geq 2$:** We present a construction of the Kitaev honeycomb lattice model on an arbitrary higher genus surface. We first generalize the exact solution of the model based on the Jordan-Wigner fermionization to a surface with genus $g = 2$, and then use this as a basic module to extend the solution to lattices of arbitrary genus. We demonstrate our method by calculating the ground states of the model in both the Abelian doubled $\mathbb{Z}_2$ phase and the non-Abelian Ising topological phase on lattices with the genus up to $g = 6$. We verify the expected ground state degeneracy of the system in both topological phases.
Eoin O'Colgain (APCTP)	**Emergence of the Classical Yang-Baxter Equation from Supergravity:** We promote the open-closed string map, originally formulated by Seiberg \& Witten, to a solution generating prescription in generalized supergravity. The approach hinges on a knowledge of an antisymmetric bivector Θ, built from antisymmetric products of Killing vectors, which is specified by the equations of motion. In the cases we study, the equations of motion reproduce the Classical Yang-Baxter equation (CYBE) and Θ is the most general r-matrix solution. Our work generalizes Yang-Baxter deformations to non-coset spaces and unlocks gravity as a means to classify r-matrix solutions to the CYBE.
Brian Dolan (Maynooth)	**Noether's theorem in diffeomorhism invariant theories: the definition of mass in general relativity:**

Titles for Public Lectures

Sabine Hossenfelder (IAS Frankfurt)	**Lost in Math: How Beauty Leads Physics Astray**
Duncan Haldane (Princeton)	**Entanglement: Einstein's Gift to Quantum Mechanics**