Physics Annual Symposium 2019/20

B.Sc. (Hons) Physics Project

PHY3209 Seminar

Date: Friday 8th May 2020
Time: 10.00 – 14.00
Venue: Remotely

10.00 – 10.15 Introduction & Objectives of the Symposium
Head of Department: Professor Andrè Xuereb

10.15 – 10.30 **Student:** Ms Maria Caruana
Title: PHY3209 Cosmological Bouncing Solutions in Extended Teleparallel Gravity
Chairman:
Supervisor: Dr Jackson Said
Examiner:

10.30 – 10.45 **Student:** Ms Christina J Pisani
Title: PHY3209 The Night Sky Brightness of Gozo
Chairman:
Supervisor: Dr Joseph Caruana
Examiner:

10.45– 11.00 **Student:** Ms Rebecca Briffa
Title: PHY3209 Testing Gravity Theories using Cosmological Observations
Chairman:
Supervisor: Dr Jackson Said
Examiner:

11.00 – 11:15 **Student:** Mr Mirko Consiglio
Title: PHY3209 Decoherence Effects on Quantum Information Processing Protocols
Chairman:
Supervisor: Dr Tony J G Apollaro
Examiner:

11:15 – 11:30 **Student:** Ms Martina Vassallo
Title: PHY3209 A Long-Range Data-Link for Real -Time, Drone-based Antenna Pattern Measurements
Chairman:
Supervisor: Dr Alessio Magro
Examiner:

11:30 – 11:45 **BREAK**

11:45 – 12:00 **Student:** Ms Maria Caruana
Title: PHY3208 Science Experiments from the far side of the Moon
Chairman:
Supervisor: Prof Kristian Zarb Adami
Examiner:

12.00 – 12:15 **Student:** Ms Rebecca Briffa
Title: PHY3208 Black Hole Thermodynamics
Chairman:
Supervisor: Dr Jackson Said
Examiner:

12:15 - 12:30 **Student:** Ms Martina Vassallo
Title: PHY3208 Detection and Classification of Fast Radio Bursts
Chairman:
Supervisor: Dr Alessio Magro
Examiner:

12:30 – 12:45 **Student:** Mr Mirko Consiglio
Title: PHY3208 Computational Techniques in Simulating Black Holes and Imaging Shadows
Chairman:
Supervisor: Dr Jackson Said
Examiner:

12:45 – 13:00 **BREAK**

13:00 – 13:15 **Student:** Ms Christina J Pisani
Title: PHY3208 Three-Dimensional Semiconductor Devices
Chairman:
Supervisor: Dr Louis Zammit Mangion
Examiner:

13:15 – 13:30 **Student:** Ms Michelle Debono
Title: PHY3208 Communicating the Physics of Tennis - A Review of Past Research
Chairman:
Supervisor: Dr Charles Bonello
Examiner:

13:30 – 13:45 **Student:** Ms Katrina Debono
Title: PHY3208 A Review linked to Amusement Parks as a Physics Communication Space
Chairman:
Supervisor: Dr Charles Bonello
Examiner:

13:45 – 14:00 **CLOSURE**

Abstracts

B.Sc. (Hons) Seminar

PHY3209 Seminar

Student: Ms Maria Caruana

Title: Cosmological Bouncing Solutions in Extended Teleparallel Gravity

Abstract: Teleparallel Gravity (TG) describes gravity as a force in terms of torsion rather than curvature with the use of the Weitzenböck connection instead of the Levi-Civita connection used in General Relativity (GR). In fact, TG can be constructed to be equivalent to GR. In this work, gravitational Lagrangian solutions were obtained in *f(T,B)* bouncing cosmology models with the flat Friedmann-Lemaître-Robertson-Walker metric, where *T* and *B* are the torsion scalar and the boundary term, respectively. Analytical solutions are obtained for symmetric, superbounce, oscillatory, matter and future/past singularity bounce scenarios. Some of the solutions realised Minkowski and Schwarzschild vacuum solutions, and viable models where evaluated to determine the possibility of *f(T,B)* gravity as a dynamical dark energy model instead of the ΛCDM model. Such results could open up prospects for *f(T,B)* bouncing cosmology as an alternative to the Big Bang cosmology with inflation.

Student: Ms Christina J Pisani

Title: The Night Sky Brightness of Gozo

Abstract: The aim of this project was to carry out Night Sky Brightness measurements in Gozo, with a view to comparing with data collected between 2017 and 2018. Current studies have shown that light pollution is on the increase. This has adversely affected the night sky and carries implications for the ecology and human health. This study assessed the situation in Gozo, and from the collected data it emerges that while some areas exhibit a decrease in night sky brightness, there are still major increases in 33.3% of the island. In addition to island-wide measurements, further data at higher resolution were collected at the site of Dwejra, a designated Dark Sky Heritage Area (DSHA), Special Area of Conservation (SAC) of International Importance, and Natura 2000 site.

Student: Ms Rebecca Briffa

Title: Testing Gravity Theories using Cosmological Observations

Abstract: Recent cosmological observations show that there is a growing tension in the expansion rate of the Universe and that the standard cosmological model ΛCDM, based on Einstein's theory of General relativity (GR), is not sufficient enough to explain or relieve this tension. This tension was first noted by the Planck Collaboration amidst other contributors. A possibility that may alleviate this tension considers extensions or alternative theories of gravity. This works considers an alternative theory of gravity identified as Teleparallel Gravity (TG) which exchanges curvature with torsion in GR. In a certain limit, TG can produce a Teleparallel Equivalent of General Relativity (TEGR). In particular, this work reconstructs the equations for the extensions of TEGR known as $f(T)$ and $f(T,B)$ in a model-independent way using Gaussian Processes and observational datasets only. This novel data analyses technique is then used to constrain these modified theories of gravity against observational data.

Student: Mr Mirko Consiglio

Title: Decoherence Effects on Quantum Information Processing Protocols

Abstract: Noisy Intermediate-Scale Quantum computers (NISQ) are fervently accelerating the capacity of Quantum Information Processing (QIP) tasks. The launch of the IBM Quantum Experience (IBM-QE) provided publicly available NISQ processors that can be accessed remotely. Apart from performing quantum computation, IBM-QE processors have been able to successfully simulate many quintessential open quantum system models. Nevertheless, decoherence is a pressing issue in QIP, as noise generated during quantum computation effectively destroys encoded quantum information. The primary objective of this work is to analyse the effects of decoherence on QIP protocols, by simulating quantum teleportation and secret sharing protocols in an open quantum systems scenario on IBM-QE processors. It is demonstrated that implementing a phase damping channel acting on the entangled quantum state utilised in the teleportation process, by means of a collisional model, results in the decay of entanglement, diminishing the state's capability as a quantum resource. It is also shown that decoherence resulting from the inherent dephasing and thermal relaxation processes occurring during quantum computation, is indeed amplified by increasing circuit depth.

Student: Ms Martina Vassallo

Title: A Long-Range Data-Link for Real -Time, Drone-based Antenna Pattern Measurements

Abstract: The antenna pattern is an important feature associated with antennas that gives information about the device's radiative properties. It is then important to be able to characterise this pattern, for a given antenna, at a distance that is representative of its application. For most antennas, this distance would lie in the far-field. The far-field for large antennas, as are radio telescopes, has quite a far-reaching lower bound, rendering traditional methods inadequate. The introduction of drones mitigates the main problems of these methods since they possess inherent maneuverability. A means of communication between the drone and a ground station is now required for the transmission of data, namely, drone telemetry. In this project, such a data link operating on the radio band is developed. Apart from the development of custom software, considerations regarding different antennas used by the data link at either end were carried out to extend the range.

B.Sc. (Hons) Short Review

PHY3208 Short Review and Philosophy of Science

Student: Ms Maria Caruana

Title: Science Experiments from the farside of the Moon

Abstract: In this review, current scientific experiments and future projects carried out from the farside of the Moon are investigated. The unique environment that the farside of the Moon provides, a hemisphere shielded from Earth's anthropogenic radio frequency interferences, makes it an ideal environment to carry out low frequency radio astronomy required for the search of the 21 cm neutral hydrogen line, the study of helio physics and ultra-high energy particles, together with the quest for the discovery of habitable exoplanets. Moreover, performing an analysis on the chemical composition of deep craters could shed light on the materials that make up the crust and mantle. These experiments are currently being explored through the Chang'e 4 mission, while the missions DARE (Dark Ages Radio Explorer) and FARSIDE (Farside Array for Radio Science Investigations of the Dark ages and Exoplanets) are set to launch in the near future.

Student: Ms Rebecca Briffa

Title: Black Hole Thermodynamics

Abstract: The dynamics of black holes enables us to synthesis two accepted theories of nature: general relativity and quantum mechanics. Moreover, black hole thermodynamics provide a deep connection between gravitation, heat and quantum gravity. *Gedanken* experiments have led to relate the behaviour of the entropy with that of the black hole area as they both seem to increase irreversibly. This comparison led physicists to consider black hole physics in light of thermodynamics. In this work, the similarities between black hole physics and the ordinary laws of thermodynamics are explored. Moreover, Hawking's discovery of the quantum thermal radiance of black holes is also discussed. In addition, the concept of black hole entropy as a measure of information about the black hole interior is also considered and the finite values of both the temperature and the entropy of a black hole are found.

Student: Ms Martina Vassallo

Title: Detection and Classification of Fast Radio Bursts

Abstract: Fast radio bursts (FRBs) are bright, millisecond radio transients from extragalactic sources. Many factors will affect the shape of radio signals as they travel from their source to the observation point. One such factor, especially predominant in FRBs, is dispersion, which is characterised by the dispersion measure (DM). Hence, for detection, several dedispersion trials using different DMs have to be carried out since this value is generally unknown. Once the signals are detected and their original shape obtained, they must be classified, that is, attributed to some phenomena. Currently, there are only about 90 classified FRBs, despite their high occurrence rate. The application of advanced technologies in the CHIME and upcoming SKA telescope, however, predicts the detection of a copious amount of FRBs. Classification then requires the aid of machine learning to reduce the amount of human inspection required. In this short review, methods of detection and classification are discussed.

Student: Mr Mirko Consiglio

Title: Computational Techniques in Simulating Black Holes and Imaging Shadows

Abstract: Black holes are objects from which light cannot escape and exhibit extreme physics. Numerical methods and simulations are essential in understanding the physical processes that occur in the neighbourhood of black holes, eventually leading to the formation of the shadow. The Event Horizon Telescope (EHT) collaboration has been able to produce the first image of the shadow of M87*, a supermassive black hole in accordance with the predictions of a Kerr hole, consequently confirming the existence of black holes in our Universe. Many numerical codes attempt to bridge the gap between realising the physics of black holes in simulations, and what is expected to be observed in reality. This review outlines the various processes occurring near black holes as represented by several numerical codes used to construct the shadow of a black hole.

Student: Ms Christina J Pisani

Title: Three-Dimensional Semiconductor Devices

Abstract: Over the years technological advancements, as well as some motivation from Moore's law, have allowed us to go from packing a few components on to a chip, to packing billions. The point contact transistor was the first step to get where we are today. Through further research and developments, the transistor evolved into the metal oxide field effect transistor - an essential component in most devices. As devices were made smaller their electrical properties deteriorated, due to what are known as short-channel effects. A solution to this was to extend the devices to the third dimension. The FINFET, invented in the 1990s, is the most successful device of this type and is discussed in this review.

Student: Ms Michelle Debono

Title: Communicating the Physics of Tennis - A Review of Past Research

Abstract: This short review paper outlines the past research work carried out on the physics underlying the sport of tennis and on how this research can be used to provide a way of communicating science in the classroom or in an informal setting outside the classroom such as a tennis court. The game of tennis has a plethora of physics elements but due to the concise requisite of this study, it will focus on the physics behind the two main principle elements, namely the racket and the ball. In order to cover in detail these elements, this study is divided into three main sections; [i] the physics behind the tennis ball and the racket, [ii] the practical implications of these factors in the game and [iii] the way forward in using these physical concepts in an informal way of learning. In using this sequence, one hopes to propose a realistic, effective and creative way to communicate some scientific principles related to the sport of tennis.

Student: Ms Katrina Debono

Title: A Review linked to Amusement Parks as a Physics Communication Space

Abstract: The amusement park is usually a place of entertainment for a variety of audiences seeking the thrills of the rides. It is easy to stop at this level and not realise that these thrills stem from scientific concepts related mostly to physics. The fact that science discussed in class can be experienced provides the opportunity for a better understanding of this subject for those who study it formally. This can also be a way to show the public at the amusement park that scientific principles are also applied there.

For this reason, this review paper shall first give an overview of the physics behind amusement park rides, focusing on roller coasters. Then it shall focus on how one can use the same physics to inform, educate and engage audiences of various science backgrounds. In this way, one hopes to get across the message that science need not be confined to classrooms and laboratories but can also be found in places of entertainment.