Fifth Physics Erasmus Summer School

From Earth to the Edge of the Universe

Valencia, 4th – 8th September 2023

Conference Booklet

Contents

Timetable

	Monday 4	Tuesday 5	Wednesday 6	Thursday 7	Friday 8
8:30-10:40	**8:30-9:35** Registration				
	9:35-9:50 Welcome Address	**9:00-9:50 Javier Cervera**: Bioelectricity of non-excitable cells: multicellular patterning	**9:00-9:50 Tuomas Grahn**: Physics of atomic nuclei and the evolution of the Universe		
	9:50-10:40 Fabio Reale: The Sun and the Stars	**9:50-10:15 *Neus Sabater**: Exploring Earth's Atmosphere and Vegetation with Satellite Remote Sensing **10:15-10:40 V. Crisafulli/S. Gimeno**: VALENSAT Project	**9:50-10:15 Alberto Torralba**: Reading the Universe between the lines **10:15-10:40 Miguel Miravet**: Gravitational waves: A new window to the Universe	**9:50-10:40 *Uwe Oberlack**: Dark matter in the universe and its detection	**9:50-10:40 Jorge Álvarez**: Palaeoclimate: understanding the past, anticipating the future
10:40-11:10	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:10-13:15	**11:10-11:35 Miriam Rodríguez**: Do stars have rhythm? (Asteroseismology in action)	**11:10-12:00 *Tiziana Di Salvo**: From stars to neutron stars and black holes: the most enigmatic objects in the Universe	**11:10-12:00 J. Martín/I. Recuerda**: Meteorology as a science: The vital role of AEMET as an institution to provide meteorological services to society	**11:10-11:35 Carina Fian**: The cosmic eyeglasses: an introduction to gravitational lensing	**11:10-11:35 Francesco Scarlatti**: Clouds and aerosol properties with machine learning and All-sky camera imagery
	11:35-12:00 Beatrice Giudici: The violent beauty of supernova explosions	**12:00-12:25 Ezequiel Albentosa**: Image of a Black Hole: exploring the limits of space and time	**12:00-12:25 Rafael Llorens**: Methodology for burned areas delimitation and fire severity assessment using Sentinel-2 data	**11:35-12:00 David Vallés**: Computational cosmology: simulating the formation of cosmic structures	**11:35-12:25 *Michael Wurm**: Detection of astrophysical neutrinos
	12:00-12:50 Luis Guanter: Satellite spectroscopy for Earth observation	**12:25-13:15 Rafael Garcia-Molina**: Playing with Physics	**12:25-12:50 Alejandro Mengual**: Oil Spill Detection at Sea. Building products for the Earth Observation Market	**12:00-12:50 Olga Mena**: Invisibles in the Cosmos and Invisibles in Science	**12:25-12:45** Biagio Giuseppe Banigi
	12:50-13:15 *David March: Artificial Intelligence, Big Data and New Technologies to support marine conservation		**12:50-13:10** Giuseppe Airo	**12:50-13:10** Poster session	**School's closing lunch**
13:15-14:35	Lunch	Lunch	Lunch	Lunch	
14:35-	**14:35-14:55** Marc Chirona Pla	**14:35-14:55** Gabriele Ippolito	**14:35-15:25 *Claudio Fazio**: Spontaneous models of knowledge and scientific knowledge	**14:35-15:15** Poster session	
	14:55-15:15 Casimiromaria Carciola	**14:55-15:15** Federico Ticali			
	15:15-15:35 Giovanni Luca Ignaccolo	**15:15-17:00** Round Table ERASMUS Mobility	**15:25-17:10** Round Table Employability	**15:15-17:10** Machine Learning course	
	15:35-16:15 Carla Tomás: Anxiety, stress, time management: Mental health in university students	**17:00-** Collaborative games	**17:30-** Visit to the Aras de los Olmos Astronomical Observatory / Valencia historical center guided tour	**17:30-** Visit to the Aras de los Olmos Astronomical Observatory / Valencia historical center guided tour	
	16:15-17:15 Adrián Lambies and Iturbi Out of Context Quintet: Physics and music				
	17:15- Collaborative games				

Topics
- Earth Physics and Thermodynamics
- Astronomy and Astrophysics
- Multidisciplinary
- Contributions from participants
- Activities

*Online

Note that the vertical size of the boxes is not related to their duration, nor are the boxes of different days synchronized. Instead, the detailed start and end times are explicitly written inside each box.

Invited and Participants Talks

Monday 4th

The Sun and the Stars

Fabio Reale

Università degli Studi di Palermo, Palermo, Italy

The Sun is our star and is a template star for us. A star is basically an energy production machine, which converts mass into energy, driven by gravity. The way the energy is transported from the core, where it is produced, to the surface, where it is radiated away in the interstellar medium, substantially determines the stellar internal structure. The external layers also create the conditions to make the Sun a laboratory for plasma physics, not feasible on earth. The observations allow us to study both the mechanisms of energy transport and the plasma processes, and they can be used for analogies and differences with other stars, thus providing an extensive exploration of the parameter space, but also to constrain the validity and limitations of the solar model.

Do the stars have rhythm? (Asteroseismology in action)

Miriam Rodríguez Sánchez

Department of Astronomy and Astrophysics, Universitat de València, València, Spain

This talk provides a brief and basic introduction to the concept of Asteroseismology which involves studying the interior of stars through their pulsations and oscillations, similar to how Seismology study the Earth's interior. By delving into stellar pulsations, researchers can obtaine relevant physical information about the

stars' evolution, chemical composition and internal processes such as convection or magnetic fields.

The presentation aims to showcase a wide range of stars that exhibit pulsations, starting from our nearest star, the Sun, to dying stars. Throughout the talk, it will be explained different concepts about the waves, the modes (g-modes, p-modes, radial and non-radial modes, etc.) and other important terms in Asteroseismology in an understandable manner.

Additionally, a more detailed review about the pulsating Delta Scuti stars will provided.

In summary, Asteroseismology is an important branch in Astrophysics and the main goal of this talk is to give to the public a glimpse of this fascinating subject.

The Violent Beauty of Supernova Explosions

Beatrice Giudici

Department of Astronomy and Astrophysics, Universitat de València, València, Spain

This talk unveils the explosive demise of massive stars, delving into the fundamental processes behind core-collapse supernovae. We examine the delicate equilibrium that sustains massive stars and the catastrophic events that lead to their explosive demise, and how these events forge and disperse heavy elements through nucleosynthesis. The talk will be a broad overview that will touch both the most recent theoretical understanding in the matter, and the most important discoveries coming from observations.

Satellite spectroscopy for Earth observation

Luis Guanter

Department of Applied Physics, Escuela Técnica Superior de Ingeniería de Telecomunicación, Universitat Politècnica de València, València, Spain

Light spectroscopy consists in the determination of the composition of a given material by the analysis of how it absorbs light at specific wavelengths. It was first introduced by Joseph von Fraunhofer in the beginning of the 19th century. Using a self-made instrument (a so-called spectrometer) he determined the composition of the solar atmosphere from the absorption lines identified in the solar spectrum at certain wavelengths. The same light absorption principle is now being applied for

the monitoring of the Earth's surface and atmosphere from space. Satellite-based imaging spectrometers record the solar light reflected by the Earth in hundreds of contiguous spectral channels. The resulting spectroscopic (or hyperspectral) images can be used for a number of applications, including the understanding of the mineralogical composition of a planet or the quantification of greenhouse gases in the atmosphere. In this seminar, we will review the principles of light spectroscopy and its use for space-based applications.

Artificial Intelligence, Big Data and New Technologies to support marine conservation

David March

Universitat de València, València, Spain

Ocean observing systems are revolutionizing marine science, bringing new opportunities to simultaneously monitor the state of the seas, their biodiversity and maritime activities in real-time. Through the epic journeys of sea turtles, birds and whales we will explore multidisciplinary approaches that integrate recent advancements in robotics, machine learning, molecular biology, and operational oceanography, all aimed at supporting marine conservation. We will uncover the immense potential of cutting-edge technologies such as drones, environmental DNA, satellite tracking of marine megafauna, numerical ocean models, and the Automated Identification System (AIS). These powerful tools enable us to track changes in species distributions, monitor ocean characteristics, and assess human pressures on marine ecosystems. By embracing these methods, we can rapidly advance the development of cost-effective and non-invasive marine biodiversity observing systems, supporting dynamic ocean management.

Conspiracies, denialism and the role of scientific dissemination

Marc Chirona Pla

Universitat de València, València, Spain

World has experienced significant growth in conspiracy theories after the COVID-19 pandemic, which has led to the proliferation and expansion of denialist movements in our society, especially those related to scientific knowledge. Therefore,

we need to ask why some of these beliefs have been accepted up to a certain point by people and what science can do to prevent and refute conspiracy theories.

Even though conspiratorial thinking and denialism are often linked, they shall not be confused with each other: a conspiracy theory tries to describe events that could be claimed to be a conspiracy, often by differing from experts' opinion and interconnecting different conspirational ideas. However, denialism refers to an attitude of systematically negating facts that can be proved but are not consistent with one's beliefs or thoughts.

Yet conspiracism and denialism are different concepts, they appear together in most or all cases, and that can be explained since they share very similar reasoning. Some of these arguments or fallacies include countering official information; dividing society between two well-defined groups: the "awaken" ones and the "system's" followers; using minor dissident voices or uncleared aspects as proofs for an alternative version of the events; or appealing to poorly documented personal experiences.

The manner of working of conspiracism completely opposes scientific research since this last one is much more sophisticated and surveilled by experts in their field. Nevertheless, the general public needs simple and accessible information that brings light to conspiracy-backed pseudoscientific ideas which are more friendly to inexpert people. Here's where scientific dissemination comes to change people's way of thinking and make them interested in scientific fields, as well as taking conspiracy theories away from society.

Is theoretical physics doomed to disappear?

Casimiromaria Carciola

Università degli Studi di Palermo, Palermo, Italy

Artificial Intelligence has improved our life pretty much from image recognition to data analysis, from vocal assistants to economics. In this particular historical period the fear of being replaced by machines or AI is increasing, but scientists and in particular we physicists are sure to be one of the few categories to be irreplaceable? What if there was an AI that did our same job but better?

In this seminar, we are going to discuss the basics of Machine Learning and some of its applications to search free-form analytical laws starting from experimental or simulated data and the research made so far in this field.

Random LASER

Giovanni Luca Ignaccolo

Università degli Studi di Palermo, Palermo, Italy

I would like to present a project that I have done in the past 3 months. The talk is organized in 3 steps:

1. Theorical explaination of the functioning of standard and Random Laser: Laser standard properties, Constitutive elements, Stimulated emission, Two level system, Laser rate equation, Random laser properties, Random laser applications
2. Description of the experimental set up used in laboratory to create a Random Laser, in particular the explaination of the optical table, including the sample.
3. Description of the results obtained, including the visibility of figures. It is showed the study of the spectral curves of the spontaneous an stimulated emission of the sample varying the pumping power.

Anxiety, stress, time management: Mental health in university students

Carla Tomás

Universitat Jaume I, Castelló, Spain

This talk consists in a brief psychoeducation about emotional regulation. In order to begin, there will be a short introduction explaining what are emotions. Then, attendee will be invited to think about and discuss different questions that the speaker will ask. Next, we will clarify the steps to follow in order to carry out an adequate emotional management, explaining some useful psychological aspects such as full attention, which forms part of mindfulness. To close this session, a series of practical indications will be given in terms of basic psychology exercises that are helpful for addressing day-to-day problems.

Physics and Music: With Physics to Somewhere Else

Adrián Lambíes[1,3], **Carlos Hernández**[2], **Iturbi Out of Context Quintet**[3]

[1] ***Faculty of Physics, Universitat de València, València, Spain***
[2] ***Escuela Técnica Superior de Ingeniería de Telecomunicación, Universitat Politècnica de València, València, Spain***
[3] ***José Iturbi Conservatory, València, Spain***

Physics is to be found in every detail of life, but are we aware of its close relationship with music? In this divulgative talk we will combine music theory and instrument making with the physical fundamentals that make it possible to admire the beauty in a Beethoven symphony or to follow the rhythm of Queen's "We Will Rock You". Why is the "Musikverein" in Vienna the ideal concert hall to listen to the New Year's Concert? How did some Argentinian comedians manage to travel around the world for almost 60 years thanks to music? How can we use electromagnetism to "play music without touching it"? All these questions will be accompanied by live music thanks to the invaluable support of one of the chamber ensembles of the José Iturbi Conservatory of Valencia, the "Iturbi Out of Context Quintet".

Tuesday 5th

Bioelectricity of non-excitable cells: multicellular patterning

Javier Cervera

Department of Earth Physics and Thermodynamics, Universitat de València, València, Spain

Cells must coordinate their individual activities towards multicellular goals, which requires efficient information processing mechanisms. Bioelectrical signals such as the cell membrane potential, defined as the potential difference between the cell inside and outside, are involved in the organization of multicellular aggregates. Bioelectricity encode instructive rules at multiple scales, from the individual cell to

the tissue and organ levels, because patterns of cell potentials are locally coupled to transcription and morphogenesis via biochemical downstream processes.

The spatio-temporal distributions of potassium and calcium ions, neurotransmitters, and specific transcription activators are correlated with electric potential patterns. This correlation results in patterns composed of dynamic subsystems (modules) with cells that share the same bioelectrical state. The integration-segregation topology of the different modules defines a multicellular pattern memory.

By acting on these separate modules and their particular integration, pattern memories can be retrieved or externally rewritten, with morphological consequences. Bioelectrical simulations suggest new opportunities for external actions at the intermediate scale characteristic of endogenous multicellular fields. These collective dynamics can be complementary to single cell centered methodologies.

Exploring Earth's Atmosphere and Vegetation with Satellite Remote Sensing

Neus Sabater

Finnish Meteorological Institute

VALENSAT Project

V. Crisafulli, J.A. Sobrino, A. Mora, S. Gimeno, A. Sobrino

Department of Earth Physics and Thermodynamics, Universitat de València, València, Spain

Remote Sensing is a powerful technique for Earth monitoring and resource studies, providing valuable insights into natural and human-induced processes at various spatial and temporal scales. Indeed, it allows the acquisition of information for continuous monitoring of Earth's surface changes in both real-time and over time. To reach this objective, it utilises satellites to capture radiation across different bands of the electromagnetic spectrum, revealing crucial information about surface temperature, vegetation, humidity, atmospheric pollution, and more.

VALENSAT, an initiative led by the Global Change Unit (GCU) at the University of Valencia and funded by the Generalitat Valenciana, aims to provide valuable environmental information to the citizens of the Valencian Community. The project

utilises satellite imagery from various sources to study and monitor changes in the land surface, among others Sentinel, Landsat, Meteosat, and VIIRS satellites. VALENSAT website provides users with access to a wide range of real-time data, such as temperature maps, vegetation indices, wildfire burn area calculations, and long-term statistical data. This wealth of information empowers users to make informed decisions, develop effective climate change mitigation strategies, and gain a deeper understanding of the environment.

From Stars to Neutron Stars and Black Holes: The most Enigmatic Objects in the Universe

Tiziana Di Salvo

Università degli Studi di Palermo, Palermo, Italy

Stars have a life cycle consisting of birth, evolution, and death. However, what remains of a star after its death can give rise to a second life. When the nuclear reactions that support the core of a star against the force of gravity cease, the core collapses to form exotic objects with unique characteristics depending on their mass. These objects include white dwarfs (with a mass of up to approximately 1.4 solar masses), neutron stars (with a mass between 1.4 and 2 solar masses), and black holes (with a mass greater than 3-5 solar masses). What sets these objects apart is that their entire mass is concentrated within a very limited space, resulting in enormous gravity and significant quantum and relativistic effects. These objects are known as compact objects. In this seminar, we will explore the main properties of these objects, how they can be observed, and which physical laws can be tested as a result of their observation. We will also discuss recent breakthroughs, such as the first direct detection of gravitational waves generated by the coalescence of two compact objects, a prediction of the General Theory of Relativity (a discovery that was awarded with the Nobel Prize in Physics in 2017) and the first "photograph" of a black hole.

Image of a Black Hole: exploring the limits of space and time

Ezequiel Albentosa

Department of Astronomy and Astrophysics, Universitat de València, València, Spain

Playing with physics

Rafael Garcia-Molina

Research Center on Optics and Nanophysics, Department of Physics, Universidad de Murcia, Murcia, Spain

Surely most people (myself among them) will agree that physics is a difficult subject (otherwise it will not be interesting), but in many cases this message is accompanied by the subliminal (or explicit) idea that physics is boring (I disagree), which has permeated society.

Physics is present in all aspects of our lives, from everyday objects (computers, cellulars, lasers...) to applications in medicine (magnetic resonance imaging, radiotherapy, computer tomography, non-invasive imaging through ultrasounds...), or in society (communications, generation and transport of energy...), to name a few cases. Besides these important and practical examples, my purpose in this conference is to show that physics can also be funny. To fight the idea that physics is boring, I have prepared a set of experiences using cheap, simple and everyday materials, with the aim to: (1) capture attention of the public (students or citizens) to show them that Physics can be as amusing as any other human activity (like music, sports, literature...), and (2) show them that fundamental Physics concepts are on the basis of most (if not everything) that surround us.

In this session I will present a selection of Physics experiments in the form of games, tricks... that are cheap, simple and, why not, funny. These activities have proven to be very successful both to catch the attention of the young people and to provide teachers with an excellent tool to complement their lectures.

Phase in Bose-Einstein condensate interference

Gabriele Ippolito

Università degli Studi di Palermo, Palermo, Italy

When bosonic atoms are trapped in a potential well and cooled down to very low temperatures, their de Broglie wavelength becomes of the order of their mean interaction distance. The system undergoes a phase transition for which a fraction of atoms are trapped in the ground state. The condensed phase can be extended to the whole system by lowering the temperature even more. The trapped atoms all belong to a global wave function. Nowadays, it is possible to study the behavior of condensates trapped in electromagnetic potential wells. Furthermore, it is possible to design interference experiments for matter waves. Phase in Bose Einstein condensate interference manifests interesting properties linked to the fluctuations of the number of bosons involved. Furthermore, the phase is not always an experimental manageable parameter and it could be a purely quantum feature, totally random, related to the measuring process.

Open quantum systems - The fundamental role of quantum coherence in biological systems

Federico Ticali

Università degli Studi di Palermo, Palermo, Italy

Excitation transfer through interacting systems plays an important role in many areas of physics, chemistry, and biology. Here, we pay attention to the large efficiency (90%) energy transfer in light-harvesting complexes whose physical mechanism is unclear. The uncontrollable interaction of the transmission network with a noisy environment is usually assumed to deteriorate its transport capacity, especially so when the system is fundamentally quantum mechanical. Here, this study identifies key mechanisms through which noise such as dephasing may actually aid transport through a dissipative network by opening up additional pathways for excitation transfer. This study shows that these are processes that lead to the inhibition of destructive interference. We illustrate how these mechanisms operate on a fully connected network by developing a powerful analytical technique that identifies the invariant (excitation trapping) subspaces of a given Hamiltonian. Finally, we present a numerical analysis of excitation transport across the Fenna–

Matthew–Olson complex, showing that the developed technique can explain high efficiency transfer of energy.

Round Table: ERASMUS Mobility

Moderator: José María Martí (Universitat de València)

Wednesday 6th

Physics of atomic nuclei and the evolution of the Universe

Tuomas Grahn

University of Jyväskylä

The physics of atomic nuclei play an important role in the evolution of the Universe. Already in the first few minutes after the Big Bang, primordial hydrogen and helium were produced. About a billion years later the first complex were formed. Elements up to iron are made through nuclear fusion reactions in the cores of the stars. The heavier nuclei are produced in stellar processes involving captures of -for instance- protons, neutrons or photons. Three main processes can be identified, i.e., the proton capture (rp-process), slow neutron capture (s-process) and rapid neutron capture (r-process) process. These processes constitute a complex network of nuclear reactions. Out of these only the r-process is capable to produce the heaviest elements up to uranium. The r-process proceeds in extreme conditions with high neutron flux. The recent detection of gravitational waves together with associated observational data from the neutron star merger has revealed one of the sites of the r-process.

The properties of nuclei are imperative for understanding the nucleosynthesis process and evolution of the Universe in general. For instance, the existence of the so-called Hoyle state in ^{12}C is a key fact that allows the nucleosynthesis to proceed to heavier nuclei and ultimately is a prerequisite for our existence.

In the present lecture I will discuss the relevance of nuclear data in the context of evolution of the matter in the Universe. I will also discuss how different nuclear properties, such as masses, decay half-lives or branching ratios and excited states impact the nucleosynthesis and help to model it.

Spectroscopy: Reading the Universe between the lines

Alberto Torralba

Universitat de València, València, Spain

Light can be interpreted as propagating waves of an electromagnetic field. These waves travel at a fixed velocity c = 299792458 m s^{-1} (which is the maximum velocity anything can travel, according to General Relativity), and oscillate with a frequency f, and a wavelength λ. The relation between these three attributes is λ = c/f. In general, the light emitted from most sources does not have a unique frequency, but it is a mixture composed of a continuum distribution of frequencies.

The light of astronomical objects (stars, galaxies, nebulae, etc.) travels huge distances to reach our detectors. This light carries information about the source: the materials it is made, the physical processes going on, the distance of that object from us, etc. Spectroscopy is one major tool in modern astronomy, consisting of decomposing the light of astronomical sources, obtaining the distribution of emitted energy as a function of the frequency (or equivalently, wavelength). This energy density distribution is called a Spectrum.

Astronomers use instruments called spectrographs to obtain such spectra. The first spectrographs used prisms to decompose light, using the same principle that allows water droplets in the atmosphere to separate the sunlight in colors generating a rainbow (red colors correspond to lower frequencies while violet correspond to the highest frequency of the visible light). Modern spectrographs use more advanced components such as diffraction gratings.

In this talk, we will explore the basic concepts of spectroscopy. We will learn what are the most common techniques, and what can we learn about astronomical sources by looking at their spectra.

Gravitational waves: A new window to the Universe

Miquel Miravet

Department of Astronomy and Astrophysics, Universitat de València, València, Spain

Gravitational waves were first predicted by Albert Einstein a century ago from the theory of General Relativity. After years of technological and scientific developments, their existence was finally confirmed with their detection in September

2015. We are going to see what gravitational waves are, which astrophysical scenarios generate the loudest gravitational wave signals and how we managed to detect these ripples in spacetime.

Meteorology as a science: The Vital Role of AEMET as an Institution to provide meteorological services to society

Javier Martín, Irene Recuerda

Agencia Estatal de Meteorología (AEMET)

Meteorology, unlike other disciplines within physics such as quantum mechanics, optics, or particle physics, holds a more prominent place within society due to its crucial significance. However, there is still a significant barrier that hinders its understanding among the population, as its behaviour is primarily governed by the principles of classical fluid mechanics, atmospheric thermodynamics, and radiative processes that lie on the atmosphere. To become a meteorology professional, a solid background in physics and mathematics is necessary but there is still room for other specialties as geography in sections such as climatology.

The Spanish Meteorological Agency (AEMET) carries out a wide range of functions aimed at improving Spanish society. Among the numerous tasks it performs, operational forecast stand out, which are focused on detecting adverse phenomena, supporting air and maritime navigation, and preventing avalanches, among others. To carry out these operational tasks, the agency has specialized personnel in weather modelling services, remote sensing, climate services, and the maintenance of an extensive observation network that covers the entire country's geography.

Since the atmosphere does not recognize political borders, meteorology would be meaningless without strong international collaboration, which receives the majority of AEMET's annual budget. Thanks to the joint efforts of European countries, we have become leaders in important areas as modelling areas with the creation of the European Centre for Medium-Range Weather Forecasts (ECMWF), and soon we will have third-generation meteorological satellites in orbit thanks to EUMETSAT. Beyond European borders, there is a constant exchange of meteorological data with other continents.

Methodology for burned areas delimitation and fire severity assessment using Sentinel-2 data

Rafael Llorens, José Antonio Sobrino, Cristina Fernández, José M. Fernández-Alonso, José Antonio Vega

Department of Earth Physics and Thermodynamics, Universitat de València, València, Spain

The goal of this study is to develop a methodology for the burned areas delimitation and fire severity assessment, in forest fires occurred in Spain between 2018 and 2022. This work is based on the use of Sentinel-2 spectral indices, which are characterized by having spectral bands in the near-infrared (NIR) and short-wave infrared (SWIR) spectral regions, allowing a high distinction between burned and unburned areas, and between different fire severity degrees too. The results were compared by the Emergency Mapping Service (EMS) and using field points classified as in Ruiz-Gallardo et al. (2004) study (null, low, moderate and high severity). The final statistic results obtained, show that the dNBR2 spectral index (using B11 and B12 Sentinel-2 spectral bands) provides the highest results of burned area delimitation (7% of commission error and 3% omission error, respectively) whereas, the combination of the BAIS2, the NBR and the modified Normalized Burn Ratio (NBR2, using B7 and B12 Sentinel-2 spectral bands), used in areas with low, mix and full vegetation respectively, provides the highest results in fire severity assessment (kappa statistic, F1-score and Balanced Accuracy equal to 0.87, 0.86 and 0.92, respectively).

Oil Spill Detection at Sea. Building products for the Earth Observation Market

Alejandro Mengual

Department of Earth Physics and Thermodynamics, Universitat de València, València, Spain

In this talk we will learn a bit about the oil spill situation worldwide, and how to tackle it from a remote sensing perspective. We will see the two ways of detecting spills using satellite imagery, by using synthetic aperture radar images and multiespectral imagery. The second part of the talk will be a brief overview of a few aspects of building an Earth Observation company and product, sharing a few key

tips and some useful resources just to have a first contact with the market side of the science.

Quantization of the electromagnetic field, and Unruh effect

Giuseppe Airo

Universitâ degli Studi di Palermo, Palermo, Italy

My presentation will be about 30 pages long, and it will be devided in two sections: in the first part it is shown the equivalence between the hamiltonian of the electromagnetic field and that of an ensamble of harmonic oscillator; while the second part is about the Unruh effect, wich is a consequence of the quantization of fields. The conclusion is a small discussion wich let us attribute the arising of the Unruh effect to the zero-point fluctuation of the vacuum state of the field.

Spontaneous Models of Knowledge and Scientific Knowledge

Claudio Fazio

Department of Physics and Chemistry – Emilio Segrè, University of Palermo, Palermo, Italy

Spontaneous Knowledge models refer to an individual's intuitive comprehension of the surrounding environment. These models are frequently derived from personal experiences, observations, and interactions with the environment. They provide individuals with a framework for making sense of the world and frequently guide their actions and beliefs. In contrast, scientific knowledge is based on the systematic investigation and exploration of the natural world using scientific methodologies. Its foundations are empirical observations, experimentation, logical reasoning, the circulation and critical validation and assessment of new information. Despite the fact that spontaneous models of knowledge may serve as a starting point for comprehending the world, they are often inconsistent, inaccurate, or limited in scope. In contrast, scientific knowledge seeks to provide a more thorough and trustworthy understanding of the natural world through a systematic and evidence-based approach. It plays a crucial role in the advancement of human

knowledge, technological advancement, and the creation of solutions to complex problems.

However, there are some similarities between the processes of building spontaneous and scientific knowledge, and some spontaneous models also resemble ancient ideas or theories now abandoned. It was hypothesized that by exposing students to these ideas and theories, they would recognize their own conceptions and be able to discuss and evaluate them, similarly to historical processes of conceptual change. In this presentation, I will first discuss the concepts of spontaneous and scientific knowledge in physics, and then provide examples of ancient ideas or theories that can be considered analogous to popular models of spontaneous knowledge. Then, I will discuss how a good comprehension of spontaneous models, and a new way to see them from an epistemic viewpoint, can aid the educator in assisting students in developing scientifically sound and personally relevant knowledge.

Round Table: Employability

Moderator: Salvador Mengual (Universitat de València)

Thursday 7th

The quest for the nature of Dark Matter

Uwe Oberlack

Johannes Gutenberg Universität Mainz, Mainz, Germany

What is the mysterious matter that leads to the formation of structures such as galaxies, galaxy clusters, superclusters and corresponding voids in the universe, and that determined the evolution of the universe from the first minutes for the first $\sim$10 billion years and still has a major influence on it today? Why can't we see this "dark" matter? And how do we hope to make it visible in the future? The lecture will present the problem and describe approaches to solve the puzzle.

The cosmic eyeglasses: an introduction to gravitational lensing

Carina Fian

Department of Astronomy and Astrophysics, Universitat de València, València, Spain

Since its first observational evidence, gravitational lensing - the bending of light by mass - has become an established tool for understanding a broad spectrum of astrophysical phenomena. In this talk, we will delve into the principles of lensing and explore its various types: strong, weak, and microlensing. We will examine diverse lensing phenomena, including multiple images, Einstein rings, Einstein crosses, as well as arcs and arclets. Beyond just theory, gravitational lensing has offered numerous applications that have reshaped our understanding of the universe. These range from the detection of exoplanets and probing large-scale cosmic structures to the discovery of dark matter and providing new ways to study the mass distribution in galaxy clusters. Furthermore, we will also discuss how gravitational lensing aids in estimating key cosmological parameters like the Hubble constant and provides unique insights into the structure and kinematics of lensed quasars.

Computational Cosmology: simulating the formation of cosmic structures

David Vallés

Department of Astronomy and Astrophysics, Universitat de València, València, Spain

The investigation of cosmic structure formation is a prominent area of research within modern Astrophysics, aiming to unravel the intricate processes at play during the formation and evolution of the diversity of structures spanning various scales in the Universe. It is now well-established that the emergence of cosmic structures follows a hierarchical pattern, with the tiny primordial density fluctuations originating during the inflationary epoch serving as the seeds, and subsequent gravitational collapse and non-gravitational processes shaping the emergence of present-day objects. These processes play a pivotal role in assembling the vast array of objects observed in the Cosmos, culminating in the formation of

galaxies and galaxy clusters, which stand as the largest gravitationally bound structures in the Universe.

Understanding the complex physics governing cosmological structure formation and evolution necessitates the integration of diverse fields, including General Relativity, thermodynamics, statistical mechanics, hydrodynamics, plasma physics, magnetism, and atomic physics, amongst others. To tackle this multifaceted problem, substantial computational resources are required.

This talk aims to provide an introduction to the fundamental components of cosmological structure formation, elucidating the approach of intensive numerical computation employed to address this challenge. We will explore the intricate interplay of physical processes and their implementation in modern computational simulations. These simulations, enabled by advanced computational facilities, have yielded significant insights into the formation and evolution of cosmic structures.

By the conclusion of the talk, notable outcomes obtained through cosmological simulations will be discussed, showcasing the wealth of knowledge garnered from these computational endeavours. This outreach talk offers a glimpse into the captivating world of computational cosmology, shedding light on the mechanisms that have shaped the Universe's cosmic architecture.

Invisibles in The Cosmos and Invisibles in Science

Olga Mena

Instituto de Física Corpuscular, IFIC (CSIC - Universitat de València), València, Spain

In this talk, I will review the invisible components of our universe, such as neutrinos, dark matter and dark energy. Neutrinos are the most abundant particles in the universe after Cosmic Microwave Background photons. Dark matter amounts to 25

In parallel, while we are exploring these Nature's invisibles, we shall also emphasize the very important and key role played by women's astronomers and scientists, unfortunately also invisible in the Cosmos and in Science, whose contributions were crucial to shape our universe and without them we would not know how e.g. to classify stars or how to measure distance in our cosmos today. Williamina Fleming, Annie Jump Canon, Henrietta Swan Leavitt, Cecilia Payne, Vera Rubin and Jocelyn Bell Burnell will be our stars and I will make sure they shine as they did along their scientific careers.

Mini-Workshop: Machine Learning

Raimon Luna, Sidhartha Gurung, Víctor Tamames

Department of Astronomy and Astrophysics, Universitat de València, València, Spain

In this mini-workshop we will explore some of the basic principles of machine learning and neural networks, which have made possible the recent fascinating developments in artificial intelligence. Join us on this amazing adventure!

First, we will see a brief introduction to artificial neural networks, which are some apparently simple mathematical structures that can be trained to adapt to very complex behaviors. This is achieved through techniques such as backpropagation and optimization algorithms based on the principle of gradient descent. We will see the inner workings of convolutional neural networks, which are very suitable for image processing and computer vision problems, and we will use them to experiment with a simple model for image identification and classification.

We will then move on to discover generative models, which are algorithms capable of automatically generating new data based on large example databases. In particular, we will focus on Generative Adversarial Networks (GANs), some very ingenious structures described in 2014 by Ian Goodfellow on which many of today's generative models are based. GANs are a set of of two independent competing neural networks: the generator and the discriminator. The generator will try to generate realistic images, while the discriminator will try to discover the fake ones. Who do you think will win?

Finally, we will enter the fascinating world of Natural Language Processing (NLP), which allows machines to interpret and reproduce human language. These techniques have given us today's machine translators, question answering systems and chatbots. We will discover the interesting concept of word embeddings, a class of algorithms that represent the meaning of words or phrases in a gemetric space. We will also talk about recurrent neural networks, very useful in language processing; and finally about attention and the transformer models, which made it possible to build systems as impressive as ChatGPT.

Friday 8th

Paleoclimate: understanding the past, anticipating the future

Jorge Álvarez-Solas

Department of Earth Physics and Astrophysics, Universidad Complutense de Madrid, Madrid, Spain

The Earth's climate has changed throughout its history at different spatiotemporal scales in response to various physical, chemical, and geological processes. Currently, our climate is being profoundly affected by human activities, particularly due to increased greenhouse gas concentrations. In this talk, we will take a journey into the past, visiting key periods whose climates were very different from the present. Studying the mechanisms that shaped the climate system during these past periods helps us understand the observed changes of our time. Additionally, it allows for a comparison of our climate models with past reconstructions and current observations. By doing so, we can project the climate system into the future and anticipate the consequences of anthropogenic climate change.

Clouds and aerosol properties with Machine Learning and All-Sky camera imagery

Francesco Scarlatti

Department of Earth Physics and Thermodynamics, Universitat de València, València, Spain

In this lesson will be presented new advances in the capability of machine learning to predict aerosol properties along with a new study concerning the definition of the intercloud zone. Three study resumes are reported: the first concerning the retrieval of aerosol properties from a geometrically and radiometrically calibrated all-sky camera with the aid of a CIMEL and a machine learning technique. The second basically generalize the first study including retrieval of the same properties in partially cloud scenarios. The third and last concerns about the radiometric definition of the transition zone between clouds and free sky, a really challenging task of first importance, along with the first two studies, for climate prediction tasks.

Observation of neutrinos from astrophysical sources

Michael Wurm

Johannes Gutenberg Universität Mainz, Mainz, Germany

Neutrinos are the most elusive particles of the standard model: without electric charge and only weakly interacting with matter, huge detectors are needed to register even a handful of neutrino interactions. However, this makes neutrinos ideal probes to investigate the interior of astronomical objects and the processes that create them. The talk will describe the current status of neutrino astronomy, ranging from the low-energy neutrinos emitted from hydrogen fusion in the center of our Sun over the bright neutrino bursts emitted in core-collapse Supernovae to the very high-energy neutrinos reaching us from cosmic accelerators over vast distances. We will discuss sources, detectors and what insights astrophysical neutrinos can give both about the objects of their creation and their very own properties.

The Quark model - From SU(N) symmetries to the eight-fold way

Biagio Giuseppe Banigi

Universitâ degli Studi di Palermo, Palermo, Italy

With the development of fundamental physics, the effort to obtain a systematic cataloguing of the enormous number of particles discovered in the period between the two world wars became increasingly important.

The observation of the hadronic family gave rise to an extraordinary new classification, now called the Standard Model. In this theoretical framework, a decisive contribution is made by the quark model, which describes the subjects of the strong interaction.

Posters

Graphs Theory and its presence in Physics

Paula Algueró Ferriols

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Mathematics and physics are two sciences that have always been related to each other. Integral and differential calculus was developed by Newton due to his need to formulate and explain physics theories. On the other hand, mathematics has always been a language for physicists to explain the universe and its laws, that's why it isn't a surprise that mathematics' branches such as geometry or calculus have an important presence in physics. Another branch of mathematics present in Physics that isn't as known as others is graph theory. This is used to represent and analyze multiple problems such as "The Königsberg bridges", which was solved by Leonard Euler and started graph theory. In Physics, we can find it at the Hubbard Model, which is used in solid state physics and is the most simple model that shows interesting phenomena such as superconductivity or metal-insulator transition and it can be seen as an extension of the Hamiltonian graph. We can also find graph theory in the Feynman integrals, which are used in the perturbative quantum field. These integrals are associated with what we call Feynman diagrams or graphs where every edge represents a particle or an antiparticle. There are lots more examples where we can find graph theory in physics; vibrational analysis in networked systems, electrical networks... That's why, though this isn't a famous mathematical branch, it is very important and nowadays is gaining importance not only in physics but also in a lot more fields such as social networks, computational networks, flight connections...

On the Cosmic Neutrino Background (CMB)

Martín Gil de Pareja Zapata

Universidad de Murcia, Murcia, Spain

The poster will talk about de Cosmic Neutrino Background (CNB o CVB) and show different detection methods and experiments. In the poster it will be shown how the detection of the neutrino coming from the Big Bang improves the information of how the universe was form in a time difference of 379.000 years respect of the CMB and 2 seconds information of the CNB. It will also explain and refer to the differences theories that support the idea and the development in the experimentation.

Women in STEM: data and statistics

Vega Jiménez Miñarro

Universitat de València, València, Spain

Even though in the last decades, we've made a lot of progress in achieving legal equality between men and women in the EU, there are some areas that still need to be reviewed thoroughly. Areas where closing the gender gap depends, not only on cultural and socio-economic context, but also factors such as self-perception or previous educational experiences.

This is the case of STEM disciplines (Science, Technology, Engineering and Mathematics), where we can see a big gap between students and also in researchers. In investigation, having a diverse team is crucial sometimes for providing a different angle of approaching experiments or having an innovative point of view, and that's why lots of associations and public organizations are working on scaling down these differences. This is also mainly the reason Gender in Physics Day (GiPD) and International Day of Women and Girls in Science was created, to promote science amongst young people, especially young girls.

In fact, la Universitat de Valencia, promotes and organizes activities to give acknowledgement of women scientists working in STEM areas and spread science among youth. This year, on the occasion of 11F (Day of Women and Girls in Science), university held a round table with important scientists and researchers to raise awareness of the situation of women working in investigation fields and in popular science, but also to disseminate the conferences, debates and activities planned by the equality committee.

This poster shows a small overview of women's situation in Europe in STEM fields, not only in research but in higher education too, based on statistics and data, focusing in the field of physics.

Maxwell: Electromagnetism

Francisco Méndez Riquelme

Universidad de Murcia, Murcia, Spain

The invention of electromagnetism and its connection to the theory of light constitutes a fundamental milestone in the history of physics. James Clerk Maxwell, a prominent Scottish physicist of the 19th century, was the main architect of this revolutionary scientific understanding.

Maxwell unified the previous theories of electricity and magnetism into a coherent set of mathematical equations, known as Maxwell's equations. These equations describe the fundamental relationship between electric and magnetic fields and establish that changes in one field generate the other. Through his work, Maxwell demonstrated that electricity and magnetism were different manifestations of a single force: electromagnetism.

A key aspect of Maxwell's equations was the prediction of the existence of electromagnetic waves, which propagate at the speed of light. This led Maxwell to postulate that light itself is a form of electromagnetic radiation. In this way, Maxwell provided a unified explanation of electricity, magnetism, and light, establishing the foundations of electromagnetic theory.

Maxwell's invention of light became a momentous milestone as it changed our understanding of the nature of light. Prior to Maxwell's contributions, light was considered an independent entity, with its own properties and behaviors. However, thanks to his theory, it was demonstrated that light is a manifestation of the interactions between electric and magnetic fields, thereby extending the scope of electromagnetic theory to optical phenomena.

Maxwell's electromagnetic theory paved the way for future scientific and technological developments, laying the groundwork for modern physics. His equations provided the mathematical framework for the study and understanding of electromagnetic phenomena, leading to advancements in areas such as wireless communication, electronics, and optics.

In summary, James Clerk Maxwell's invention of electromagnetism and its connection to the theory of light represent a momentous achievement in physics. His Maxwell's equations unified electric and magnetic fields and demonstrated that light is a form of electromagnetic radiation. These groundbreaking ideas laid the foundations of modern physics and have had a significant impact on science and technology to this day.

Cognitive biases: How far can someone trust their brain? The importance of self awareness

Aleksandra Mitkova

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Our species, known as ***Homo Sapiens***, is distinguished from other animals by our intellectual abilities. Yet, we are still not unaffected by our own capacity of processing information. Cognition refers to the process by which animals collect, retain and use data from their environment. A set of cognitive skills impact an animal's behaviour and influences how they react to changes in environment; this mechanisms that our brain has developed throughout evolution have been essential for our survival. However, nowadays, life has changed an enormous amount, and our cognitive processes did not remain unaffected.

Cognitive biases are systematic cognitive dispositions in human reasoning that often do not comply with the tenets of logic, probability reasoning, and plausibility. These intuitive and subconscious tendencies are at the basis of human judgment, decision making, and the resulting behavior.

This phenomenon can also be seen in science and gender. This systematic cognitive errors present themselves in search processes, homosociality, in the evaluation of teaching and research, and the think-manager think male-effect, which associates attributes to men that benefit them in the scientific environment.

Research focusing on conscious or deliberate biases toward women, particularly in workplace settings, has led to the study of unconscious bias. This occurs when a person consciously rejects gender stereotypes but still unconsciously makes evaluations based on stereotypes; meaning, not having deliberatively sexist behaviours, but rather unconscious predispositions forced upon us in our childhood.

All of us are susceptive of cognitive biases, and we need to challenge our believes and perceptions in order to obtain objective and rigorous data; for that matter, it is crucial to be aware of our limitations, and, as a well-rounded scientists would be, question all knowledge and predispositions we bear in ourselves.

An Insight on Maxwell's equations

Juan Moya Rico

High School Senior Student

The idea of this project is to provide evidence for some relations regarding the gravitational, electric and magnetic fields by operating with a 3D space definition of the magnitude and direction of the field at every point defined by the variables x,y,z. We start by using our known definition of the field strength and generalise it with unit vectors to give it a direction and magnitude at any point in a 3D or 2D space. As a starting point we will use Newton's law of gravitation, Coulomb's law for point charges and the Biot-Savart law. We then, with the aid of the gradient, divergence and curl operations attempt to prove some of the most important relations which are held true when working with these fields.

Firstly, for the gravitational field we define both the gravitational field and the gravitational potential and relate them. We do the same for the electric field and then using Gauss's divergence theorem we prove two important relations for the electric and gravitational flux. When approaching the magnetic field, we consider a 2D plane perpendicular to a conductor to reproduce the magnetic field that is left behind by this conductor. We find a way to express the magnetic field strength at a point using the Biot-Savart law and generalise it to a 2D plane with some basic vector knowledge. We then are able to find proof for Ampère's law by taking the curl of the field and note some important truths about the field.

In conclusion, the aim is to provide a different approach to the understanding of some of these relations that many of us have been using since high school. It will also try to open a debate on what this can reveal about the nature of fields by posing some interesting questions and attempting to interpret the meaning of some relations.

A brief introduction to dark matter

Octavio Miguel Muñoz Bausili

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Dark matter is a type of non baryonic matter, which does not interact with electromagnetic radiation and it is only noticeable due to its gravitational effects. It is known to be five times more abundant than ordinary matter [1,3].

Numerous observations made by Oort, Zwicky or Rubin indicated that a large amount of non luminous matter must be considered in order to justify the gigan-

tic difference when calculating masses of astronomical objects such as clusters or galaxies through observational and theoretical procedures [1].

Moreover, the composition of dark matter remains to date a mystery. Multiple evidences presented by collaborations, such as the MACHO project and observations of the Cosmic Microwave Background prove that dark matter can not be made of baryonic, ordinary matter, rather of a new particle, which does not fit with any other found in the Standard Model (SM) [1,3].

Therefore, the existence of dark matter proves that the SM needs to be upgraded and one of its possible expansions, supersymmetry (SUSY) does offer a possible candidate, called neutralino, which is nowadays considered to be the best candidate for constituting dark matter. Nevertheless, there are lots of other candidates, such as the axion, Kaluza-Klein particles or branons. Dark matter candidates are typically referred to as WIMPs (Weakly Interacting Massive Particles) [1,2,3].

Lots of experiments are currently trying to detect WIMPs, such as ADMX. Dark matter could be detected both directly (through devices that could be able to detect small interactions of WIMPs with some element it contained) and indirectly (according to SUSY, neutralinos should annihilate with each other, giving off various products which could be detected) [1].

Therefore, dark matter is currently an attractive research topic as it is necessary to describe large scale structures and its formation and has relevance in other fields of physics, such as particle physics [1].

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Employment of a dictionary learning algorithm for the detection of the gravitational signal emitted by a "hypermassive" neutron star

Joan Paulo Martínez

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The collision of two neutron stars gives rise to a transient object called a "hypermassive" neutron star, an unstable object that, within milliseconds, releases the rotational energy that maintains its shape as high-frequency gravitational waves

and collapses into a black hole. By studying the waves emitted during this millisecond period, we can obtain information about the "hypermassive" neutron star. Despite the difficulty associated with detecting the post-merger part of the signal, as it lies at the sensitivity threshold of current detectors, Advanced LIGO and Advanced Virgo will be able to perform these types of detections in the next generation. Therefore, this work presents a study of their possible detectability. We focus on obtaining relevant data about the equation of state followed by dense matter. To archieve this, waveforms from the region of interest of the signal, obtained through numerical relativity simulations, are used. Specifically, the public catalog of CoRe signals is employed. An existing dictionary learning algorithm is trained to reconstruct signals and correctly classify them based on the equation of state of the simulations used in the catalog. To test the reconstruction, these signals from the catalog will be mixed with real noise frames from the detectors, and the classification of the signals will be verified.

The nature of light in the 17th century

Anna Quintero Bueno

High School Senior Student

In this poster I will discuss theories about the nature of light during the 17th century. It was a considerable debate during this period and during the following ones. There were two main theories: the corpuscular theory, defended by Isaac Newton with the book Optiks in 1704, and the wave theory, defended by Christian Huygens with the book Traite de la lumière in 1690. According to the corpuscular theory, light was composed of tiny material particles emitted at high speed in a straight line by luminous bodies. Newton also used the corpuscular model to explain reflection and refraction. However, the latter was erroneous because Newton assumed that light traveled faster in denser media than in less dense media. And according to the wave theory, light was propagated by mechanical waves andneeded a material medium to propagate, which was called ether. In addition, Huygens' principle made it possible to explain the phenomena of reflection, refraction and diffraction. Huygens demonstrated that in refraction, the velocity was higher if the medium was less dense, contrary to Newton's ideas. Due to Newton's great prestige, his ideas prevailed over those of Huygens for more than a century. Years later, new theories emerged.

The nature of light: 19th against 20th century

Diana Radita

High School Senior Student

The nature of light has been unbeknown to humankind throughout the centuries. In the 17th century Newton defended corpuscular theory which stipulates that light acts like a particle despite Huyghens' opposition, who claimed that light acts like a wave. Two centuries later Young confirmed Huygens' hypothesis with his double-slit experiment, where light experiences diffraction, a phenomenon characteristic to waves. The experiment consists of shooting a laser through two narrow slits. When passing through these slits, the "waves" of light act as new spotlihgts i that interfere with each other. This interference causes patterns in a photosensitive screen that demonstrate wave behavior. However, a century later Einstein postulated the existence of photons, light quantums that behave like particles. This reopened the debate about the real nature of light. In this project I will be reviewing both theories and analysing them.

The future of energy production: Nuclear Fusion

Albert Resta

Universitat de València, València, Spain

It is well known that we are experimenting an energetic crisis due to the low reliability of the current energy sources. Nowadays, most of the energy we consume is obtained by non-renewable processes such as coal burning or extraction of petroleum since they can provide large amounts of energy quickly. These procedures have many downsides, the most noticeable being an environmental crisis.

Renewable energy sources are progressively gaining ground and many countries are investing on them installing solar panels, windmills, etc. These instruments take advantage of natural processes which cannot produce as much energy as traditional non renewable alternatives, so it is not possible to exclusively rely on them. Although, nuclear fusion is the best alternative, surpassing fission in every aspect; more energetic, less nuclear waste, etc.

Nuclear fusion consists in obtaining energy by combining atoms, which can happen in extreme conditions of pressure and temperature, for example in the Sun. The main reaction being investigated on is the combining of deuterium and tritium, which are two isotopes of hydrogen. These can be found on water, but tritium is

radioactive, so it must be bred from lithium. Moreover, a small quantity of material stores loads of energy meaning supplying is not a big deal.

Currently, there are many experiments taking place in the world which mainly use a Tokamak reactor that consists of a toroidal shaped chamber where plasma is heated and confined by strong magnetic fields, thus, conditions for fusion to occur are achieved. The latest project, ITER, which is in construction, will test the capabilities of nuclear fusion reactors as power plants.

Maxwell's Magnetic Masterpieces: Electrifying Elegance

Santiago Sánchez

High School Senior Student

The poster would mainly focus on the four Maxwell's equations and their interpretation. Each one would be explained term by term with a small diagram and drawing. Besides that, there would be a short text explaining why these equations are so important and how these changed the world in so many ways. Not only on how we understand it but also the impact on industry, and our daily routines (such as smartphones, household appliances, new energetic resources based on induction and so).

At the bottom of the poster there would be some photos of physicists that contributed to the development of the connection and understanding of magnetic field. Below each image there would be their achievements in this field.

To sum up, the poster structure would be constituted by: Explanation of Maxwell's equations, Text about the importance of these, Daily usage, Energetic usage and Physicists images and their contributions.

Cherenkov radiation: illuminating the path to scientific breakthroughs!

Larissa Schlecht

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Cherenkov radiation, named after the scientist Pavel Cherenkov, is electromagnetic radiation emitted when a charged particle passes through a dielectric medium

faster than the speed of light in that medium, emitting a blue glow (Figure 1a). But how can something be faster than light? While the speed of light in vacuum is c = 299792458 m s^{-1}, the light slows down in other mediums. This makes it possible for particles, in other mediums, to be faster than light. A interesting example is the sonic boom of a supersonic aircraft given that the Cherenkov radiation is the optical equivalent to it.

Nowadays, this great discovery has many applications: detect and identify particles, medical imaging, among others. To identify particles, which means, to know its mass, it is necessary to determine the speed of the particle. The characteristic angle of the Cherenkov radiation cone and the amount of radiation depend on the speed of the particle which makes it possible to determine its mass, through relativistic relations, if the moment is known (Figure 1b). Regarding to the detection of particles, a great example is a neutrino detector in Japan, the Super-Kamioka Neutrino Detection Experiment. This detector uses the produced Cherenkov radiation, as a result of the interaction between the electrons and nuclei of the water, to detect and analyze the characteristics of the neutrino.

In conclusion, thanks to the fascinating Cherenkov radiation, there is another way to unveil the mysteries of the universe, advancing in knowledge in all fields.

Physics in Ancient Greece

Álvaro Serrano

High School Senior Student

Humans have been searching for knowledge in nature since ancient times. Some of the earliest discoveries happened in ancient Greece, where natural philosophers tried to find rules to describe the world. Three remarkable conclusions are the development of the heliocentric model by Aristarchus of Samos, Archimedes' principle by Archimedes of Syracuse, and the pursuit of the arche, which was the first attempt to find a substance from where everything came.

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Celia Yelo	Universidad de Murcia

Additional Information

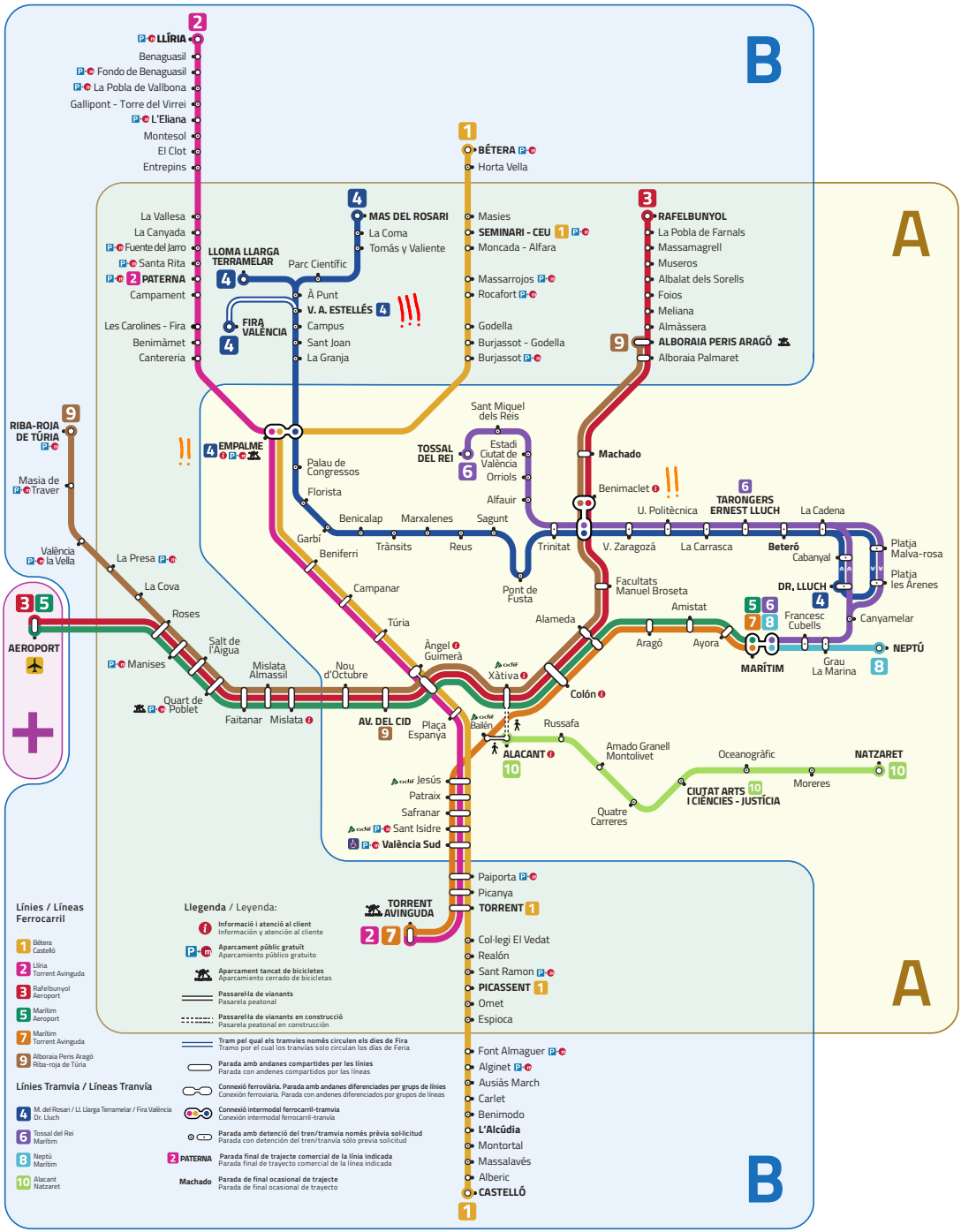
During the days of this School, the only way to get to the Campus is by **Metrovalencia tram, line 4**. Three stations lie next to the Campus: Sant Joan, Campus and **V.A. Estellés** (this one being the most appropriate). On Monday and Friday, you must stop on V.A. Estellés (we will guide you from there on Monday and it will be the only open gate on Friday).

If you come by car, we suggest to first check the route on Google Maps, OpenStreetMap or equivalents. You will most probably end up in the CV-35. There, the panels indicate explicitly ***universitat***. There is a free parking right behind the Campus, which can be accessed by the side of the Burjassot cemetery.

Coffee breaks will take place at the Faculty's Hall. Lunches will take place at the Faculty of Pharmacy canteen. Closing Lunch will take place at "El Delgadito", near the Godella station (Metrovalencia line 1).

metrovalencia

PLÀNOL ZONAL TARIFARI



GENERALITAT VALENCIANA

ATMV Autoritat de Transport Metropolità de València

FGV

Xarxa apta per a persones de mobilitat reduïda excepte València Sud
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AENOR TRANSPORTE DE PASAJEROS

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