Sixth Physics Erasmus Summer School

Unveiling the Secrets of Matter and Light

A unique opportunity to know our Faculty of Physics as a potential Erasmus destination, to discover the city of Valencia, and to establish contacts with Physics students from various European universities

September 9th-13th, 2024

Facultat de Física, Universitat de València

Universitat de València · forthem. Fostering Outreach within European Regions, Transnational Higher Education and Mobility · Università degli Studi di Palermo · Johannes Gutenberg Universität Mainz · Facultat de Física · University of Jyväskylä · Latvijas Universitāte · R.S.E.F.

Contents

1. Programme

	Monday 9	Tuesday 10	Wednesday 11	Thursday 12	Friday 13
8:30-10:40	8:30-9:35 Registration	9:00-9:50 *Peter van Loock: Quantum computation, communication and internet with light	9:00-9:50 *Jiahui Zhuo: Study of matter, antimatter and dark matter at the LHCb experiment.	9:00-9:50 Saara Kaski: Laser-induced breakdown spectroscopy	
	9:35-9:50 Welcome address	9:50-10:15 Heitor da Silva: Quantum Fluids of Light	9:50-10:15 Jorge Prado: Astroparticles: messengers from the cosmos.	9:50-10:15 Rosa Vila: Holography: from Physics to daily life	9:50-10:40 Valeria Militello: Molecules in Vision Science
	9:50-10:40 Víctor Martín-Lozano: Standard Model of Particle Physics: What's (the) matter?	10:15-10:40 Anna Garrigues: Mass measuring using light, sound, and their interplay	10:15-10:40 Adriana Bariego: Dark matter: what is it and how to detect it.	10:15-10:40 *Anabel Martínez: A general overview of multifocal intraocular lenses and their optical properties	
10:40-11:10	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:10-13:15	11:10-12:00 *Lucia Masetti: Studying elementary particles at the LHC and highlights from the ATLAS experiment.	11:10-12:00 Laura Molina: The invisible particles: neutrinos.	11:10-12:00 *Mauro Paternostro: Alice through the looking glass	11:10-12:00 Tuomas Grahn: What holds atomic nuclei together?	11:10-11:30 Contributed talk
	12:00-12:25 Helena Burriel: Computing challenges in particle physics.	12:00-12:25 Vicent Giménez-Alventosa: Applications of physics in medicine.	12:00-12:25 Paula García: Predicting and modeling human color vision	12:00-12:25 Mireia Simeo: Environmental radiation.	11:30-11:50 Contributed talk
	12:25-13:15 Pascuala García: How to include gender dimension in physics?	12:25-12:45 Contributed talk	12:25-13:15 Alberto Aparici: Heroines to the core: the history of the atomic nucleus	12:25-13:15 Experimenta fair	11:50-12:40 Álvaro Pons: Visual Illusions
		12:45-13:05 Contributed talk			School's closing lunch
13:15-14:35	Lunch	Lunch	Lunch	Lunch	
14:35-	14:35-15:25 Varis Karitans: Phase Retrieval in Optics	14:35-15:25 José Manuel Calatayud: Career opportunities in Medical Physics	14:35-14:55 Contributed talk	14:35-14:55 Contributed talk	
	15:25-15:45 Contributed talk		14:55-15:15 Contributed talk	14:55-15:15 Contributed talk	
	15:45-16:05 Contributed talk	15:25-17:10 Round table on Career prospects	15:15-17:00 Round table on Erasmus mobility: Studying in Europe	15:15-16:05 *Ana J. López Using lasers to unlock the secrets of art and archaeology	
	16:05- Collaborative games	18:00- Historic Valencia & la Nave guided tours	18:00- Historic Valencia & la Nave guided tours	16:05-16:45 Poster session	
				16:45-17:15 Live connection with the control room of ATLAS	
				17:30- Open air concert	

Topics
Optics, optometry & vision science
Atomic, nuclear & Particle physics
Multidisciplinary, Cross-cutiing topics
Contributed talks
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.

2. How to get to the School's venue

The Campus of Science is located at Doctor Moliner 50, Burjassot. There are three ways to arrive from afar:

1. By car. There is a free parking lot south of the Campus.
2. By tram. Line 4 → Vicent Andrés Estellés station. Underground connection at Benimaclet and Empalme.
3. By bus. EMT, line 63 → Campus de Burjassot station.

3. Invited speakers' lectures

Heroines to the core: the history of the atomic nucleus

Alberto Aparici, Instituto de Física Corpuscular (IFIC)

The nucleus is the inner sanctum of the atom. It contains 99.9% of the atomic mass and its electric field herds the clouds of electrons into the orbitals that make chemistry possible. Yet what does the nucleus look like at a close glimpse, and how do protons and neutrons organise inside it are questions that proved very hard to crack, and in some cases are still unanswered. This talk will tell this story, from the discovery of the nucleus to the elucidation of much of its internal structure. Notably for a field like physics, known to be a male- dominated discipline, nuclear physics benefited from the insight of some of the most brilliant female physicists of the 20th century. This will also be their story, and the story of how their ideas changed forever our picture of the nucleus.

Dark matter: what is it and how to detect it

Adriana Bariego, Instituto de Física Corpuscular (IFIC)

Dark matter (DM) holds a privileged position in the formation of the universe. The existence of Dark Matter has been postulated from its gravitational effects on astrophysical objects at various scales. So far, a particle nature of this non-baryonic form of matter remains unknown. Weakly Interacting Massive Particles (WIMPs) are an interesting candidate that is in agreement with the observations of DM at different scales.

The method of Indirect Detection of DM involves observing its annihilation or decay products originating from astrophysical objects, where large amounts of it are believed to accumulate. Searches for the products of DM annihilation are performed in dense regions, such as the Galactic Centre, because galaxy formation theory predicts the existence of galactic DM halos with very high densities at the centre of the object; and near heavy celestial bodies, such as the Sun.

Computing Challenges in Particle Physics

Helena Burriel, Universitat de València

Particle physics, the branch of science dedicated to understanding the fundamental particles and forces that constitute the universe, relies heavily on advanced computing technologies. The challenges faced in this field are related with the immense volume of data generated by particle accelerators such as the Large Hadron Collider (LHC). Experiments at the LHC, like the ATLAS experiment, can produce petabytes of data per second, requiring robust data acquisition, storage, and processing systems. Efficient data management within the LHC tiered architecture is crucial, involving algorithms for filtering and reducing data without losing essential information. Additionally, the need for high- performance computing (HPC) to simulate particle interactions and analyze experimental results, often based on Monte Carlo methods, require immense computational power and resources, generating vast amounts of synthetic data. The Institute of Corpuscular Physics in Valencia, Spain, is involved in the ATLAS experiment. ATLAS is one of the major experiments conducted at the Large Hadron Collider (LHC) at CERN (the European Organization for Nuclear Research) in Switzerland. The involvement of the IFIC is in the Tier-2 and Tier-3 of the ATLAS experiment, and it involves developing and maintaining the hardware infrastructure for particle physics research and providing the computing solutions for integrating and ensuring interoperability among the diverse computing systems. As the complexity of particle physics experiments increases, innovative computing solutions such as machine learning and artificial intelligence are becoming essential. These technologies offer potential improvements in data analysis and pattern recognition but also introduce new complexities and the need for specialized expertise.

Career opportunities in Medical Physics

José Manuel Calatayud, Hospital Francesc de Borja

Medical physics is an interesting yet often overlooked career in the field of physics, especially when it comes to its application in hospitals. Many people, including healthcare professionals, are not fully aware of its role. However, the contribution of medical physics is essential for ensuring the quality and safety of diagnostic and treatment procedures involving ionizing radiation.

To become a medical physicist in a hospital, there exists a residency training program called RFIR (Radiofísico Interno Residente). This is similar to other medical specialty training programs like MIR (for doctors) or FIR (for pharmacists). There are three main areas involving of work: radiological protection, nuclear medicine, and radiotherapy.

In radiological protection and radiodiagnostics, medical physicists ensure that

X-ray imaging equipment operate safely, minimizing radiation exposure to both patients and staff, maintaining high safety standards, and ensuring accurate diagnostic images.

In nuclear medicine, the calibration of equipment for the detection of radioactive sources is required for accurate diagnostic and therapeutic procedures, as well as ensuring proper dosing of radioisotopes, which means calculating and administering the correct amount of radioactive material to patients. Radiotherapy is perhaps the most relevant area for medical physicists within hospitals, where most physicists work. The design and optimization of radiation treatments is required to target tumors precisely while protecting surrounding healthy tissue. Also, quality controls of accelerators and radioactive sources need to be designed and supervised by medical physicists.

In summary, medical physics, which is more physics than medicine, offers an interesting career for physicists.

Predicting and Modeling Human Color Vision

Paula García Balaguer, Universitat de València

This presentation explores the relationship between light, the human visual system and computational models designed to simulate color perception. Vision processes about 80% of external information, with color vision being crucial. Developing mathematical models to predict color vision benefits fields such as painting, imaging, video, artificial vision and robotics. Color vision involves both the physical properties of light and the attributes of the visual system. Light reflected from an object travels through various ocular media before reaching the retina, where it is converted into neural impulses directed to the brain. Photoreceptors, cones and rods, play key roles in the retina, each with different spectral sensitivities and behaviors. The information gathered in the retina is then transmitted to the primary visual cortex for processing. However, the neural processes converting these light stimuli into subjective color experiences are like a black box; we know the input entering the visual system, but what happens inside is challenging to model accurately. Mathematical models aim to simulate what happens along the visual system by combining biological structures, physiological factors, experimental results and theoretical assumptions to predict human color vision. By simulating the behavior of cones and the subsequent neural pathways, these models offer insights into the mechanisms underlying color perception, color constancy and individual differences in color vision. Additionally, this presentation will feature demonstrations showcasing the challenges faced by individuals with color vision deficiencies in everyday situations. Using color vision models, we will illustrate how color vision anomalies impact tasks such as shopping, working, playing video games or managing medications.

But... photons have no sex/gender! So...how to include gender dimension in physics?

Pas García-Martínez, Universitat de València

Physics is considered to be "objective", so it is not affected by sex or gender, and people who do physics (researchers, teachers, students) do not interfere in such objectivity. But it is not true because physics classrooms, labs, history are extremely affected by sex or gender, and it is almost always dominated by men, so male perspective becomes the standard and female perspective is marginalized. In physics women are still under-represented and there is a low level of gender mainstreaming that can affect research and innovation. Gender stereotypes and cultural biases seems to be decisive factors in early career choices.

When we talk about gender mainstreaming in science, we are referring both to women as scientific subjects - considering the number, position and trajectory of those who carry out research-, as well as women as the as the object of science, as part of the social reality, with its particular demands and experiences. So, there are aspects of science that can be improved by embracing gender perspective.

We can hide behind the definition of physics that only include logical discussions, equations, and formal mathematics (it is true that equations have no sex/gender), but in real life, physics must be contextualized: how is it performed? who does it benefit, what is the purpose? Physics is not only dominated by men, but is also loaded with masculine connotations on a symbolic level, and this limited and limiting construction of physics has made it difficult for many women to find a place in the discipline. In this presentation we will try to change such a "culture of physics" to make it more inclusive.

Light, sound and their interplay: a (fiber) ring to measure them all!

Anna Garrigues, Universitat de València

Optical fibers are waveguides that are known in telecommunications and sensing. They are responsible for taking internet to your house, however, they can be used for so much more. At the Laboratory of Fiber Optics at Universitat de València (LFO-UV), we study the fundamentals of the interaction between light and sound (optomechanics) in fibers. We see fibers not only as platforms for optics but also for acoustics. This talk will focus on the study of nonlinear processes such as Forward Brillouin Scattering (FBS) to built precise, smaller, and resistent sensors.

We will cover basic aspects of fiber optics and resonators, fundamentals of nonlinear processes and scattering to get familiar with FBS, the nonlinear process in which optical and acoustic waves speak to each other.

This research work was part of the undergraduate and master thesis of the presenter so it also aims to motivate the interest of the audience on applied and experimental physics research.

Applications of physics in medicine

Vicent Giménez-Alventosa, Instituto de Física Corpuscular (IFIC)

Explore how physics revolutionizes medicine, from advanced imaging techniques to cutting-edge therapies, and discover the future of healthcare driven by scientific innovation.

What holds atomic nuclei together?

Tuomas Grahn, Jyväskylän yliopisto

Atomic nuclei are intriguing objects of nature, since their existence and properties are governed by an interplay of the three fundamental forces, the strong, weak and electromagnetic interaction. In this talk I will go through the observations and theory that helps us to understand such a complex systems. I will start with the constituent protons and neutrons and introduce concepts that are used to simplify the complexity.

Phase retrieval in optics

Varis Karitans, Latvijas Universitāte

Detectors are unable to follow the extremely fast oscillations of the electromagnetic field and register only intensity while the information about the phase is lost. This is known as the phase problem. Phase retrieval deals with retrieving the missing information about the phase from intensity measurements. Phase retrieval has found applications in many fields of science (crystallography, materials science etc.) and especially in optics.

In optics, phase retrieval algorithms are based on coherent diffractive imaging (CDI). The first algorithm to retrieve the phase successfully was the Gerchberg-Saxton algorithm based on propagating the object back and forth thereby updating the information about phase while preserving the information about intensity. Now, other algorithms based on masking the object and capturing far-field diffraction patterns have become popular. One typically uses either amplitude or phase, or complex masks to modulate the object under study. Next, coded far-field diffraction patterns are acquired, and the phase of the object is retrieved by solving an optimization problem.

At the Institute of Solid State Physics, University of Latvia, several projects dealing with phase retrieval have been realized. The goal of the postdoctoral project

"Reducing/cancelling the effects of vitreous floaters using a phase retrieval method based on coded diffraction patterns" was to develop a method how to reduce the visibility of vitreous floaters using phase retrieval. The goal of an ESA project "Feasibility of phase retrieval adaptive optics for Satellite-Ground optical communication" was to develop a system for real-time correction of atmospheric aberrations based on phase retrieval.

Laser-induced breakdown spectroscopy - spectroscopic insight on material analysis

Saara Kaski, Jyväskylän yliopisto

A powerful laser beam directed to the target with such an intense energy, that the surface immediately explodes into scorching plasma...

Such a "Star Wars Death Star phenomenon" is the essence of the laser-induced breakdown spectroscopy (LIBS) technique – but in notably smaller scale than planets. Laser pulse generates a hot (about 10000 K) plasma plume of the ablated material, but the crater area typically is only of few hundred square micrometers. The chemical composition of the material can be determined based on spectroscopic analysis of the laser-induced plasma. As the optical emission originates from the excited atomic, ionic, and molecular species from the ablated area, LIBS is an advantageous method in both direct mapping of sample surfaces and depth profiling. The lecture covers the basic principles of spectroscopy and characteristics of LIBS: the generation of plasma, the influence of the laser wavelength and pulse energy and how the signal can be optimized with time-resolved detection. Also, several examples of applications of LIBS to material analysis will be given at wide range up to Mars, where the LIBS currently is operating in both rovers Curiosity (ChemCam) and Perseverance (SuperCam).

Quantum computation, communication, and internet with light

Peter Loock, Johannes Gutenberg-Universität Mainz

In this talk, I shall give a little overview of light-based approaches to quantum technology. Especially for communication, employing light as an information carrier is a great choice, because it's fast, as we all know from optical classical communication and the classical fiber-based internet. Naturally high speed and large clock rates are also a benefit in computing, and for quantum computing, photons offer room-temperature operations unlike the typical solid-state quantum computer platforms. On the other hand, photons get easily lost and they don't like to interact with each other (they prefer to interfere) which is bad for quantum communication and computing. I shall try to explain the most commonly considered remedies to circumvent photon losses and suitably boost photon interferences.

Using lasers to unlock the secrets of art and archaeology

Ana Jesús López Díaz, Universidade da Coruña

Lasers have become invaluable tools in art and archaeology, revolutionizing the ways artefacts are analysed, restored, and preserved. In art conservation, lasers are used for precise cleaning of delicate surfaces. Techniques like laser ablation allow conservators to remove layers of dirt, varnish, and pollutants from artworks without damaging the underlying material. For instance, in paintings, the controlled energy of lasers can strip away unwanted layers without harming the paint or canvas. In archaeology, lasers facilitate detailed analysis and documentation. Furthermore, lasers are used in the field of spectroscopy, where they help identify the composition of materials. Techniques like Raman spectroscopy and Laser-Induced Breakdown Spectroscopy (LIBS) analyze the molecular and elemental make-up of artefacts. This non-destructive analysis is crucial for understanding the provenance and historical context of archaeological finds. Additionally, 3D laser scanning captures detailed digital models of artefacts and sites, preserving their current state and providing a basis for virtual reconstructions. This technology aids in the study, preservation, and public dissemination of cultural heritage, allowing for detailed analysis and remote access to digital replicas. In summary, the use of lasers in art and archaeology enhances the ability to analyze, restore, and preserve cultural heritage with unprecedented precision and care, fostering deeper understanding and safeguarding history for future generations. In this talk, we will present examples of the work of our research group in the field of cultural heritage analysis and conservation, as well as the new projects we are developing in order to make progress in unlocking the past.

A general overview of multifocal intraocular lenses and their optical properties

Anabel Martínez-Espert, Universitat de València

In the condition known as cataract, the crystalline lens of the eye becomes opaque, resulting in decreased vision. The usual treatment for cataracts is to replace the opacified crystalline lens with an intraocular lens. Nowadays, several types of multifocal intraocular lenses are available to meet the visual demands of the patients for clear vision at different distances. In addition, multifocal lens implantation, even before the crystalline lens opacification, has become an increasingly common alternative for the treatment of presbyopia.

Multifocal intraocular lenses can be classified according to the number of foci they produce. In this sense they can be classified as monofocal, bifocal, trifocal, and extended depth of focus lenses. Additionally, they can be classified according their design technology: refractive or diffractive. Refractive lenses might feature concentric designs, where alternating zones provide different powers, or segmented designs, which divide the lens into distinct zones for varying powers. Diffractive lenses utilize the wave properties of light to achieve multifocal vision. Considering the wide variety of commercially available intraocular lenses, it is essential to use objective methods to evaluate their optical quality and focusing properties. One effective approach is in vitro assessment using an optical bench.

Advances in the design of multifocal intraocular lenses have significantly enhanced cataract surgery and vision correction, offering patients a wide range options to meet their individual visual requirements.

Studying elementary particles at the LHC and highlights from the ATLAS experiment

Lucia Masetti, Johannes Gutenberg-Universität Mainz

The proton-proton collisions inside the Large Hadron Collider allow us to study the properties of matter particles and their interactions in similar conditions just to moments after the Big Bang. The lecture will first introduce the general principles of particle detection at a high energy collider and will then discuss how the data recorded by the ATLAS experiment are used in statistical analyses to improve our understanding of elementary particles and their interactions within and beyond the very successful Standard Model. Results regarding the Higgs boson and the top quark will be used as examples.

Molecules in Vision Science

Valeria Militello, Università degli Studi di Palermo

Biological systems are essentially nonlinear complex systems, equipped with a hierarchical organization developed on various levels, which present synergistic responses to environmental changes and interactions with external conditions. Physics provides very powerful theoretical (and computational) methods and experimental approaches to investigate the structure of biological macromolecules. In this lesson we can see the specific role of some molecules involved in vision in terms of the relation between structure, function and dynamics and when their changes can induce pathologic structures which lose the function. The optical spectroscopic methods used for studying the molecules will be shown.

The neutrinos: the ghost particles

Laura Molina, Instituto de Física Corpuscular (IFIC)

Neutrinos are one of the most abundant particles in our universe. They can be produced in a wide variety of processes such as collisions of cosmic rays with the particles in the atmosphere, in particle accelerators, in nuclear reactions inside stars as the Sun, or even in other astrophysical phenomena as supernovas. Nevertheless, many characteristics of these particles are still puzzling for the particle physicists. In 2015, Arthur B. McDonald y Takaaki Kajita, won the Nobel prize "for the discovery of neutrino oscillations, which shows that neutrinos have mass". This measurement represents the first experimental evidence of physics beyond the Standard Model of particle physics and could have significant implications for our understanding of the universe. In this talk, we will study the complexities of such elusives particles as well as the experiments aiming to solve the open questions related to the neutrino sector.

Alice through the looking glass (or a discussion on light and [quantum] mechanics)

Mauro Paternostro, Università degli Studi di Palermo

In this talk, by placing "mechanics" right at the center of quantum mechanics, I will illustrate how it is possible to drive mechanical systems so as to explore quantum effects at the large-scale limit. I will also describe how system that are currently developed, managed and controlled in optomechanics labs can be used to build prototype quantum thermal machines and ultra-sensitive sensors for the exploration of the foundations of quantum theory.

Astroparticles: messengers from the Cosmos

Jorge Prado, Instituto de Física Corpuscular (IFIC)

More than four hundred years have passed since Galileo pointed his telescope at the sky. During this time, and especially in the last century, humanity has significantly advanced its understanding of the Universe through the study of the electromagnetic spectrum. However, there are also other messengers that can reveal to us insights about what is happening beyond the boundaries of our Solar System. In this lecture, we will briefly review the current status of the so-called "multi-messenger astronomy", a recently born field of astroparticle physics that aims to combine the information from various astronomical messengers, such as photons, neutrinos, charged particles, and even gravitational waves.

The analogy between matter waves and nonlinear optics: insights into Quantum Fluids of Light

Heitor da Silva, Universitat de València

For a long time, analogies have been employed to understand certain physical phenomena by relating them to others that are already better understood. These analogies are prevalent across many areas of physics, but one of the most fruitful and far-reaching lies between quantum physics, classical physics, and optics. Such analogies often emerge from similarities in physical concepts, which are then reflected in the mathematical formalism. In this presentation, I will focus on the analogy that can be drawn between matter waves, particularly Bose-Einstein condensates (BECs), and nonlinear optics. A brief comparison of the two descriptions will be provided, concentrating on how the physical parameters of each system correspond to one another, ultimately introducing the concept of a quantum fluid of light. Finally, I will discuss some recent theoretical and experimental studies on quantum fluids of light.

Holography: from Physics to daily life

Rosa Vila, Universitat de València

In this talk, we will explore the concept of light as a wave and the diffraction phenomena, as well as related practical applications in science and daily life. Firstly, we will focus on diffraction principles and what happens when light traveling along free space comes across with an obstacle. Secondly, I will explain the diffraction grating concept by means of practical live demonstrations and how the different wavelengths interact with it. Moreover, practical applications of diffraction such as the measurement of thickness in objects will be presented so as to end up explaining the concept of holography, firstly introduced by Dennis Gabor, starting from its semantic significance ('holo-', meaning 'all' and '–graphy', related to 'written representation') and followed by the introduction of its main characteristics that have lead this technique to become nowadays a widely used tool for metrological and other applications such as tri-dimensional and bi-dimensional imaging techniques. Regarding these aspects, the relationship between optical phase information of samples and the associated Optical Path Differences (OPD) that can be translated to topographical data will be explained providing examples of concrete biological applications using different holography arrangements, as well as topographical characterization of surface defects and engravings present in widely used ophthalmic materials. However, other interesting approaches that can be currently found in our daily lives will be explained, thus involving the use of holography in arts, metrology and security protocols used in the manufacturing of banknotes, credit cards and identity cards, as well as in product guarantee labels.

Standard Model of Particle Physics: What’s (the) matter?

Víctor Martín Lozano, Universitat de València

Visual illusions

Álvaro Pons, Universitat de València

Environmental radiation

Mireia Simeó, Universitat de València

Study of matter, antimatter and dark matter at the LHCb experiment

Jiahui Zhuo, Instituto de Física Corpuscular (IFIC)

4. Participants' oral contributions

An alternative refraction using power vectors

Alicia Barber, Universitat de València

The refraction process allows the optometrist to compensate for the patient's ametropia by placing lenses in front of the eye. By convention, this compensation is done using the notation (S, C x-axis), where "S" represents spherical diopters and "C" represents cylindrical diopters, which correct astigmatism at a given axis. However, in this formula the three values are interdependent, which leads to a practical problem for situations such as addition of lenses with power in different axes (for example, intraocular lens and cornea, or corneal and internal astigmatism), as well as for carrying out statistical studies. An alternative method that avoids these problems is the power vector notation, with the formula [M, J0, J45], where "M" is the spherical equivalent while "J0" and "J45" are the pure astigmatic values obtained at those meridians. These values follow the Fourier decomposition of the dioptric power of any lens, which consists of a constant term, a cosine term, and a sine term This notation addresses the aforementioned problem while offering multiple applications. To calculate these parameters in the clinic, instead of going through the extended conventional refraction process (best vision sphere, bichromatic, JCC, best vision sphere, binocular balance, etc.), we will place a pinhole slit in four positions (at 0°, 90°, 45°, 135°) and we will transform the results into its power vector notation, which can then be placed in glasses once converted to spherocylindrical notation.

Quantum Dots: Chemistry Nobel Prize 2023

Laura C. Martínez-Leal, Universitat de València

Nowadays, we have Q-LED televisions all around us while some years ago we only had LED televisions. Why have TVs acquired a Q? Well, that Q stands for Quantum, as new devices are incorporating quantum dots into their screens. These quantum dots are special because of their shining and intense colours that allow screens to emit very sharp images with a bigger colour range than normal LEDs. Quantum dots provide new advantages such as working faster and occupying much less space. All these wholesome characteristics are possible due to their particular structure, which is obtained after a careful synthesis that has been in constant improvement since their first discovery in 1958.

The particle in a box model applied to conjugated π bonds: a easy way to solve numerically the Schrödinger's equation

Leyre Falcón Martínez, High School Senior Student

Physical chemistry is a discipline that, despite being introduced in secondary school, does not receive much attention. Emission and absorption spectra and the photoelectric effect are poorly explained, without going into detail. Indeed, the Schrödinger's equation (the time-independent wave function version) is introduced mentioning that it can be solved by applying advanced mathematical methods to calculate electronic transitions.

However, it is possible to try to solve the wave function and the calculation of the emission and absorption spectra for simple molecules. I propose calculating the absorption wavelength for simple molecules by approximating the conjugated π bonds to the particle in a box model. For this aim, the wave function will be solved numerically using a spreadsheet (MS Excel) taking into account several variables such as the energy (E), the box length (a), the size of the interval of the objective function (h) and the energy of the level considered (n).

The Role of the Stokes Lens in Adjustable Astigmatic Devices

Sara Ferrer Altabas, Universitat de València

The versatility of variable optical devices has been demonstrated to be highly applicable in a multitude of fields. Regarding variable astigmatic optics, the concept has already a long history. In fact, one of the first variable optical devices presented was precisely the astigmatic Stokes lens in 1849. The invention combined two cylindrical lenses of equal dioptric power but opposite sign which rotation one relative each other generated pure astigmatic power (with no spherical component). Stokes' idea may appear to have gone unnoticed, but it is, in fact, present every day in optometric practice thanks to its fixed version known as Jackson cross-cylinders. Over the years, the design presented by Stokes contributed to the development of the tunable optics field beyond astigmatism, and also was a pioneer approach to power vectors formalism. Focusing on the concept of the astigmatic Stokes lens, several different applications have been emerging, most of them related with ocular astigmatism. These applications could be classified according to their primary function: measuring (quantification) or compensating (improving image quality). In this presentation, we will revisit the Stokes lens design and its applications along the years. In particular, the presentation will include a detailed account of specific applications conducted by our research group as, for instance, the measurement of ophthalmic lenses in a modified manual lensmeter.

Never stop looking up

Jorge García Martí, High School Senior Student

First of all, as the title suggests, we are going to talk about astronomy, more specifically about amateur astronomy and astrophotography. So let me explain to you my history about how I discovered my passion for the universe. So that, a few years ago I discovered that to observe the universe you do not need to be a professional. Since then, not only have I spent my time in visual astronomy but also in astrophotography. Thus, now we are going to learn the basic knowledge about how to photograph the night sky: astrophotographic disciplines (focus in Deep Sky Objects, DSO), DSO astrophotography equipment, how light works, how a camera works (and how to use it in astrophotography), how to photograph a DSO (galaxies, nebulae, etc.) and image stacking and processing. Also we are going to talk about light pollution and its consequences and maybe some more topics. Finally, the goal of this presentation is to encourage people to "look up".

How to build your own radio telescope

Octavio Miguel Muñoz Bausili, Universitat de València

Studying celestial bodies using the visible light that reaches Earth will usually not give us the complete picture, as these objects do not only emit radiation as visible light but in the complete electromagnetic spectrum. Thus, if a solid understanding of these bodies is wanted, a study of all their emitted radiation is required, including the radio range, and here radio astronomy comes into play. Radio astronomy is the branch of astronomy that studies celestial bodies using their emitted radio signals, giving huge research opportunities as these signals can be produced from very energetic processes or from dark objects that emit no visible light.

Typically, radio telescopes are the antennas used by astronomers to pick up these radio signals, which are usually weak as their emission sources are very far away, making these machines usually big and expensive. Nevertheless, the basic technology behind them is actually quite simple and with a small budget and some easy access materials it is possible to build a simple but functional radio telescope that will be able to detect radio emissions from the sun, some satellites and even nearby buildings.

5. Participants' posters

Carnot's Theorem

Bernat Abad Orenga, Universitat de València

The poster to be presented will consist of Carnot's Theorem, concretely on understanding its statement and explaining its applications and its philosophical implications.

Carnot's Theorem states that *there cannot be a heat engine that operates between two given heat sources that has a higher efficiency than a Carnot that works between these same thermal reservoirs*:

$$\eta \leq \eta_c, \eta = \frac{|W|}{Q_c}$$

Thus, if we consider that the machine in question is reversible, the equality is accomplished. These propositions are a consequence of Kelvin-Planck's statement about the second law of thermodynamics, which states that *no thermodynamic process is possible whose only result is the absorption of energy in the form of heat from a single reservoir and the production of an equivalent amount of energy in the form of work*. It should be noted that these statements are, fundamentally, empirically inferred and therefore induced from the observation of the material world. Both the theorem and the corollary will be proved verbally during the presentation.

This theorem has many applications for the engineering of engines (such as internal combustion ones), refrigerating machines, steam turbines, etc. This is because this theorem establishes a limit on the efficiency of this type of machines with which it is quite useful to improve the design of these, since the efficiency of the Carnot machine can be easily calculated based on the temperatures of the thermal sources.

This theorem seems to be far from the domain of philosophy, but as the second principle of thermodynamics is not only restricted to the study of machines but transcends the energetic processes of matter in general, the theorem now gains philosophical significance. There are times when in physics there are phenomenological impossibilities such as an object with mass moving faster than light, or also like Carnot's Theorem. These examples have in common that they are faced with a restriction of an imperative nature as a result of being matter and that it obeys the laws of the universe we know, a restriction imposed by an ontologically superior entity: since we are matter and these impossibilities affect us, then it is unapproachable for us to alter the effects of these and to observe and thus understand its nature. We may see this entity as in the hands of God, but if we look at our starting point, these impossibilities come from empirical induced statements. If we assume that the induction is completely true, then, could it be that what is known as *God* (abstractly, the ontologically superior entity) could be nothing more than a finite or infinite set of statements that govern the universe?

EEG Analysis: Normal Versus Abnormal Streopsis

Albina Abdullayeva, Mehrdad Naderi, Tatjana Pladere & Gunta Krumina, Latvijas Universitãte

Modern technology has transformed our experience of three-dimensional (3D) environments, reliant on depth perception. While prior research has focused on the effects of 3D technology on brain activity in individuals with normal stereopsis, there is still limited understanding of its impact on those with abnormal stereopsis. This study seeks to fill this gap by using electroencephalography (EEG) to compare brain activity between individuals with normal and abnormal stereopsis.

In the study, participants with normal stereoacuity (40 arc seconds or better) and those with abnormal stereoacuity (100 arc seconds or worse) were asked to identify whether images were 3D or two-dimensional (2D). Each trial began with a fixation cross for one second, followed by the display of four circles. In 3D trials, one circle appeared closer to the participant, while all circles were on the same plane in 2D trials. EEG monitoring was used throughout to capture event-related potentials (ERPs) linked to depth perception.

The P3 component of the ERP exhibited significant differences at the Pz electrode between 2D and 3D conditions for both normal and abnormal stereopsis, underscoring its role in depth perception. Power Spectral Density (PSD) analysis revealed slightly higher alpha wave activity in those with normal stereopsis, but no significant differences in beta waves were found. These results offer objective insights into how different stereopsis abilities affect the perception of 3D images.

This research is funded by the Latvian Council of Science (project No. lzp-2021/1-0399, "Development of guidelines for evaluating the visual effectiveness and ergonomics of innovative 3D displays").

The importance of Noether's theorem

Irena Barba la Orden, Universitat de València

Emmy Noether was a German mathematician specialized in theoretical physics and abstract algebra. In 1918, within the realm of physics, she formulated Noether's Theorem, which establishes a connection between physical laws and conservation laws. The theorem states: *To every differentiable symmetry generated by local actions, there corresponds a unique conserved quantity*. Mathematically, suppose we have an infinitesimal variation (with f^i specific functions and ε an infinitesimal parameter):

$$q^i \to q^i + \varepsilon f^i(q, \dot{q}, t)$$

If we can express the differential of the Lagrangian as the derivative of a function with respect to time, we can identify a conserved quantity as:

$$\partial_\varepsilon L = \varepsilon \frac{F(q, \dot{q}, t)}{dt} \;\to\; C(q, \dot{q}, t) = \frac{\partial L}{\partial \dot{q}^i} f^i - F$$

We can see different examples in classical mechanics. By finding different symmetries to which a conserved quantity corresponds, some examples are:

- Invariance under time translations: conserved energy
- Invariance under rotations: conserved angular momentum

On the other hand, an example in quantum physics is the Kronig-Penney model (a simplified model of a periodic potential seen by free electrons in a crystalline solid). Since it presents a discrete translational symmetry, the quasi-momentum is conserved (which will appear in the wave function).

In conclusion, we see this theorem provides a very important result because it allows us to unify conservation laws under a common symmetry principle, thereby simplifying and deepening our understanding of the system we are studying.

A drop in the ocean of reality: Detecting the Higgs boson

Lucía Benages Guijarro, Universitat de València

The Higgs boson was first introduced in a scientific paper written by Peter Higgs in 1964. It was proposed as a fundamental particle in the standard model crucial in explaining the weak force using quantum field theory as well as the mass of fundamental particles.

Given its large mass and short mean lifetime the Higgs boson is extremely unstable and therefore cannot be found in nature. Consequently, studying this particle was not possible until the construction of the Large Hadron Collider. Even using the particle accelerator the boson decays too quickly for it to be observed directly, it is only possible to detect the particles it decays into which unfortunately are also abundantly produced in particle collissions that do not result on the creation of the Higgs boson.

In order to determine if the Higgs boson is indeed being produced in particle collisions it is necessary to analyse the resulting particles and calculate the rest mass of the particle they decayed from. If they decayed from a certain particle the rest mass will have a set value, if they did not come from a particle decay the value of the rest mass will follow a certain statistical distribution, a histogram of these results would show this statistical distribution but with a certain "peak" at the mass of the Higgs boson.

Finally, in 2012 a particle compatible with these predictions was discovered and later confirmed to be the Higgs boson, leading to our current understanding of the standard model.

Luminous Phenomena in the Sky

Aroa Castillo Calatayud, Universitat de València

Human beings have always been curious about that huge space above them that limits with the only territory they're able to explore. The sky. Our ancestors were able to observe lots of phenomena that happened in the air and seemed impossible to explain, from bright dots to colorful sights.

Usually, the most appealing phenomena are the most colorful, such as rainbows or aurora borealis. On the one hand, rainbows have a leading role in fairy tales or fantasy histories. They are perceived as magical even though nowadays has a scientific explanation. Rainbows are caused due to the reflection of light inside the droplets, this reflection separates the light into its component wavelengths.

On the other hand, the aurora borealis. Lots of people want to enjoy them at least once in their lives. This phenomenon is caused by electrically charged particle from the Sun. They are captured in the Earth's magnetic field and with atoms and molecules in our atmosphere. Its wavy paterns are originated by the lines of force in the Earth's magnetic field.

People are amazed by this type of phenomena and they've been trying to explain them during centuries. The sky has always been an endless source of curiosity and desire to understand.

Optical Tweezers

Alejandro Estellés Roig, Universitat de València

Optical tweezers are an optical trap which allow the confinement of particles using a laser beam. When the particle is very small compared to the wavelength of the light of the laser beam, the Rayleigh aproximation, the particle is treated as an induced dipole in an electric field, being the total force the one applied for the electric potential on the induced dipole. In the opposite case, the Mie aproximation, geometrical optics and radiation pressure can be used to explain the phenomenon. With this, gradient and scattering forces can be explained through the transference of momentum from the beam to the particle. This invention suposed a revolution and now is very useful, being used everyday in research in fields like physics, chemistry or biology.

The Spider Web of the Cosmos: The universe from the perspective of graph theory

Hannah Ferrer Domínguez, Universitat de València

The order of celestial bodies and the relationships established between them are not the result of chance, so it is possible to establish a conditions that determine these relationships. Therefore, from the perspective of graph theory, considering celestial bodies as nodes and the relationships that exist between them as arcs, it is possible to creat a formalization that allows a general study of each of the different systems or sets that are observable in the universe.

Astroparticle Physics

Germán Guijarro Pardo, Universitat de València

The astroparticle physics is a very new type of searching events across the universe. We are used to look to the space with normal telescopes and that gives us a very few information of what's happening outside. This new type of physics is using the neutrinos to study the same things the astronomy's does, but this time with particles.

We don't really know lot of this new branch but we can assume and we are certain that when we have more knowledge about the relation between neutrinos and all the events are happening we will be able to find lots of new things that with the normal astronomy are not able to.

It is also interesting the large telescopes are being making to do this such difficult task of detecting de neutrinos such as IceCub and Km3net.

Gravitational waves, ripples in spacetime

Pau Huerta Solís, Universidad de València

Gravitational waves are ripples in the fabric of spacetime, first predicted by Albert Einstein in 1915 through his theory of general relativity. These waves are produced by violent and energetic processes in the universe, such as colliding black holes, merging neutron stars, and supernovas. Essentially, they are the result of massive objects accelerating through space, causing disturbances that propagate outward at the speed of light.

The detection of gravitational waves was a monumental achievement in physics and astronomy. It was not until September 2015 that the Laser Interferometer Gravitational- Wave Observatory (LIGO) made the first direct observation using interferometry techniques such as the Michelson interferometer or Fabry Perot cavities. This discovery opened up a new way of observing the universe, allowing scientists to study celestial events that are invisible to traditional telescopes which rely on electromagnetic radiation.

Gravitational waves provide a unique method of gathering information about the cosmos. For instance, they can reveal details about the nature of black holes, the behaviour of neutron stars, the fundamental properties of gravity itself... They also enable tests of general relativity under extreme conditions. The study of gravitational waves is a rapidly growing field, with ongoing and future missions planned to detect waves from various sources across different parts of the spectrum.

In essence, gravitational waves have revolutionized our understanding of the universe, giving us a new lens through which to view the most cataclysmic events and the fundamental workings of spacetime.

The Impact of Climate Change on Extreme Weather Events

Carmen López, Universitat de València

In this poster we will talk about:

- The science behind climate change and its effect on weather patterns.
- Examples of extreme weather events (e.g., hurricanes, heatwaves, floods) that have been linked to climate change.
- Statistical analysis of the frequency and intensity of extreme weather over the past few decades.
- Predictions for future weather patterns based on current climate models.
- Mitigation and adaptation strategies for communities affected by these events.

Dark Matter in Universe

Jennifer López López, High School Senior Student

Dark Matter is a mysterious component that makes up over the 80% of the matter in the universe. Unlike normal matter, it doesn't interact with the electromagnetic force. In fact, dark matter interacts very weekly or almost not at all with the ordinary matter. It is extremely difficult to detect with current instruments. But we know of its existence because of the gravitational effects that it appears to have on galaxies and galaxies cluster. Scientists have studied gravitational forces for years, and they concluded that the measured gravity exceeds what can be explained by ordinary matter. Without the dark matter the structure of the universe doesn't make sense and we can't explain how galaxies were formed. Alternative theoretical explanations for the effects of dark matter don't fit with observational evidence.

Why is it that space-time curves?

Nathan Alexander Marin Lupsa, Universitat de València

In this poster I will try to explain how Einstein's and other scientists' theories began to understand that gravity is not actually a force but the curvature of space-time itself, trying to compile some more information about gravitational laws, the equivalence principle and general relativity and combining it with nice drawings to illustrate what I'm explaining and to make the poster come alive. Thank you.

The Mandelbrot set and the Fibonacci sequence

Alfredo Martínez Solaz, Universitat de València

The poster explores the intriguing relationship between the Mandelbrot set, a complex and infinitely detailed fractal, and the Fibonacci sequence, a series of numbers where each number is the sum of the two preceding ones. It delves into how these seemingly unrelated mathematical constructs intersect.

Chaos theory

Diana Radita, Universitat de València

Chaos theory is a captivating field within mathematics, physics, and other sciences, focusing on the hidden patterns and deterministic laws of dynamical systems that are extremely sensitive to initial conditions. These systems, once thought to be entirely random and disordered, actually exhibit underlying patterns, interconnections, constant feedback loops, repetition, self-similarity, fractals, and self-organization.

A central idea in chaos theory is the butterfly effect, which illustrates how a small change in the initial state of a deterministic nonlinear system can lead to significant differences in a later state. This concept highlights the sensitive dependence on initial conditions. Edward Lorenz, a pioneer in this field, famously summarized chaos with the statement: "When the present determines the future, but the approximate present does not approximately determine the future."

Edward Lorenz's research was instrumental in developing chaos theory. His work, especially on weather systems, demonstrated how tiny differences in initial conditions could result in vastly different outcomes, challenging the predictability of long-term weather forecasts.

This poster will explore various systems exhibiting chaotic behavior, such as weather patterns, planetary orbits, and population dynamics. It will also discuss the origins of chaos theory, including Lorenz's significant contributions, and highlight its practical applications in fields like meteorology, ecology, and engineering.

In summary, chaos theory reveals that within the seeming randomness of complex systems, there are deterministic laws and patterns. This theory has profoundly impacted our understanding of complex systems and continues to influence various scientific disciplines.

The standard model (and the point particle theory)

Marina Sendra Ferrando, High School Senior Student

Many physicists have tried to give an explanation to the universe itself, what are its fundamental blocks and the interactions that take place in it. This poster explains the most accurate picture we have of this structure, the standard model.

It will contain the point particle theory and the both types of elementary particles that exist, the ones that form matter, fermions, and the 3 generations, and the cause of the forces, bosons. Also I intend to put some of the most important formulas that are in this eld for example the Dirac equation, which describes all particles.

Another point I would like to talk about the problematic it brings when we try add the graviton, the quantic explanation to the gravity. Which only leads us to use Einstein's general relativity as the "for now" solution.

This poster would contain drawings and pictures that help understanding more the matter of subject. And I'll like to add a QR that leads the reader of the poster into one of the most promising, but for now failed theory that tries to solve the problem of gravity, string theory.

This is just an idea, that's why, even if the main subject will maintain the same, maybe all of the topics I would like to cover, don't t in a single poster, that's why they could might change a bit or be less.

6. List of participants

Students

Name	Affiliation
Bernat Abad Orenga	Universitat de València
Albina Abdullayeva	Latvijas Universitãte
Àngela Albuixech Bisquert	Universitat de València
Maria Antonietta Monachello	Università Degli Studi Di Palermo
Leire Aresti Guijo	Euskal Herriko Unibertsitatea
Lucia Arrufat Sorli	Universitat de València
Irene Barba La Orden	Universitat de València
Alicia Barber Sancho-Tello	Universitat de València
Rita Belda Albero	High School Senior Student
Lucía Benages Guijarro	Universitat de València
Giorgia Borruso	Università Degli Studi Di Palermo
Adrián Cabrera Pérez	Universitat de València
Aroa Castillo Calatayud	Universitat de València
Jorge Catalá Moratal	Universitat de València
Zhaojie Cheng	University of Manchester
Marc Chirona Pla	Universitat de València
Álvaro Colomina Núñez	Universitat de València
Stefania d'Anna	Università Degli Studi Di Palermo
Miguel Debón Verdejo	Universitat de València
Ioan Denis Cazacu	High School Senior Student
Aura Descals Ruzafa	Universitat de València
Miguel Díaz Girona	Universitat de València
Albert Esparza Bonafé	High School Senior Student
Diego Espí Amigo	High School Senior Student
Alejandro Estellés Roig	Universitat de València
Leyre Falcón Martínez	High School Senior Student

Hannah Ferrer Domínguez	Universitat de València
Marina Fons de la Rica	High School Senior Student
Leonardo Fu	High School Senior Student
Laura Fuentes Valderrama	High School Senior Student
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Carlos Gómez Forriol	Universitat de València
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Germán Guijarro Pardo	Universitat de València
David Huélamo Longás	Universitat de València
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Francisco Jara Pérez	Universitat de València
Eduard Julián Peiró	Universitat Politècnica de València
Arttu Kinnunen	Jyväskylän yliopisto
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Andrea Muñoz Ros	Universitat de València
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Giorgia Tumminia	Università Degli Studi Di Palermo
Unax Unzueta Carreras	Euskal Herriko Unibertsitatea
Carlos Fernando Valenzuela Gill	High School Senior Student
Sara Wohlonen	Jyväskylän yliopisto

Invited speakers

Name	Affiliation
Alberto Aparici	Instituto de Física Corpuscular (IFIC)
Adriana Bariego	Instituto de Física Corpuscular (IFIC)
Helena Burriel	Instituto de Física Corpuscular (IFIC)
José Manuel Calatayud	Hospital Francesc de Borja
Pascuala García	Universitat de València
Paula García	Universitat de València
Anna Garrigues	Universitat de València
Vicent Giménez-Alventosa	Instituto de Física Corpuscular (IFIC)
Tuomas Grahn	Jyväskylän yliopisto
Ana J. López	Universidade da Coruña
Varis Karitans	Latvijas Universitãte
Saara Kaski	Jyväskylän yliopisto
Peter van Loock	Johannes Gutenberg Universität - Mainz
Víctor Martín Lozano	Universitat de València
Anabel Martínez	Universitat de València
Lucia Masetti	Johannes Gutenberg Universität - Mainz
Valeria Militello	Universitâ Degli Studi Di Palermo
Laura Molina	Instituto de Física Corpuscular (IFIC)
Mauro Paternostro	Universitâ Degli Studi Di Palermo
Álvaro Pons	Universitat de València
Jorge Prado	Instituto de Física Corpuscular (IFIC)
Heitor da Silva	Universitat de València
Mireia Simeó	Universitat de València
Rosa Vila	Universitat de València
Jiahui Zhuo	Instituto de Física Corpuscular (IFIC)

Organising Comittee

Name	Affiliation
Josu Cantero	Universitat de València
Sara Ferrer	Universitat de València
Roser Forment	Universitat de València
Iván García Blanes	Universitat de València
Alejandro García Ten	Universitat de València
Mª Jesús Hernández	Universitat de València
Guillermo Lagunas	Universitat de València
Neus López March	Universitat de València
José María Martí	Universitat de València
Laura Martínez	Universitat de València
María Moreno Llácer	Universitat de València
Carlos Navarrete	Universitat de València
Raúl Oblaré	Universitat de València
Sonsoles Riscos	Universitat de València
Enric Valor	Universitat de València
Miguel Villaplana	Universitat de València