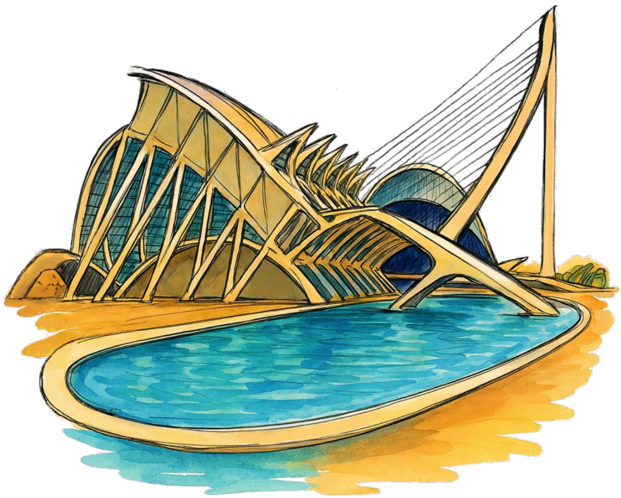
Seventh Physics Erasmus Summer School

Ideas that come true

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 diverse European universities



September 8th-12th, 2025

Facultat de Física, Universitat de València

Universitat de València
Facultat de Física
forthem. Fostering Outreach within European Regions, Transnational Higher Education and Mobility
R.S.E.F.
Università degli Studi di Palermo
JGU Johannes Gutenberg Universität Mainz
Jyväskylän yliopisto
Latvijas Universitāte
Universitatea Lucian Blaga din Sibiu

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Topics
Theoretical Physics
Applied Physcis
Multidisciplinary, cross-cutting 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 Ubication

The E3F school will be held in the *Salón de Grados Joan Lepelchano*, ground floor of Block 0.1.10 of the School of Engineering (ETSE-UV), Avinguda de la Universitat, Burjassot. There are three ways to arrive from afar:

1. By car. There is a free parking lot inside the campus.
2. By tram. Line 4 → "À Punt station". If frequency is too low, Line 4 → "V. A. Estellés" station, then walk 5 min. Underground connection at Benimaclet and Empalme.
3. By bus. EMT, line 63 → "Campus de Burjassot" station, then walk 5 min.

Here we offer a link with the location of the ETSE: https://links.uv.es/RP7l2z2

3 Invited speakers' talks

Monday, 8th September

Theoretical Foundations of Nuclear Physics

Tuomas Grahn, Jyväskylän yliopisto

In this talk I will outline, on the general level, the necessary theories needed to undertand the the structure and dynamics of the atomic nucleus. I will also give few examples of contemporary developments and shed light on connections to other fields of (fundamental) physics.

Introduction to open quantum systems

Francesco Ciccarello, Università degli Studi di Palermo

Introductory quantum mechanics textbooks teach that the time evolution of a system is described by the Schrödinger equation. The resulting dynamics is reversible: differentinitial states will evolve into different final states. However, this is only true in the special case of a closed system; that is, one isolated from the external environment.

We can intuitively see that this is not the general case by considering the example of spontaneous emission, where an atom decays by emitting a photon. If the atom is in its ground state, it remains unchanged; but if it starts in the excited state, it decays into the ground state. Thus, two different initial states (ground state and excited state) both evolve into the same final state: the ground state. This kind of dynamics is therefore not reversible. In fact, for the atom to decay, it must interact with the electromagnetic field (which acts as the external environment). The atom is therefore not a closed system. In such cases, we speak of an "open quantum system".

What is the analogue of the Schrödinger equation for open quantum systems? As of today, no general answer to this question has been found (assuming one even exists). So how are irreversible dynamics described in the quantum world? This seminar will present a short introduction to some basic concepts in the quantum mechanics of open systems.

Controlling the Atomic Structure: The Science Behind Crystal Growth

Carolina Férnandez Saiz, Universitat de València

Understanding and controlling the atomic-scale mechanisms that govern crystal growth is critical for advancing next-generation electronic materials. In this talk, we delve into the fundamental principles of crystal formation, with a particular emphasis on the influence of growth parameters and crystal phase stability. By unravelling these mechanisms, we can strategically engineer materials for high performance electronic and optoelectronic applications.

Moreover, we will present the crystal growth techniques employed within the CreCYCSem group at the University of Valencia, with a special focus on the Mist-CVD method. This technique enables the determination of optimal growth parameters for gallium and indium sesquioxides, materials that offer great potential for advanced applications in power electronics, deep-UV photonics, and emerging electronic technologies.

The quantum sense

Marta García Matos, Museu de la Ciència CosmoCaixa

The arrival of quantum physics represents a change of paradigm. It challenges theories and models which up to that point gave sense to our understanding of the Universe. Randomness seems to rule and realism dissolves along with the boundary between observer and experiment. No certainty nor intuition are there to hold on to, and even though we must accept that we can no longer make sense of it, we need to create a reliable system to represent the world and predict its evolution. What better attitude to tackle this task than the sense of humour? Sense of humour is based on humility and our ability of acknowledging that we have arrived to our limit -and it is at the limit where science is working right now. From this perspective, this talk proposes the definition of "The Quantum Sense", an extra sense to find some extra meaning. And it does so by relying on something that already exists, the literature of nonsense.

G. K. Chesterton considered nonsense literature to be one of those primitive elements that appear from time to time in the world in order to renew it, enabling us not only to feel that we are "the heirs of all ages" but also "the ancestors of primal antiquity". And as an example, he compared the originality of Edward Lear's The Dong with a Luminous Nose with that of the first ship and the first plough. If we must furthermore include it within the greats, we need to show that nonsense literature comes equipped with its own admissible view of the world. "The Iliad is only great because all life is a battle, the Odyssey because all life is a journey, the Book of Job because all life is a riddle." If Alice in Wonderland has to be one of the greats, "the world must not only be tragic, romantic, and religious, it must be nonsensical also".

Accepting that the world is a nonsensical place requires a certain dose of humility. Fortunately, we have very good reasons to be humble.

Nuggets of Relativity

Angelo Carollo, Università degli Studi di Palermo

Relativity is the branch of physics that explains, in a consistent and elegant way, how space and time behave. More than a century after its foundation, the physics of relativity (with all its counterintuitive effects) continues to inspire journeys into the imagination. Using the popular science fiction film Interstellar as a backdrop, I will present a brief and accessible account of some of the most fascinating consequences of special and general relativity, ranging form time dilation to gravitational redshift, from black holes to wormholes.

Tuesday, 9th September

Unfathomable neutrinos - hunting for the ghost particles with light, sound and radio waves

Sebastian Böser, Johannes Gutenberg - Universität Mainz

Neutrinos are the strangers in the Standard Model of particle physics. Despite being the secondmost abundant particle in the universe, little is known yet about their properties and, in part, their sources. Key questions persist about their precise masses, the nature of their oscillations, their role in the early universe, and even the full range of their astrophysical sources.

They only interact weakly, with trillions of solar neutrinos passing through our bodies every second unnoticed. At the same time, these weak interactions allow neutrinos to reach us from the most extreme environments in the universe, such as the core of stars, the center of a supernova explosion, or the jets of active galactic nuclei. This makes them invaluable messengers in astroparticle physics and a smoking gun in the hunt for the long-sought-after sources of cosmic rays, albeit with exceedingly lower fluxes.

Consequently, detectors of immense scale are required to detect their rare and faint signatures. To obtain the required low background levels,these detectors have to be further shielded from the abundant cosmic rays, and are thus often buried deep underground, in polar ice, or submerged in deep water. These gigantic detectors can often only be sparsely instrumented, so that the energy deposits of the neutrinos have to be detected over large distances, providing ample technical challenges. Similar challenges exist when studying neutrinos from artificial sources, such as radioactive decays. Tiny changes in the tails of these spectra offer insight into the very nature of neutrinos, and can potentially explain why their masses are so small.

In this presentation, I will show how neutrinos can be detected using photons, radio waves, and potentially acoustic waves to learn about their sources and infer their properties.

Quantum technologies with single photons

Guillermo Muñoz Matutano, Universitat de València

In the past century, the invention of devices that harness properties of quantum mechanics, such as the laser, completely revolutionised the development of technology. Now, novel quantum communication and computational technologies are on the verge of being invented, which promise a similar technological revolution. Their applications range from classically-unachievable computational power and fully secure communication networks and quantum teleportation to superior sensing devices and quantum simulation physical platforms.

Single photon sources are fundamental elements for photonic quantum technologies, such as quantum sensing, quantum encryption systems and linear optical quantum computing. Photonic quantum information systems are particularly advantageous due to their low decoherence compared with other quantum information platforms combined with a large number of degrees of freedom in which to encode information. Naturally, they are also most readily integrated into existing classical information networks. For these applications, stringent conditions must be met regarding the brightness of the single photon source, the purity of single photon emission (i.e., a low probability of multi-photon emission), and the indistinguishability of the emitted photons.

In this seminar we will review the development of new quantum technologies with single photons, as well as the prospects for their future integration as new applications.

At the edge of Knowledge: Quantum gravity and Strings

Irene Valenzuela, Instituto de Física Teórica (UAM-CSIC)

Introduction to Dark Matter: evidence and theoretical challenges

Giacomo Landini, Instituto de Física Corpuscular - Universitat de València

The Standard Model of particle physics successfully describes the particles and interactions observed in Nature. Despite its great success, it is unable to explain the origin and nature of dark matter. The existence of dark matter is supported by a large number of astrophysical and cosmological observations. In particular, precise measurements of the Cosmic Microwave Background indicate that dark matter constitutes more than 80% of the total matter content of the Universe. Therefore, the very existence of dark matter is one of the main motivations for introducing new physics beyond the Standard Model. In this talk, I will review the main experimental evidence for dark matter, as well as the current status of dark matter models and experimental searches.

Can we hunt cosmic Pokémon using a microwave oven?

Adrián Lambíes Asensio, Universitat de Barcelona

Over the past few decades, dark matter detection has become a fascinating branch of physics. There is sufficient evidence of its existence, but yet scientists still know virtually nothing about its true nature. In some sense, researchers try to detect dark matter going in blind. That reminds us of the augmented reality mobile game Pokémon GO, released in 2016, where players explore the world to capture these amusing creatures. Through this playful analogy, we will explore the axion, a theorised particle that, to date, stands as one of the most promising candidates to explain the nature of dark matter.

Within this context, the haloscope emerges as a method for axion detection. This technique exploits the theoretical coupling properties between the axion and the electromagnetic field of a resonant cavity mode. For outreach purposes, we will see that this instrument is not much different from the microwave oven of our kitchen. In our cosmic Pokémon hunt, the spherical geometry is proposed as an alternative to the simple cubic or cylindrical shapes, commonly used in the design and fabrication of haloscopes.

New ways of entrepreneurship

Lola Garzón Benítez, Universitat de València

In this session, participants will learn about the entrepreneurial ecosystem at University of Valencia so that they can see how entrepreneurship is promoted at our university and compare it with the one at their universities of origin. Throughout the session, entitled "New ways of entrepreneurship", they will see which are the common characteristics and motivations of entrepreneurs and for what reasons they decide to undertake entrepreneurship. We will see the reasons why they choose one idea or another, the values that guide them in the ideation and development of their projects, and how they want to change the world. We will also get to know the type of projects that arise from the University's students, with special emphasis on those developed by physics students. Finally, some interesting tools will be presented so that those who wish to learn more about entrepreneurship can further analyse them in detail.

Wednesday, 10th September

Beyond classical limits: How quantum technologies improve measurement precision

Manuel Gessner, Instituto de Física Corpuscular - Universitat de València

For much of the 20th century, quantum mechanics was seen as afundamental obstacle to making precise measurements. The uncertaintyprinciple, with its built-in limits, seemed to set a hard boundary onhow accurately we could observe the world. But in recent years, rapidprogress in controlling quantum systems has turned that challenge intoan opportunity. In this talk, we'll explore quantumtechnologies—especially quantum sensors—and how they exploituniquely quantum properties, such as stronger-than-classicalcorrelations, to improve measurement precision. This progress is madepossible by an unprecedented level of control over quantum systems, and is already playing a key role in technologies like atomic clocksand gravitational wave interferometers.

Searching for New Physics with gravitational waves

Pedro Schwaller, Johannes Gutenberg - Universität Mainz

In this presentation, we explore the potential of gravitational waves as powerful instruments for investigating new physics in the early Universe. We will start with an introduction to gravitational waves and an overview of current and future gravitational waves detectors. This will be followed by a survey of primordial gravitational waves sources, containing exciting topics such as cosmic strings, domain walls, phase transitions and tachyonic instabilities. I will explain what these could tell us about the early Universe and nature at the shortest scales. Finally we will discuss interpretations of the recent observation of gravitational waves in pulsar timing arrays and their interpretation in terms of new physics.

Interference and plasmonic resonance in absorbing thin films

Varis Karitans, Latvijas Universitates

Thin films and nanostructures play a critical role in numerous applications, for example, micro and nano photonics, microelectronics, photovoltaics, lithography, sensors energy harvesting, photochemical cells, etc. The lecture will focus on absorbing thin films and nanostructures used in optics and photonics. Various structures of dielectric and metallic thin films (for example, metal-dielectric-metal) and arrays of different nanostructures (such as rings and squares) will be covered. Absorption in thin films is based on interference, and the fabrication of such films do not require nanostructuring. Absorption by nanostructures is based on plasmonic resonance, and such absorbing nanostructures can be made either by chemical synthesis, or nanostrucuring and deposition methods. Such structures exhibit different sensitivity to the state of polarization, they have various dependence on the angle of incidence and the spectral range.

At the Institute of Solid State Physics, University of Latvia, we are working on the development of a stack of Si/Cr/Au/Ge/SiO2 thin films and their application in wave guides with absorbing sidewalls. We also synthesize core-shell nano structures with noble metals forming their core and SiO2 shell. Arrays of nanorings and nanosquares fabricated with electron beam lithography will also be shown. Reflectance maps of the stack of thin films depending on the state of polarization and the agle of incidence will also be demonstrated.

COMSOL and MATLAB simulations of phase retrieval from diffraction patterns obtained with a waveguide with absorbing sidewalls will also be presented. These diffraction patterns will be compared to those obtained in free-space.

The Physics Behind Your Screen (and Everything Else): Discovering Condensed Matter and Density Functional Theory (DFT)

Josep Mas García, Universitat de València

Condensed matter physics is one of the most dynamic and far-reaching branches of modern physics. It offers the theoretical and computational tools to understand, predict, and design the physical properties of materials at the atomic scale. Despite its enormous impact (both scientifically and technologically) it is often underrepresented in early physics education.

This talk aims to provide a conceptual introduction to condensed matter physics, with a particular focus on Density Functional Theory (DFT), the most widely used ab initio method for electronic structure calculations. DFT enables the study of complex materials from first principles, with applications ranging from fundamental research to industrial innovation.

Rather than focusing on mathematical formalism, this presentation will highlight the unifying concepts and broad applicability of condensed matter physics. We will discuss how it integrates a wide array of physical principles (including thermodynamics, statistical mechanics, quantum mechanics, and many-body theory) and how it continues to evolve with modern developments such as beyond-DFT methods (e.g., GW approximation, DMFT), high-throughput materials design, and machine-learning-based approaches.

By tracing the historical roots of the field and its current frontiers, this talk will showcase how condensed matter physics stands at the intersection of deep theory and tangible application, and why it remains one of the most fertile grounds for future research and innovation.

Emmy Noether, the lady of rings and symmetries

Lucía Sanus, Universitat de València

This talk aims to explore the life and work of the mathematician Emmy Noether, a figure highly respected by both physicists and mathematicians. Often considered one of the most important mathematicians of the 20th century, Noether made major contributions to abstract algebra and theoretical physics, especially in relation to Einstein's theory of relativity. In addition to her scientific contributions, the talk will touch on the historical context in which she lived, offering a view of her personal and academic journey. Designed for a general audience, this talk combines historical perspective with scientific insight.

Thursday, 11th September

Applications of Nuclear Physics

Panu Ruotsalainen, Jyväskylän yliopisto

My aim is to outline the various applications of nuclear physics in industry and medicine. These applications have been largely developed from the fundamental nuclear physics research activities.

Various applications of liquid metal magnetohydrodynamics

Imants Kaldre, Latvijas Universitates

Liquid metals are used in various fields in industry. They can be pumped and stirred by magnetic fields. Interestingly this is the same effects which determines the processes on the sun and in the earths core.

Finding needles in a quantum haystack: Machine Learning in high-energy physics

Rosa María Sandá Seoane, Instituto de Física Teórica - Universidad Autónoma de Madrid

High-energy physics (HEP) aims to understand the fundamental laws of nature by studying the smallest building blocks of matter and their interactions. To explore these questions, physicists rely on particle colliders, our most powerful laboratories to probe nature at the smallest scales. The Large Hadron Collider (LHC), the world's largest and most energetic collider, generates an enormous amount of data by smashing protons together at unprecedented energies, effectively recreating the conditions of the early universe in a controlled environment. Analyzing this data to uncover rare and subtle physical phenomena is one of the key challenges in the field.

In this talk, we will explore how Machine Learning (ML) has become an indispensable tool in modern collider physics. With billions of proton-proton collisions recorded, ML algorithms assist physicists in sifting through massive datasets, both to identify signatures of elusive particles and to search for signs of physics Beyond the Standard Model. ML techniques are employed at every stage of collider experiments, from triggering and event reconstruction to particle identification and statistical analysis.

Concrete examples will be presented to illustrate how ML is currently being applied in LHC experiments, highlighting both its role in major discoveries, such as the Higgs boson, and its contribution to ongoing efforts to find hints of new physics. The talk will also address the opportunities and limitations of these methods, and how they are shaping the future of particle physics.

(Machine) Learning the Universe

Androniki Dimitriou, Instituto de Física Corpuscular (CSIC-UV)

Friday, 12th September

ESRF-EBS: Recent opportunities for Synchrotron Science

Gema Martínez Criado, European Synchrotron Radiation Facility

Launched in 2020, the Extremely Brilliant Source (EBS) at the European Synchrotron Radiation Facility (ESRF) delivers up to 100 times superior X-ray brilliance, coherence, and emittance. This enhancement enables scientists globally to explore new research fields and analyse materials at atomic resolution, addressing pressing global challenges in health, energy, and the environament. This talk will cover the benefits of the EBS upgrade, recent applications, and latest experimental capabilities available to academic and industrial users across various research fields. It will highlight scientific breakthroughs achieved with flagship and refurbished beamlines, demonstrating how improved X-ray performance and advanced instruments facilitate deeper insights into diverse materials and phenomena. Additionally, the presentation will provide an overview of the status of beamline portfolio, ongoing strategic research, and future perspectives.

The Physics Behind Tomorrow's Solar Technologies

Miriam Mínguez Avellán, Universitat de València

What really happens when sunlight hits a solar panel? In this talk, we'll explore how light becomes current, why the materials behind it matter, and what makes solar technology such a rich field for physicists. We'll also take a look at perovskites, a new class of semiconductors whose unusual properties are opening the door to cheaper and more efficient solar cells — and raising new questions about how materials behave under light. Whether you're into quantum mechanics, solid-state physics, or just curious about the energy technologies of the future, this talk connects with every corner of physics.

Entangled worlds: Art and science

Miguel Peiró, La Academia Arte y Ciencia

In this talk, we will explore the power of metaphors in science communication. One of the main challenges when communicating science to a general audience is how to convey abstract and complex concepts without losing coherence or depth. Through a participative and engaging approach, we will discover how art can offer powerful images and frameworks to illuminate scientific ideas. We will also analyze a couple of examples, focusing on quantum physics and complex systems, to see how metaphors can bridge the gap between scientific knowledge and human understanding.

4 Participants talks

Monday, 8th September

Khoomei: A physical perspective on biphonic singing

Asier Godino Duro, Universitat de Valência

The structure of musical sound is deeply influenced by the physical properties of stationary waves. Understanding harmonic phenomena is crucial for comprehending complex vocal techniques and instrumental timbre, particularly the phenomenon of overtones that follow the harmonic series. One technique that captured the attention of Richard Feynman was Tuvan throat singing (Khoomei or Xöömij), due to the technical skill involved in producing two pitches simultaneously, or *biphonation*, as Feynman described it: "a man with two voices". But how is it possible for a singer to produce two pitches simultaneously? Even today, the biophysical fundamentals of this human biphonic vocal style remain unclear.

In an attempt to understand this ability, we will explore the manifestation of harmonic content in traditional instrumental music and the human voice, using spectral analysis as our main tool. The starting point for the establishment of the basis of the harmonic series and music theory will be the analysis of the harmonic spectra in instruments such as the violin, the organ, and the human voice, among others. Building on this foundation, we will determine how Tuva's distinctive singing technique produces two sounds simultaneously: a deep, resonant sound accompanied by a high-pitched whistling tone that seems to defy gravity.

The importance of optimization in numerical solving

Petteri Tuomola, Jyväskylä yliopisto

Many fields of physics utilize numerical solving in researching various phenomena. In fields such as high-energy physics, solid state physics and thermodynamics, numerous problems have to be computed numerically due to their nonlinearity, chaos-like behaviour or just sheer complexity. Thus the performance of these numerical methods might make the difference between an article or just a frustrated physicist. However, it is not always clear what is the optimal way of solving a numerical problem. In this talk, using my own work and experience as an example, I present the basic features of optimization in the framework of cosmology and a numerical simulation of the inflation period.

Tuesday, 9th September

Limitations of the Standard Model

Jakob Weiß, Johannes Gutenberg - University Mainz

The Standard Model of particle physics is one of the most successful theories in the history of science, yet it is widely recognized as an incomplete theory. It fails to incorporate gravity, explain dark matter and dark energy, or account for the observed matter-antimatter asymmetry. Moreover, it treats neutrinos as massless and leaves the hierarchy problem unresolved.

In this presentation, we will briefly revisit the Standard Model and its major triumphs before providing an entry-level overview of the above-mentioned key limitations. In doing so, the ongoing search for physics beyond the Standard Model is motivated.

The Mysteries of Physics: Ettore Majorana

Gaspare Russo, Università degli Studi di Palermo

My presentation will be dedicated to Ettore Majorana, one of the most fascinating and mysterious characters in the history of physics. Born in Catania in 1906, Majorana was a theoretical physicist of exceptional talent, considered by colleagues such as Enrico Fermi one of the most brilliant of his time.

In the first part of the presentation, I will talk briefly about his life and the historical context in which he lived, describing his academic path and his connection with the group of "I ragazzi di Via Panisperna", a group of young Italian physicists who made fundamental contributions to the study of the atom.

The second part will be devoted, in a simple and informative way, to his most famous contribution: the idea that some particles, such as neutrinos, can be their own antiparticle. This concept, now known as the "Majorana neutrino", is still being studied in modern experiments. I will not go into mathematical details, but I will explain the basic insight and why it is still so important.

Finally, I will talk about the mysterious disappearance of Majorana in 1938, never clarified, which helped to make him a legendary figure. I will briefly recount the main hypotheses and reflect on how this affair still influences today the way in which we remember it.

The presentation is intended to be a tribute to a great Sicilian scientist, who has left a deep mark in physics, while remaining partly an enigma.

Thursday, 11th September

Quantum foundations and the nature of reality: A historical and experimental journey

Lorena Terrón Egido, Universidad Complutense de Madrid

The Nobel Prize awarded in 2022 to Alain Aspect, John Clauser and Anton Zeilinger for their experiments with entangled photons demonstrated violations of Bell's inequalities and laid the foundations for the emerging field of quantum information of science.

The prize reflects the attempt to describe the nature of the reality and examines fundamental elements from the scientific vision, such as the principle of causality. Combining both theoretical and experimental physics, we bring to an end a historical physics paradox that began around one century ago, commencing with scientists in the golden era of quantum physics and finalising in the modern era of quantum mechanics.

Our story begins in 1935 with the EPR paradox proposed by Einstein, Podolsky, and Rosen, when they questioned the description of reality, suggesting that either quantum mechanics is incomplete or it leads to a disturbed physical reality.

We then jump to 1964, when John Bell presented his work about the EPR paradox, converting a theoretical, maybe philosophical, problem into something measurable and subject to an experimental approach. Bell's three main points are: free will, locality and the idea that quantum mechanics is not a complete theory and that a reasonable reality exists underneath. Here we want to touch the implications of the understanding of reality, causality, and measurement, aiming to fully understand what nature is and how it behaves.

We finally get to the experimental perspective of the paradox, now in the 21st century. The experiments are all fully optical, the source produces entangled pair of photons, being this entanglement the the key for quantum information. With two different experimental procedures in 2022 Aspect, Clauser and Anton recieve thir Nobel for the violation of Bell´s theorem, confronting whether our reality is not real, it is nonlocal, we lack free will, or all at once.

Bosonic quantum error correction

Florian Spieß, Johannes Gutenberg - Universität Mainz

Quantum error correction (QEC) is essential to mitigate decoherence and operational imperfections in quantum processors, enabling reliable information storage and processing. As quantum states are inherently fragile, uncontrolled interactions with the environment lead to errors that accumulate rapidly, precluding scalable quantum computation. Developing QEC protocols is a prerequisite for realizing quantum advantage in algorithms such as Shor's factoring and Grover's search.

Historically, the introduction of the nine-qubit Shor code marked a major milestone by demonstrating the correction of arbitrary single-qubit errors through concatenated encoding and syndrome measurement. Subsequently, the formalism of stabilizer codes generalized this framework, employing group-theoretic structures to define efficient error-detecting subspaces.

The landscape of QEC is shaped by strong academic-industry collaboration. Major technology companies such as IBM and Google have actively contributed to stabilizer code research, implementing small-scale logical qubits on superconducting platforms.

More recently, the development of bosonic QEC codes (BQECC) has gotten more attention. BQECCs exploit the infinite dimensional Hilbert space of an electromagnetic or mechanical oscillator to encode redundancy, offering hardware efficient QEC. Among these, "cat codes" utilize superpositions of coherent states to detect and correct photon loss and dephasing errors. Research groups have demonstrated experimental cat code stabilization in microwave cavities, reaching the break-event point of QEC and making it attractive for companies like Amazon and the start-up Alice & Bob to explore this new QEC paradigm even further.

This talk will first motivate and introduce the basics of QEC shortly. We'll consider the simple three-qubit repetition code, showing how redundancy can be implemented by stacking up qubits before moving to the more hardware efficient scheme of BQEC. Along the way, the ever growing interest and involvement of tech-companies will be discussed, highlighting the impact that fault tolerant quantum computers could have.

Friday, 12th September

The Art of Imperfection: From Chaos to Cosmos

Valeria Hernández Díaz, Universidad de Murcia

Several main theories attempt to explain the origin of the universe, with the Big Bang standing as the most widely accepted.

According to this theory, the universe began as a hot, dense state and expanded over time. A crucial idea in this process is symmetry breaking, which helps explain how the early, uniform universe developed into the complex structures we observe today.

From there, the multiverse theory suggests that our universe might be just one among many, each governed by different physical laws. This concept challenges our understanding and raises new questions about the nature of reality.

Exploring these ideas leads to recognizing the limits of science and highlights the role of philosophy and faith in confronting mysteries beyond our reach. Accepting the universe's imperfection allows us to appreciate its beauty and the resemblance of our own imperfection.

5 Participants posters

From bits to qubits: At the dawn of a paradigm shift?

Teresa Benet Casaña, Universitat de València

In 1922, Thomas Kuhn defined the term "paradigm" as a worldview (a set of experiences, beliefs, and values) that shapes how individuals and societies perceive reality and prevails within a given historical context. Some major scientific revolutions that triggered paradigm shifts include: the transition from Ptolemaic to Copernican cosmology; Darwin's pangenesis to Mendelian inheritance; Newtonian to relativistic physics; Aristotelian to classical mechanics; classical to quantum mechanics; and possibly, classical to quantum computing.

Feynman proposed that if computers reached atomic scales, they would need to follow the laws of quantum mechanics. Two key principles (superposition and probabilistic measurement) are essential to understanding quantum computing. Superposition refers to the ability of an electron to be located in a combination of states (A and B) simultaneously. When measured, this superposition collapses into a single, random state.

Classical computing encodes information in bits, which take the value $|0\rangle$ or $|1\rangle$. Quantum computing uses qubits, capable of representing values in the form $a\,|0\rangle + b\,|1\rangle$, where a and b are probability amplitudes. While N bits store N binary values, N qubits can encode 2^N possible states. This memory advantage has a drawback: measuring a qubit collapses it to either $|0\rangle$ or $|1\rangle$, losing the rest of the information. As long as it remains unmeasured, it preserves the full quantum state.

Currently, classical computers still outperform quantum systems in practical tasks. Quantum computing faces obstacles such as measurement collapse, forbidden operations, technical errors, and decoherence. Still, as Michael Nielsen and Isaac Chuang noted, quantum computation is an abstract paradigm for information processing that could have many different possible technological implementations.

Challenging our intuition

Aroa Castillo Calatayud, Universitat de València

Albert Einstein's theory of relativity shows that space and time are relative to the observer. Some of its consequences are illustrated in two famous paradoxes.

On one hand, the twin paradox describes the separation of two twins. One of them travels in a spaceship at high speed, while the other waits for his return to Earth. When they meet again, both think their sibling should be younger. However, they discover that the twin on the spaceship is the younger one due to time dilation. Special relativity predicts that time moves slower for an object traveling at high speeds.

On the other hand, the ladder paradox tells how a ladder moving at near-light speed contracts in length, seemingly allowing it to fit inside a garage (with an entrance and exit) that would normally be too small for it. From the garage observer's perspective, the ladder shrinks because of its speed. However, from the ladder observer's point of view, it's the garage that becomes smaller. This happens because different observers perceive simultaneous events differently, which means that simultaneity is relative.

Both paradoxes prove that space and time are not absolute but depend on relative motion. While the twin paradox reveals the flexibility of time, the ladder paradox shows the relativity of space. These paradoxes challenge our everyday intuition.

Photometric study of Delta Cepheid with a DSLR

Sara Castro Raya, Universitat de València

Photometric analysis of Delta Cepheid (a Cepheid-class variable star -as its name suggests- located in the constellation of Cepheus) using a digital single-lens reflex (DSLR) camera and a non-tracking photographic tripod are presented. We will collect images over approximately twelve nights, enough time to observe two and a half elementary osculations. The observation site is located far enough away from the polluting lights of the city.

First, after obtaining images of the star's variation and processing them (reduce the noise with calibration images), we will obtain a light curve using AstroimageJ to extract the information needed as a data table (a software specifically designed for astronomical photometry). We will fit the curve that passes through the points using different methods, such as interpolation or Fourier series, to find the most suitable model and compare our estimated period with the theorical. Finally, we will compare the data with those from AAVSCO.

Next, the distance between the star and us will be estimated using the data obtained and the calculations will be perform.

Enhancing the Efficiency of Solar Cells Using Advanced Materials: Perovskites and Quantum Dots

Hicham Chelouche, Université Badji Mokhtar Annaba

This poster presents an overview of novel photovoltaic materials (perovskites and quantum dots) and their integration into tandem solar-cell architectures. Highlighting recent lab efficiencies exceeding 30%, it examines their light absorption, charge transport, stability challenges, and potential for next-generation low-cost, high-efficiency solar energy.

A Single Electron Travelling Through Time

Lucía Cifuentes Canós, Universitat de València

Within theoretical physics, we encounter a surprising idea: what if all the electrons in the universe were the same electron moving backward and forward in time? This hypothesis, proposed by John Wheeler to Richard Feynman, stems from the fact that all electrons are completely identical and that, in Feynman diagrams, a positron can be interpreted as an electron travelling backward in time.

This proposal could be compatible with special relativity. Under certain conditions, a particle could follow a closed timelike curve, as long as it does not exceed the speed of light and respects the light cone, which defines physically possible movements in spacetime.

Therefore, a particle could return to the past without violating physical laws, provided no paradox is created. This is what Novikov's self-consistency principle states, allowing us to conceive causally consistent time loops where the past cannot be altered.

Finally, we can connect this idea with CPT symmetry, a fundamental symmetry that asserts physics remains unchanged if we reverse charge, parity, and the direction of time.

To conclude, we must keep in mind that this is purely speculatve. Nevertheless, it is highly interesting and allows us to delve deep into relativity.

The use of simulations in condensed matter physics from undergraduate to research level

Gonzalo de la Calle García, Universidad Complutense de Madrid

Simulations take an important role in both theoretical and experimental aspects across all the disciplines of physics. They are a valuable tool for predicting results that are obtained in the laboratory as well as for solving numerical problems without analytical solutions. In particular, in the field of condensed matter there are of great help since they can be used for solving many body problems, as well as modelling interactions which have no analytical solution. The purpose of the communication is to show different simulations using different open programs which have applications both in teaching Solid State Physics at undergraduate level and in research and more advanced courses.

The CUPS program is a valuable tool for learning the basics of Solid State Physics at an undergraduate level. This software solves numerically different basic problems (phonon dispersion, simple energy bands...) and provides an interface where the solutions can be visualized and the initial conditions modified.

On the other hand, the *mumax3* software is a simulation program used for simulations in micromagnetism, a powerful open-source software that can be used in research. With this software one can explore the consequences of reducing dimensionality in solids and the new physics that it involves without the necessity of advanced laboratory equipment.

In short, the aim of the poster is to present the importance of simulations as tools for better understanding of solids at different levels, in order to be able to get a complete overview of the field of condensed matter physics when combined with the theoretical and experimental aspects.

The atomic nucleus: the core of matter

Pau Gallego Boluda, Universitat de València

Atoms are composed of electrons and a nucleus, which is made up of nucleons: protons with positive charge (referred to as the fundamental charge, equal to the absolute value of electron's charge), and neutrons with no charge. Both protons and neutrons are formed of quarks, which are fundamental particles: the up quark with +2/3 of the fundamental charge, and the down quark with 1/3 of the fundamental charge. The quark structure of the proton and the neutron are p=uud and n=udd respectively

The forces that govern the atomic nucleus are the electromagnetic force, the strong nuclear force and the weak nuclear force. Due to the electromagnetic and strong forces, the nucleus must be in an equilibrium between the two of them in order to be stable. If that's not the case, protons (neutrons) may decay into neutrons (protons), seeking for that stability. Stability is obtained by several factors, such as having a balanced number of protons and neutrons, the shape and the symmetries of the nucleus, or having a special number of protons or neutrons (known as magic numbers: 2,8,20,28,50,82,126).

Several models have tried to explain the structure of the nucleus, such as the Shell Model (or Nuclear Orbital Model), the Liquid Drop Model or the Collective Model. In this poster we will discuss about the strengths and weaknesses of these diverse models.

The Three Gorges Dam and the moment of intertia

Lucía García Gómez, Universitat de València

According to a NASA study, the construction of the Three Gorges Dam in 2012 in China caused days on Earth to become slightly longer. In this poster we will explore the causes of this phenomenon.

First of all, we will explain the concept of angular momentum, used in rotational mechanics, and how it is derived from quantities like moment of inertia and angular velocity.

After that we will discuss the concept of moment of inertia and examine how, in systems where the angular momentum remains constant (such as the Earth), changes in the moment of inertia result in changes in the angular speed. We will include some practical examples such as how figure skaters change the speed of their spins by extending and retracting their arms.

Lastly, we will apply all the previously explained concepts to the case of the Three Gorges Dam. We will describe how it was built and explain why it altered Earth's moment of inertia, thereby slowing its rotation speed. We will conclude with some facts about how this construction really affects us in our daily life.

Thinking with quantum bits

Diego García Martínez, Universitat de València

Quantum computing is an emerging paradigm that takes advantage of the laws of quantum mechanics to process information in fundamentally different ways than classical computing. Its roots are recent, and it has a long way to go, but what can it offer or promise? Artificial intelligence, cryptography, and new materials design are just a few examples of the fields that could be revolutionized by the processing power this technology brings. This poster explores the basic principles that make quantum computers work and how, with different algorithms, we can transform those principles into powerful tools for addressing real-world problems. Additionally, we will explore the differences and advantages that quantum computing has over classical computing, analyzing the potential of this emerging science.

Nucleosynthesis and nuclear fusion

Carlos Gómez Forriol, Universitat de València

Some minutes after the Big Bang, the first nuclei were created through a process known as Big Bang nucleosynthesis, but most of the atoms in the periodic table are created in other processes like stellar nucleosynthesis or supernova nucleosynthesis. The physics of this phenomena intersects most of the branches of physics and relates to modern problems like nuclear fusion.

Analysis of the natural optical activity: polarization rotation via circular birefringence at different sugar concentrations.

Patricia González Piquero, Universidad Complutense de Madrid

The rotation of the polarization plane of linearly polarized light when transmitted through aqueous sugar solutions has been analyzed in this project, demonstrating the optical activity of these samples. This phenomenon arises from the chirality of sugar molecules, which is a consequence of the presence of asymmetric carbon atoms in their molecular structure. Sucrose is dextro-rotatory (+66.5°), but when it is hydrolyzed, it is decomposed in a mixture of D-glucose (+52.5°) and D-fructose (−92°), which is levo-rotatory. Therefore, we are dealing with an anisotropic medium, meaning some of its properties vary depending on the direction of observation.

This study explores several parameters that influence this phenomenon. We can analyze the rotation angle of polarized light propagating through solutions with different known concentration. By this we are able to determine the concentration of unknown samples.

In addition, we can also study its wavelength dependence and what would happen when light with different polarization is used.

Other factors investigated include the change in polarization at different temperatures, which varies the density of our sample, or inducing current in our solution.

A homemade method for investigating this effect is presented. Although simple, it can be further improved and applied to other fields, such as in the determination of blood sugar levels.

Finally, several examples of anisotropic materials in nature and applications of this phenomenon in other fields are presented.

The Role of Physics in Modern Finance

David Gozalo Leal, Universitat de València

Financial markets are complex systems where millions of agents—investors, banks, and institutions interact in real time, influenced by incomplete information, uncertainty, and human behaviour. Traditional economic models often fall short in capturing this complexity, especially during crises or extreme events.

This poster explores how physics, particularly statistical mechanics, chaos theory, and complex systems analysis, offers powerful tools to better understand and model financial phenomena. One key application is modelling price movements using stochastic processes such as the Geometric Brownian Motion, which captures both trend and randomness in asset prices. However, real markets exhibit fat-tailed distributions and abrupt jumps, features that require more advanced models rooted in power laws and fractals.

Furthermore, financial systems can be viewed as networks, where interdependence and feedback loops mean that small disturbances can lead to large-scale instability, similar to behaviour observed in chaotic physical systems. Physics-based approaches allow for the identification of systemic risk, fragile structures, and the propagation of financial stress.

Rather than focusing solely on prediction, physics emphasises understanding the underlying dynamics and structure of the system. This perspective enriches our ability to analyse volatility, risk, and crises with greater depth and nuance.

This poster aims to illustrate how concepts from physics can provide a complementary and often more realistic framework for analysing financial systems, bridging the gap between economic theory and empirical behaviour.

Neutrino oscillation

Germán Guijarro Pardo, Universitat de València

The neutrino oscillations are a phenomenon when we measure the lepton avor of the neutrino and is not the same than the one when it was created. The neutrino can have three different avors depending of which charged lepton they are associated with.

The interesting thing here is that we are seeing that this avor is changing. This phenomenon can only happen when a neutrino has mass, and going into more detail, in three differents masses, each one for every avor. This is not supported by Standard Model as we know it at the moment, because this model doesn't give any mass to the neutrino, and more far away it can't tell three different masses for the three neutrinos that exists. The study of this oscillations can give us more information about the masses of the neutrino and his properties.

The oscillations happens because the different neutrino avors doesn't only have his own mass, each one is composed by three different kind of it, but in different proportions. When a neutrino travels, this three different masses change their phase (because the cuantity of each kind is always the same), resulting in a different combination and giving a different avor of neutrino. Therefore, depending on the distance travelled, the avor measured will be the same as at the beginning or one of the other two left, resulting in a oscillatory motion.

Energy generation in nuclear power plants

Lorena Gutiérrez Portolés, Universitat de València

Nuclear power plants use enriched uranium (3-5% U-235) as fuel. We know that natural uranium consists of two isotopes: uranium-238 and only 0.7% uranium-235, this last is the isotope needed for nuclear reactions. In order to increase the concentration of uranium-235, uranium must be enriched. For this, it is first converted into a gas (uranium hexafluoride), which gets funneled into a centrifuge that spins very fast. As U-235 is lighter than U-238, these molecules migrate to the center and the U-238 is pushed outward. Repeated cycles of this process increase the proportion of U-235 producing enriched uranium suitable to be used as fuel in nuclear power plants.

A nuclear power plant with a pressurised water reactor has three separated water circuits. In the primary circuit, the heat released during the fission of the uranium heats up the water, which is kept under high pressure so it does not steam, in the reactor vessel. The hot water passes via the primary circuit to a steam generator. Here the water in the secondary circuit heats up and turns into steam. This steam drives steam turbines and this in turn drives a generator, which produces electricity. Then, the cooling water from the tertiary circuit cool down the steam in a condenser. The steam from the secondary circuit condenses to water and is returned to the steam generator to be heated again to steam.

Used nuclear fuel remains radioactive for millions of years. It is stored in a special way to minimize harm for the environment. For the first few years after use, it is kept in cooling pools to dissipate heat. Then, it is hermetically sealed in concrete casks for a hundred years. Finally, it is permanently buried in deep geological repositories, where it remains isolated for millions of years.

Quantum Dots: Tiny Giants of Quantum Technology

Laura Hortelano, Universitat de València

Quantum dots are nanoscale semiconductor structures that confine electrons and holes in all three spatial dimensions, leading to quantized energy levels similar to those found in natural atoms. This property allows us to qualify them as artificial atoms and makes them essential in exploring quantum phenomena at the nanoscale.

The poster introduces the fundamental physics behind quantum dots, focusing on quantum confinement effects, discrete energy states, and tunable optical and electronic properties determined by their size, shape, and material composition. It also covers the most common fabrication techniques.

Furthermore, quantum dots have a wide range of practical applications. In optoelectronics, they are used in quantum dot LEDs (QLEDs) and displays due to their precise color emission. In quantum computing, QDs can function as qubits through spin and charge states.

Oscillation of neutrinos as they travel through space and its influence on the current standard model

Alicia Lafuente, Universitat de València

The discovery of the phenomenon of neutrino oscillations was a major scientific event that earned Takaaki Kakita and Arthur McDonald, the discovering scientists, the Nobel Prize in Physics in 2015. The great importance of this discovery lies in the fact that the demonstration that neutrinos oscillate also implies that neutrinos should have mass, which contradicts the current standard model of particle physics.

Neutrinos can be divided into three families, each of which is associated with a corresponding charged lepton (electron, muon or tau). Neutrinos have no electric charge, but can acquire charge through interaction with other particles, thus becoming the corresponding charged lepton depending on their flavor.

Neutrino oscillation consists in the change of flavor experienced by the neutrino as it moves through space, thus altering the way it interacts and the particle with which it is associated. This phenomenon is closely related to the neutron masses, since they allow the connection between the three flavors and the neutrinos to change from one flavor to another along their path. Thus, thanks to experimentation with oscillations it is possible to obtain information about the masses of neutrinos, although the exact values are not known at present, only that they are enormously small, about a million times smaller than that of the electron.

Finally, the study of neutrino oscillations not only leads to new fundamental properties of matter, but also constitutes one of the most promising clues for physics beyond the Standard Model, which would have important implications for the origin of mass and the structure of the universe.

Magnetic induced transparency in cavity-magnon polaritons

Adrián Lambíes Asensio et al., Universitat de Barcelona

Magnons and phonons are collective excitations of the spin system and the atomic lattice of a material, respectively, interacting via magnetostrictive forces. In high-quality magnets such as Y3Fe5O12 (YIG), strong coupling of these quasiparticles has been observed, revealing phenomena like Magnomechanical Induced Transparency (MMIT). Recently, these effects have garnered significant scientific interest due to their potential applications in low-power information processing and quantum communication technologies. MMIT is a quantum coherent phenomenon that arises when magnons hybridize with mechanical vibrations (phonons). This interaction leads to destructive interference between excitation pathways, creating a transparency window around the magnon resonant frequency.

In this work, we investigate magnon-phonon coupling in a magnetic YIG film grown on a nonmagnetic Gd3Ga5O12 (GGG) substrate. Through phonon pumping, magnetization dynamics generate phonon currents that leak into the substrate, which acts as a phonon cavity, carrying away energy and angular momentum from the ferromagnet. Specifically, we report ferromagnetic resonance (FMR) spectra of these bilayers over various power and magnetic field ranges and analyze their associated parameters (phonon and magnon linewidths, magnetoelastic coupling strength, cooperativity, etc.) to detect and characterize magnetic transparency.

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Solar Energy and Photovoltaic Technology: Current Research and Innovations

Jennifer López López, Universitat de València

Solar energy is a renewable source of power derived from sunlight. Among the various technologies that harness it, photovoltaic (PV) solar energy is the most widely used. This technology converts sunlight directly into electricity using semiconductor materials, offering a sustainable alternative to fossil fuels. Over the past decade, photovoltaic energy has seen rapid global growth due to advances in efficiency, decreasing costs, and growing environmental awareness.

One of the key research areas today focuses on the recycling of solar panels at the end of their useful life. While these devices typically operate for 25 to 30 years, millions will begin reaching the end of their lifecycle in the coming decades.

Current innovations aim to develop cheaper and more sustainable recycling methods. Alongside improvements in efficiency, energy storage, and the use of more sustainable materials, these advances represent the path toward a truly circular and environmentally responsible solar energy system.

The Effect of Climate Change on Tectonic Events

Carmen López, Universitat de València

Here we will explain how climate change can affect tectonic events indirectly through the redistribution of weight over the earth, ice melt and pressure over the earth's crust.

The strange nature of reality: quantum tunneling and entanglement

Nathan Alexander Marin Lupsa, Universitat de València

The universe we live in doesn't always follow classical rules. One such phenomenon is quantum tunneling, where particles can pass through energy barriers they classically shouldn't overcome. This effect is explained by the wave-like nature of particles. Another quantum effect is quantum entanglement, which explains how particles become linked such that the state of one instantly affects the state of the other one, regardless of the distance between them. This poster will explore how this two strange phenomena emerge form the same foundational principles of quantum theory, and finally highlight real-world applications, from the scanning tunneling microscope to potential roles in quantum computing and quantum teleportation.

Characteristics of the Strong Interaction Quarks and QCD

Leo Maurer, Johannes Gutenberg - Universität Mainz

The theme of the poster is the strong interaction with special focus on quarks and Quantum Chromodynamics (QCD). The strong force is one of the four fundamental forces and binds quarks into hadronic states. QCD offers the theoretical framework to understand this interaction on a deeper level and introduces the color charge as a new quantum number. The color charge is carried by the quarks and gets exchanged via the gluons, which are the exchange particles of the strong interaction.

The introduction of QCD was necessary, due to some hadrons, like the delta++ baryon, violating the Pauli principle. Some important characteristics of the strong force are confinement and asymptotic freedom. Asymptotic freedom describes the concept of quarks behaving like free particles at close distances or high energies. Confinement states that it is impossible to observe an isolated color charge, only the color-neutral state of white. Since quarks carry only one color charge and can't carry the charge white, an isolated quark can't be observed. The binding energy of the strong force between two quarks increases with their distance from each other. When the energy reaches a threshold, the bond breaks and a new quark-antiquark pair gets created instead, preventing an isolated quark.

A current focus of high-energy physics research is the Quark-Gluon Plasma (QGP), a state of matter in which quarks and gluons are no longer confined within hadrons. In this deconfined phase, the strong interaction behaves differently, allowing these fundamental particles to exist freely over short distances and time scales. This state can only be reached at extremely high temperatures or baryon density. In nature, it was only reached a few microseconds after the Big Bang and can only be found in the present day in the cores of neutron stars. It can be created artificially in particle accelerators by colliding high speed gold nuclei with each other.

Star trails: capturing celestial paths

Octavio Miguel Muñoz Bausili and Fernando Luis Macias Garrido, Universitat de València

Star trails are a photographic technique that visually represents the apparent motion of stars in the night sky due to Earth's rotation. By taking a series of long-exposure photographs on well picked locations over a long period of time and stacking them together using specialized software the stars appear as continuous circular or arced trails around the celestial pole.

These images are not difficult to obtain and anyone with a camera, a tripod, an intervalometer, a dark sky and a cup of coffee can create their own pictures.

With the goal of creating our own star trail, we moved to different places throughout the Valencian Community, where we took several series of photographs using two different, despite similar, cameras. Once the photographs had been taken, star trails were edited using free but specialized softwares, such as StarStaX or Startrails, which are commonly used by astrophotographers.

Star trails' popularity has recently increased, as they show the beauty of the night sky in a way that gives useful information to scientists (indeed, astronauts such as Don Pettit have created star trails from the ISS in order to show celestial bodies' motion throughout some time) but they are also appropriate in a scientific divulgation context, as not much knowledge in Astronomy is needed to understand them.

On the rocket engines that made history

Enrique Puig Cruz, Universitat de València

Space exploration has fundamentally changed our understanding of the universe, a fascination that has captivated societies from ancient Babylon and the Maya to the present day. This poster, however, will focus on the engineering behind a critical component of space exploration: rockets. Thanks to these incredible inventions, we've launched telescopes, rovers, satellites, and more, providing invaluable information that has revolutionized our interpretation of the cosmos. Specifically, this work emphasizes rocket engines, which are the very heart of any space vehicle. Throughout aerospace development, numerous types of engines have been designed, each tailored to different requirements for thrust, efficiency, or reusability.

This poster will showcase a selection of the most significant rocket engines in history. We'll begin with the German V-2, a precursor to modern rocket technology, and move on to the enormous F-1 engine of the Saturn V, which powered the Apollo missions to the Moon. We'll also highlight revolutionary engines such as the Soviet RD-170, notable for its power and efficiency, and the Space Shuttle's RS-25, one of the most sophisticated engines ever constructed. Finally, contemporary advancements like SpaceX's Merlin and Raptor engines will be included, illustrating how they have revolutionized the industry through reusability.

Beyond exploring their technical characteristics (such as propellants used, power, and combustion cycles) and history, this poster aims to demonstrate how these engines represent not only remarkable engineering achievements but also significant cultural and scientific milestones. Each engine has played a pivotal role in different stages of space exploration, and collectively, they allow us to understand how humanity has managed to leave Earth and look beyond.

Quantum Effects in Photosynthesis: A New Perspective

Rebeca Reig Puerto, Universitat de València

Photosynthesis, essential for life on Earth, has long been understood through classical biology and chemistry. However, recent discoveries in biophysics suggest that, in some organisms, the efficiency of energy transfer during photosynthesis cannot be fully explained by classical physics alone. The emerging field of quantum biology proposes that quantum phenomena (like tunneling and quantum coherence) play a role in how light energy moves through photosynthetic systems.

Experiments have shown that energy packets, or excitons, can travel through different molecular pathways at the same time thanks to quantum superposition. This helps them find the most efficient route to the reaction center. Quantum tunneling also allows electrons to cross energy barriers that would be impossible to pass using classical laws. These effects have been observed in structures such as the Fenna-Matthews-Olson (FMO) complex in certain sulfur green bacteria, using ultrafast spectroscopy techniques.

These findings may explain why some photosynthetic organisms achieve nearly 100% energy transfer efficiency. They also inspire new technologies, like quantum-based solar panels, bioinspired computing, and improved energy storage systems. Importantly, this challenges traditional ideas about quantum behavior, showing that quantum coherence can survive in warm, “messy” biological environments for surprisingly long times (up to several picoseconds).

This work offers an accessible and updated overview of how quantum mechanics might help explain the mysteries of photosynthesis. It brings together recent experiments, new theories, and possible applications, pointing to a future where nature’s quantum tricks could lead to major technological advances.

What makes the strong interaction so special?

Vanessa Roos, Johannes Gutenberg - University Mainz

The Strong Interaction is responsible for keeping the protons and neutrons inside the nucleus of an atom and needs to be much stronger than the Coulomb interaction so that the protons do not repel each other. The phenomena that render the Strong Interaction so special are, amongst others, the existence of the Strong Coupling Constant, which is energy-dependent. Furthermore, it will be discussed why there are only colour-neutral observable particles, the existence of three charges instead of one and the Gluon-Selfinteraction.

Redshift, a source of information about the universe

Isabela Silva Restrepo, Universitat de València

A redshift is a change in the wavelength of electromagnetic radiation. There are three ways one can observe this phenomenon: Doppler redshifts, occasioned by the relative motions of radiation sources; gravitational redshifts, where the electromagnetic waves travelling out of a gravitational well lose energy; and cosmological redshifts, caused by the universe's expansion.

This concept helps us understand the observations we have about the cosmic microwave background and it also provides us with useful information about the celestial bodies we study.

In this poster, I will dive more into the different sources of redshift, and what information about the universe does it provide.

Magnetic Monopoles: The Missing Half of Maxwell's Equations

Darío Satorres Hernández, Universitat de València

In this poster, we embark on a fascinating exploration of the idea of magnetic monopoles. These hypothetical particles present one of the most profound asymmetries in the fundamental laws of electromagnetism, challenging the relationships established by Maxwell's equations. Unlike electric charges, which exist independently (positive and negative), magnetic poles are invariably observed in inseparable pairs, forming dipoles. This striking absence of isolated magnetic charges is deeply embedded in Maxwell's equations.

We will discuss the specific modifications these hypothetical particles would establish in these equations and the profound consequences they would entail for our understanding of fields. Our journey will explore the powerful theoretical motivations suggesting their existence, rooted in Grand Unified Theories (GUTs), and their potential origin in the universe's earliest moments, shortly after the Big Bang.

Subsequently, we will examine the intensive experimental efforts dedicated to finding these elusive particles, and how this persistent search has motivated significant advances in our understanding of the universe. Finally, we will consider the revolutionary implications their discovery would have for the unification of forces and the potential applications of these enigmatic objects, inviting a new perspective on the inherent symmetry of the cosmos.

Music in the key of Ohm

Guillem Sendra Cortés, Llorenç Vèrnia García and Jordi Guillem Mompó, High School Senior Students

Our poster is a visual and conceptual simplification of the entire process of construction and experimentation involved in the development of our own theremin. This idea emerged from the increasing presence of the theremin in popular culture, where it has become an icon of electronic music. Its peculiar and otherworldly sound has been featured in TV series such as The Big Bang Theory and The Simpsons, in chilling soundtracks like American Horror Story, and in performances by legendary rock bands like Led Zeppelin. In addition, we were inspired by the virtuosity of Clara Rockmore (the greatest thereminist in history) and the innovative spirit of Lev Theremin, its creator.

This cultural exposure motivated us to take on the challenge of building a functional theremin at home. We also wanted to understand its inner workings in greater depth, particularly the fascinating way it produces sound without any physical contact. A theremin is an electronic musical instrument invented by Russian physicist Lev Theremin in 1920. It operates using the principle of electromagnetic wave interference, generating sound waves whose pitch varies according to the distance between a conductive object and the antenna.

This project was done following the scientific model, we proceeded with the investigation to create a theoretical model and finally we demonstrated it. Our project started with the settling of 5 objectives that were related in its construction, scientific investigation through a theoretical model and other related physical principles. Besides, we also proposed its divulgation and the accomplishment of some SDG from the 2030 agenda, innovating and getting an interdisciplinary project, combining different STEAM areas. Finally, as it's a musical instrument, we decided to learn and play some popular songs.

The theoretical model of the frequency equation of the theremin

Guillem Sendra Cortés, Llorenç Vèrnia García and Jordi Guillem Mompó, High School Senior Students

This poster is made to demonstrate how our project works. By coming from a public institute, we were not able to purchase an instrument like this, therefore we had to build it ourselves. In this way the idea of our theoretical model was born.

In our model there are present three principal things: lots of mathematics, experimental approximations and own principles of analytic mathematics like the Taylor series of the function $1/1 + f(x)$.

We started off with two expressions that we developed to get the desired result. Moreover, constant agrupations can also be seen during the process. In this way, we got the expression that related the frequency that we hear with the natural logarithm of the distance of a conductive object to the pitch antena.

Finally, three graphics can be seen. All three of them prove our theoretical model. The first one was measured with both antenas. The second one with the pitch antena. The third one also with the pitch antena.

6 List of assistants

Students

Name	Affiliation
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Jorge García Martí	Universitat de València
Diego García Martínez	Universitat de València
Alejandro Garcia Olza	Universidad de Zaragoza
Felipe García Serrano	Universidad Complutense de Madrid
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Stefano Cristian Voineag	Universitatea “Lucian Blaga” din Sibiu
Jakob Weiss	Johannes Gutenberg - Universität Mainz

Invited speakers

Name	Affiliation
Sebastian Böser	Johannes Gutenberg - Universität Mainz
Androniki Dimitriou	Instituto de Física Corpuscular (CSIC - UV)
Carolina Fernández	Universitat de València
Marta García Matos	Museu de la Ciència CosmoCaixa
Lola Garzón	Universitat de València
Manuel Gessner	Instituto de Física Corpuscular (CSIC - UV)
Tuomas Grahn	Jyväskylän yliopisto
Varis Karitans	Latvijas Universitāte
Adrián Lambíes Asensio	Universitat de Barcelona
Giacomo Landini	Instituto de Física Corpuscular (CSIC - UV)
Gema Martínez	European Synchrotron Radiation Facility (ESRF)
Josep Mas Garcia	Universitat de València
Miriam Mínguez	Universitat de València
Guillermo Muñoz	Universitat de València
Miguel Peiró	La Academia Arte y Ciencia
Panu Ruotsalainen	Jyväskylän yliopisto
Rosa Mª Sandá Seoane	Instituto de Física Teórica (UAM - CSIC)
Lucía Sanus	Universitat de València
Irene Valenzuela	Instituto de Física Teórica (UAM - CSIC)

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Iván García Blanes	Emma Rebollar
Alejandro García Ten	Paula Romero
Anna Garrigues	Gonzalo Sánchez
Marc Girona	Marina Sendra