11/07 Monday morning
Lunes por la mañana

09:00-09:35 Welcome / Acto de bienvenida

09:35-10:10 Pedro Miguel Echenique Landiribar (Donostia International Physics Centre)
Ciencia después de la pandemia. La sublime utilidad de la ciencia inútil

10:10-10:45 Pilar Hernández Gamazo (IFIC, Universitat de Valencia-CSIC)
On the matter-antimatter asymmetry

10:45-11:15 **Coffee Break**

11:15-11:50 Maria Ángeles Chamarro Calvo (Sorbonne Université-- Institut de Nanosciences de Paris)
Lo que siempre quiso saber sobre los excitones y las perovskitas a base de halógenos pero nunca se atrevió a preguntar...

11:50-13:20 Round table
Promoting Gender Equality in Physics in Europe

Panelists:

- GENERA (Gender Equality Network in Physics in the European Research Area): Lisa Kamlade (Deutsches Elektronen-Synchrotron DESY, Germany)
- WIDERA project (Horizon Europe) and QUANTERA project (European partnership on Quantum technologies): Lydia González (Spanish Foundation for Science and Technology, Spain)
- JUNO Project: Jane Smith and Fiona Dorrington (Institute of Physics, UK)

Moderator: Pas García Martínez (Universitat de València)

12/07 Tuesday morning
Martes por la mañana

09:00-09:35 Àngels Ramos Gómez (Universitat de Barcelona)
Strangeness Nuclear Physics and astrophysical implications

09:35-10:10 Alejandro González-Tudela (Instituto de Física Funsamental, CSIC)
Nanophotonics for quantum technologies

10:10-10:45 Rafael Garcia-Molina (Universidad de Murcia)
Physics in everyday life

10:45-11:15 **Coffee Break**

11:15-11:50 María Luisa Castaño Marín (CIEMAT)
¿De que hablamos cuando decimos Transición Energética?

11:50-13:20 Round table
Energía y sostenibilidad

Panelists:

- Mercedes Ballesteros (CIEMAT)
- Roberto Gomez Calvet (Universida Europea de Valencia)
- Antonio Gonzalez Jiménez (Director de Estudios y Apoyo Técnico en Foro Nuclear)
- Maria de la Mercedes Vazques (Sostenibilidad y Medio Ambiente en Red Eléctrica Española)

Moderator: María Luisa Castaño Marín (CIEMAT)

13/07 Wednesday morning
Miércoles por la mañana

RSEF Medals Session

Session chairman: Luis Viña

09:00-09:35 Eugenio Coronado Miralles (Universitat de Valencia)
Molecular Control Over the Properties of 2D Materials

09:35-10:10 Pablo Artal Soriano (Universidad de Murcia)
Peripheral optics in the eye: from myopia to cataracts

10:10-10:45 Andrius Baltuska (Vienna University of Technology)
Nonlinear spectroscopy with amplified femtosecond bursts

10:45-11:15 **Coffee Break**

11:15-11:50 Florian Macquardt (Max Planck Institute for the Science of Light)
Physical Self-Learning Machines

11:50-13:20 Round table
Agencia Estatal de Investigación

Panelists:

- Domènec Espriu Climent, Director de la AEI (Universitat de Barcelona)
- Francisco J. García Vidal, Presidente del área de Ciencias físicas de la AEI (Universidad Autónoma de Madrid)

Moderator: Pablo Artal Soriano (Universidad de Murcia)

14/07 Thursday morning
Jueves por la mañana

Jaime I Awards Session

Session chairman: Pablo Artal

09:00-09:05 Javier Quesada (Secretario General de la Fundación)
Presentación

09:05-09:35 Laura Lechuga Gómez (Catalan Institute of Nanoscience and Nanotechnology)
Nanophotonic biosensors for ultrasensitive and decentralised diagnostics at the point-of-need

09:35-10:10 Francisco J. García Vidal (Universidad Autónoma de Madrid)
Nanophotonics: the first 30 years

10:10-10:45 Licia Verde (Universitat de Barcelona)
Precision Cosmology, when the party is over

10:45-11:15 **Coffee Break**

11:15-11:50 Rafael Rebolo (Instituto de Astrofísica de Canarias)
High precision spectroscopy in astrophysics: implications on fundamental physics and the characterization of Earth-like planets

11:50-13:20 Round table
Presente y Futuro de las Grandes Instalaciones Científico-Técnicas

Panelists:

- Ángela Fernández Curto (Subdirectora General Adjunta de Grandes Instalaciones Científico-Técnicas, Madrid)
- Caterina Biscari (Sincrotrón ALBA, Barcelona)
- Luis Roso (Centro de Láseres Pulsados de Salamanca)
- Martín Guerrrero (Instituto de Astrofísica de Andalucía, Granada)
- Carlos Peña (Laboratorio Subterráneo de Canfranc, Huesca)

Moderator: Juan M. Bueno (Universidad de Murcia)

15/07 Friday morning
Viernes por la mañana

Session chairman: Miguel Ortuño

09:00-09:40 Boris Altshuler (Columbia University)
TBA

09:40-10:20 Pablo Jarillo-Herrero (Massachussetts Institute of Technology)
The Magic of Moiré Quantum Matter

10:20-10:45 Entrega de Premios de los concursos de Estudiantes y de Jóvenes Doctores

10:45-11:15 **Coffee Break**

11:15-12:00 Centenario de la IUPAP

Panelists:

- Luis Viña, Presidente del Comité de Enlace Español de la IUPAP, Universidad Autónoma de Madrid
- Raúl Toral, Miembro de la Comisión C3-Física Estadística, Universitat de les Illes Balears
- Hermann Suderow, Miembro de la Cosmisión C5-Física de Bajas Temperaturas, Universidad Autónoma de Madrid
- Gloria Platero, Secretaria de la Comisión C8-Semiconductores, Instituto de Ciencia de Materiales de Madrid-CSIC
- Alfonso Muñoz, Miembro de la Comisión C20-Física Computacional, Universidad de La Laguna

12:00-13:15 Junta General Ordinaria de la Real Sociedad Española de Física

13:15-14:30 Cocktail de despedida

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Ciencia después de la pandemia. La sublime utilidad de la ciencia inútil

Pedro Miguel Echenique

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La pandemia del Covid ha puesto a la ciencia en el escaparate y ha revelado su importancia decisiva para el futuro de la humanidad. También ha revelado la importancia de la comunicación científica, y la necesidad de entender correctamente cómo funciona la ciencia.

La ciencia actual no contesta a todo, está en una fase primitiva e infantil, pero es lo mejor que tenemos, la gran esperanza de la humanidad.

Más importante, y sobre todo más rentable que fijar objetivos a la ciencia, es crear una atmósfera, un caldo de cultivo donde la creatividad pueda florecer. Los cambios cualitativos, los grandes avances de la Humanidad, han surgido de preguntas fundamentales de la Ciencia Básica.

Sería un error centrarnos solamente en lo biomédico, o en lo aplicado. Si así lo hacemos podemos avanzar en problemas conocidos, pero seremos sorprendidos cuando aparezcan nuevos frentes. No sabemos lo que va a venir por lo que tenemos que tener un arsenal de posibilidades que solo puede venir de la ciencia básica.

Incluso en la práctica médica el desarrollo de la curiosidad acerca de los hechos básicos de la naturaleza ha demostrado ser la ruta más eficiente para conseguir medicinas y aparatos con éxito.

La preeminencia en investigación requiere mucho, no puede adquirirse en pocos años, pero puede dañarse rápidamente.

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On the matter-antimatter asymmetry

Pilar Hernández

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The existence of ordinary matter in the Universe remains an unsolved mystery. The possibility that it might be understood from the fundamental properties of particle interactions is under intensive investigation, both from a theoretical as well as an experimental point of view. Three essential ingredients are required: violation of the charge conjugation and parity symmetries of fundamental interactions, the non-conservation of baryon number, and a cosmological evolution that is not fully thermal. I will review recent progress in this area and explain what are the future measurements that can reveal the origin the matter-antimatter asymmetry.

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Lo que siempre quiso saber sobre los excitones y las perovskitas a base de halógenos pero nunca se atrevió a preguntar

Maria Angeles Chamarro Calvo

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Las perovskitas a base de halógenos han sido durante estos últimos años, y continúan siendo, el centro de la atención de una multitud de estudios y conferencias sobre los temas de la optoelectrónica y las aplicaciones fotovoltaicas. Estos materiales aparecen como una nueva clase de semiconductores que han permitido una sorprendente y fulgurante evolución del rendimiento fotovoltaico en las células solares y que presentan una eficiencia de emisión excepcional. A la base de estas propiedades se encuentra el "exciton", la pareja formada por un electrón y un hueco, que aparece en el material semiconductor después de una absorción de fotones de energía superior a la energía de la banda prohibida.

En esta charla nos centraremos sobre la descripción de las principales características de los excitones en las perovskitas a base de halógenos y discutiremos su íntima relación con el rendimiento fotovoltaico y con la eficiencia de emisión de estos materiales.

Strangeness Nuclear Physics and astrophysical implications

Àngels Ramos

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Strangeness Nuclear Physics extends the scope of conventional nuclear physics to a new degree of freedom (strangeness) and accommodates a variety of new phenomena which have fascinating consequences in various fields of research.

Hypernuclei are bound systems composed of neutrons, protons, plus one or more strange baryons, like the hyperons Λ, Σ or Ξ. Spectroscopic studies of hypernuclei permit constraining the properties of the hyperon-nucleon and hyperon-hyperon interactions. These are crucial ingredients for understanding the physics of neutron star interiors, where the extreme density conditions favor the presence of hyperons which reduce the maximum mass the star can support, challenging many of the present models of the nuclear equation-of-state.

Strangeness in nuclear matter can also be present in the form of mesons, like the antikaons. Provided their nuclear interactions are attractive enough, it has been argued that negatively charged antikaons could replace energetic electrons inside a neutron star, giving rise to the phenomenon of kaon condensation. Although still a matter of debate, the more modern theories do not support this claim, but new information on the antikaon nuclear interaction from kaonic atoms experiments or heavy-ion collisions might soon resolve this issue.

In this talk I will review the progress, challenges, and state-of-the art developments in the field of strangeness nuclear physics, paying a special attention to problems and phenomena of astrophysical relevance.

Nanophotonics for quantum technologies

Alejandro González-Tudela

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Recent experimental advances in the integration of quantum emitters with nanophotonic structures opens up unprecedented for quantum technologies [1]. In particular, the low dimensionality of the photons enables to obtain longer ranged interactions than with free-space setups that can be harnessed for quantum simulation purposes [2], as well as for improving the figures of merit of non-classical light-generation [3]. Besides, the possibility to engineer topologically non-trivial photonic band structures [4] opens the realization of topological light-matter interfaces [5], opening a path to engineer robust quantum devices based on such effects [6]. In this talk, I will review some of my main contributions to this field [2,3,6].

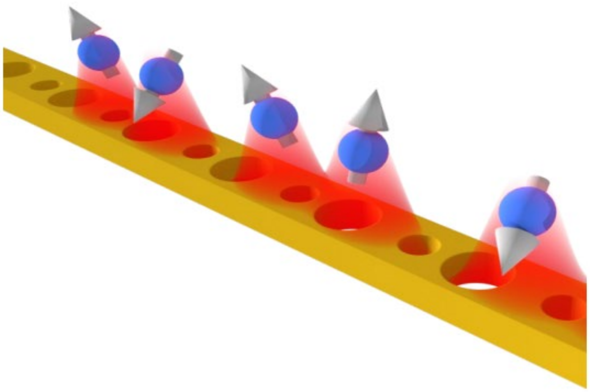

Figure 1. Quantum emitters interacting with the confined photonic modes propagating in photonic crystals

[1] D. E. Chang, J. S. Douglas, A. Gonzalez-Tudela, C. L. Hung, H. J. Kimble, *Reviews of Modern Physics* **90** (3), 031002 (2018).
[2] A. Gonzalez-Tudela *et al.*, *Nat. Photonics* **9** (5), 320 (2015); J. Douglas *et al.*, *Nat. Photonics* **9** (5), 326 (2015).
[3] A. Gonzalez-Tudela *et al*., *Phys. Rev. Lett.* **115** (16), 163603 (2015); *Phys. Rev. Lett.* **118** (21), 213601 (2017).
[4] T. Ozawa *et al*., *Rev. Mod. Phys.* **91**, 015006 (2019).
[5] S. Barik *et al*., *Science* **359,** 666 (2018).
[6] M. Bello, G. Platero, I. Cirac, A. Gonzalez-Tudela, *Science Advances* **5** (7), eaaw0297e (2019); I. García-Elcano, A. Gonzalez-Tudela, J. Bravo-Abad, *Phys. Rev. Lett.* **125** (16), 163602 (2020); E. Kim *et al.*, *Phys. Rev. X* **11** (5), 011015 (2021); C. Vega *et al*., Phys. Rev. A **104** (5), 053522 (2021).

Acknowledgements: AGT acknowledges support from CSIC Research Platform on Quantum Technologies PTI-001, from Spanish project PGC2018-094792-B-100 (MCIU/AEI/FEDER, EU), and from the Proyecto Sinérgico CAM 2020 Y2020/TCS-6545 (NanoQuCo-CM).

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Physics in everyday life

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We can find numerous phenomena and activities in everyday life where physics is present. In addition to the technological devices that make our lives easier (such as GPS, lasers, computers…, which will not be discussed in this talk), it is enough to look around us to be acquainted how physics permeates our daily lives, in circumstances as diverse as sports events (curved trajectories of ball throws, reduction of friction through the design of sportswear...) [1], circus shows (risky balances and synchronization of trapeze artists...) [2], visits to amusement parks (where conservation of energy is present in roller coaster rides, or how you can perform experiences of weightlessness during free fall…) [3], magic shows (with challenges to the laws of nature that are nothing more than a consequence of optical, mechanical, magnetic effects...) [4]. Physics is also at the foundations of toys (from classic ones as the spinning top or the yo-yo, to more recent innovations, such as the Levitron) [5], after-lunch conversations can be enriched with physics entertainments, the (un)plausibility of physics laws can be checked in the storyline of many science fiction films and novels [6], and even references to physics appear in opera [7]. These are just a few examples of the many cases in which physics can be appreciated and enjoyed just around us. But to perceive these manifestations of physics all over we need to open our eyes (as well as all of our senses) and especially our minds.

Throughout this plenary talk different topics (and even historical periods) will be covered where I will present various examples of the role that physics has had and has in our daily lives, showing that this scientific discipline is everywhere and can also be fun (two important points to raise awareness in society of the importance of physics in our daily lives).

[1] J. E. Goff, *Gold Medal Physics. The Science of Sports*, The Johns Hopkins University Press (2010).
[2] *The Science Behind the Circus with Imperial Opa*, https://scienceatl.org/the-science-behind-the-circus-with-imperial-opa/Authors (December 18, 2017); A. Volfson, H. Eshach, Y. Ben-Abu, *Physical Review Physics Education Research* **16**, 010134 (2020).
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[4] Robert-Houdin, *Magia y física recreativa (obra póstuma)*, Pascual Aguilar Editor (1887). [Reproducción facsímil en la editorial Alta Fulla, Barcelona, 1998].
[5] R. Garcia-Molina, *Revista de Física (Societat Catalana de Física)* **2**, 34 (1998); H. Biezeveld, R. Garcia-Molina, *Physics on Stage 2000*, p. 28, ESA Publications Division (2001); J. Güémez, C. Fiolhais, M. Fiolhais, *Physics Education* **44**, 53 (2009).
[6] M. Moreno Lupiáñez, J. José Pont, *De King Kong a Einstein. La física en la ciencia ficción*, Edicions UPC, 1999; R. Flack, *Physics Education* **44**, 430 (2009).
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What are we talking about when we say energy transition?

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There is no doubt about the most important challenge facing the planet: global warming caused by human activity. The development of modern society and its industrialization linked to the use of enormous amounts of fossil fuels have caused an increase in the concentration of greenhouse gases (GHG) in the earth's atmosphere, the main consequence of which is the increase in the planet's temperature.

Global warming, as a consequence of the use of fossil fuels, is causing a deterioration of the planet of such magnitude that, if the energy paradigm was not radically changed immediately, the effects would be irreparable

The historic Paris Agreement on Climate Change in 2015 confirms a growing interest in achieving viable energy solutions with low or zero CO2 emissions, economically competitive and integrated into the energy system. In the case of the European Union (EU), the legislative package "Clean Energy for all Europeans" and the European Green Deal, establish binding objectives for the EU to 2030.

One of the obligations established by this proposal is that the Member States have to carry out “Integrated National Energy and Climate Plans” with objectives, goals and contributions until 2030 and 2050, and frame them in their national legislation. Spain, immersed in this process, has drawn up its National Integrated Energy and Climate Plan (PNIEC), with the commitment to reduce greenhouse gas emissions by 23% compared to the 1990 level, to reach 42% renewable energy on the use of final energy in the country, a 74% penetration of renewable energies in the electrical system and an improvement in energy efficiency of 39.5%.

These objectives represent a radical change in the way of generating and consuming energy, with a direct impact on residential and services use of energy, on the electrical system, on the mobility of people and goods, as well as the energy use of industry.

In this process of energy transition you can be an actor or a spectator. Being a protagonist means taking advantage of opportunities to achieve national energy, technological and industrial sovereignty

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Molecular Control Over the Properties of 2D Materials

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Graphene and other 2D materials are almost exclusively based on inorganic lattices. Except for the chemical functionalization of the surface of the 2D material, molecules have been scarcely considered in this area. Here I will focus on the association of functional molecules with 2D materials with the aim of creating smart molecular/2D heterostructures in which the properties of the "all surface" 2D material are tuned *via* an active control of the hybrid interface. This new class of heterostructures may be at the origin of a novel generation of hybrid materials and devices of direct application in highly topical fields like electronics, spintronics and straintronics. To reach this goal I propose to interface stimuli-responsive molecular systems with graphene and semiconducting transition metal dichalcogenides (MoS_2 and WSe_2). As smart-molecular systems I will choose magnetic spin-crossover materials able to switch between two spin states upon the application of an external stimulus (temperature, light or pressure) [2]. This spin transition is always accompanied by a significant change of volume in the material (by ca. 10%), so it can generate strain in its surroundings. I will show that in these heterostructures the electronic properties of graphene and the optical photoluminescence of monolayers of semiconducting metal dichalcogenides can be switched by light or by varying the temperature due to the strain concomitant to the spin transition [3, 4].

[1] J. Lopez-Cabrelles *et al*, *J. Am. Chem. Soc.* **143**, 18502 (2021).
[2] E. Coronado, *Nature Rev. Mater.* **5**, 87 (2020).
[3] R. Torres-Cavanillas *et al, Nature Chem.* **13**, 1101 (2021).
[4] C. Boix-Constant *et al, Adv. Mater.* **34**, 2110027 (2022).

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Physical Self-Learning Machines

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Machine learning using artificial neural networks is revolutionizing many areas of science and technology. This increases the urgency for exploring alternatives to artificial neural networks running on digital hardware. These alternatives might eventually be faster and/or more power-efficient. With this in mind, we ask the question whether one can identify a general principle that would enable a nonlinear physical system to become a self-learning machine – i.e. a physical information-processing device where internal degrees of freedom self-adjust by physical interactions to learn a desired input-output relation.

In this talk, I will present our recent idea on how this might be achieved for arbitrary time-reversal-invariant Hamiltonian systems. I will introduce the principle of 'Hamiltonian Echo Backpropagation', and demonstrate how efficient learning could be possible in a wide class of physical systems. The main idea is to apply a time-reversal operation to the output of the device (e.g. waves emerging from the device) before adding a small error term that reflects the deviation from the desired output. As we show in our manuscript, the subsequent physical dynamics (independent of its details) will produce a change in some persistent, arbitrary 'learning degrees of freedom' that eventually ensures minimization of the cost function during training. Thus, using this approach, arbitrary nonlinear time-reversal-invariant Hamiltonian systems can be trained to achieve some desired input-output relation. These systems include in particular nonlinear optical wave fields as well as superconducting microwave circuits in the classical regime.

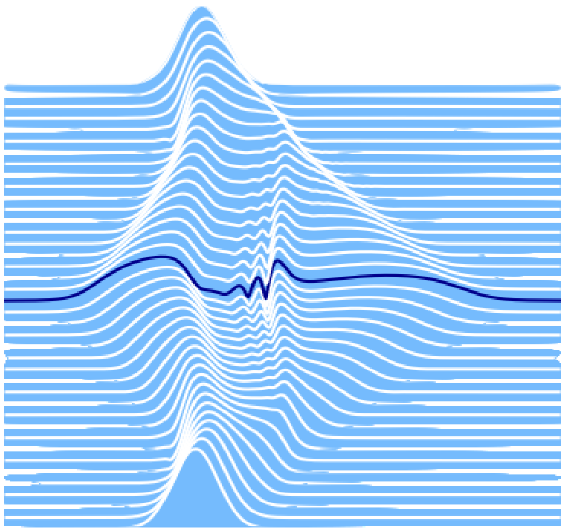

Figure 1. Schematic depiction of a nonlinear wave field evolving forward in time, getting subjected to a time-reversal operation, and continuing to evolve afterwards. Hamiltonian Echo Backpropagation injects an "error signal" right before the time-reversal operation.

[1] Victor Lopez-Pastor, Florian Marquardt, *Self-learning Machines based on Hamiltonian Echo Backpropagation*, arXiv 2103.04992 (2021).

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Nanophotonic biosensors for ultrasensitive and decentralised diagnostics at the point-of-need

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COVID-19 pandemics has evidenced the urgent need of having portable diagnostic tools that enable rapid testing and screening of the population with sensitivity and specificity levels comparable to laboratory techniques. Biosensor technology is one of the best prepared to tackle the challenging goal of offering fast and user-friendly diagnostics tests than can be employed at the point-of-need. In particular, nanophotonic biosensors based on eveanescent wave detection can provide sensitive, reliable and selective analysis, while reducing test and therapeutic turnaround times, decreasing and/or eliminating sample transport, and using low sample volume. Our main objective is to achieve ultrasensitive Point-of-care (POC) platforms for label-free analysis using nanophotonics biosensing technologies and custom-designed biofunctionalization protocols, accomplishing the requirements of disposability and portability.

Photonic biosensors are systems that seize different light-based phenomena for the fast detection and quantification of substances. We have demonstrated cutting-edge nanophotonic biosensors based on Nanoplasmonics and in Silicon photonics technologies that enables ultrasensitive analysis of body fluids in few minutes. By custom tailoring the biochemistry of the sensor biochips, our POC nanophotonic biosensor technology can perform direct detection of proteins, genetic biomarkers or pathogens within <15 min, with high sensitivity and selectivity. The diagnostic potential has been demonstrated and validated among others, for the drug monitoring of anticoagulants in plasma, antibiotic allergy diagnosis in plasma, early cancer diagnosis (colorectal and lung cancer) and bacterial, and viral infectious diseases [1-3]. During COVID-19 pandemic, our POC biosensor has been fully validated with hundreds of clinical samples for the direct detection of anti-SARS-CoV-2 immunoglobulins in COVID-19 patients, confirming excellent diagnostic performance [4].

Our nanophotonic biosensor approach paves the way for modern decentralised disease diagnostics. The nanobiosensor POC devices could be employed by non-expert personnel at the bed-side of patients and could have a strong impact in guiding quick medical decisions across various clinical scenarios.

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[2] J. Maldonado, M. C. Estévez, A. Fernández-Gavela, J. J. González-López, A. B. González-Guerrero, L. M. Lechuga, *Analyst* **145** (2), 497 (2020).
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Nanophotonics: the first 30 years

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During the last thirty years, a new area of research within Physics has emerged, aiming to control the flow of light at length scales of the order or even smaller than the wavelength. This new frontier is named Nanophotonics and has become an interdisciplinary field of research that combines expertise from Condensed Matter Physics, Classical and Quantum Optics and Materials Science. The basic idea of Nanophotonics is to tune the material properties of the medium in which light flows to devise its propagation at will. To frame our own research, in the first part of my talk I will briefly introduce the three main developments that have emerged in Nanophotonics during these thirty years: Photonic Crystals, Plasmonics and Metamaterials.

The main part of the presentation will be devoted to describing two main findings achieved in our theoretical group in this field of research: the phenomenon of the transmission of light through subwavelength apertures [1] and the concept of spoof surface plasmons [2]. First, we will show how surface plasmons can be utilized to overcome the two main limitations that diffraction imposes to light when passing through subwavelength apertures: low transmission and propagation into all directions. Next, we will discuss how structuring metallic surfaces allows for the support of surface electromagnetic modes at low frequencies that mimic the behavior of surface plasmons at optical frequencies. We will also illustrate how these spoof surface plasmon modes can be used in applications that require the manipulation of electromagnetic fields at microwave and terahertz frequencies.

Finally, we will briefly show how light-matter interaction can be used not only to control light propagation as classical Nanophotonics does but, by taking advantage of the quantum hybrid nature of the polaritons formed when light-matter coupling is strong enough, to modify material and chemical properties by tailoring vacuum electromagnetic fields [3].

[1] F. J. García-Vidal, L. Martín-Moreno, T.W. Ebbesen, and L. Kuipers, *Reviews of Modern Physics* **82**, 729 (2010).
[2] Francisco J. García-Vidal *et al*., *Reviews of Modern Physics* **94**, 025004 (2022).
[3] Francisco J. García-Vidal, Cristiano Ciuti and Thomas W. Ebbesen, *Science* **373**, eabd0336 (2021).

Precision Cosmology, when the party is over

Licia Verde

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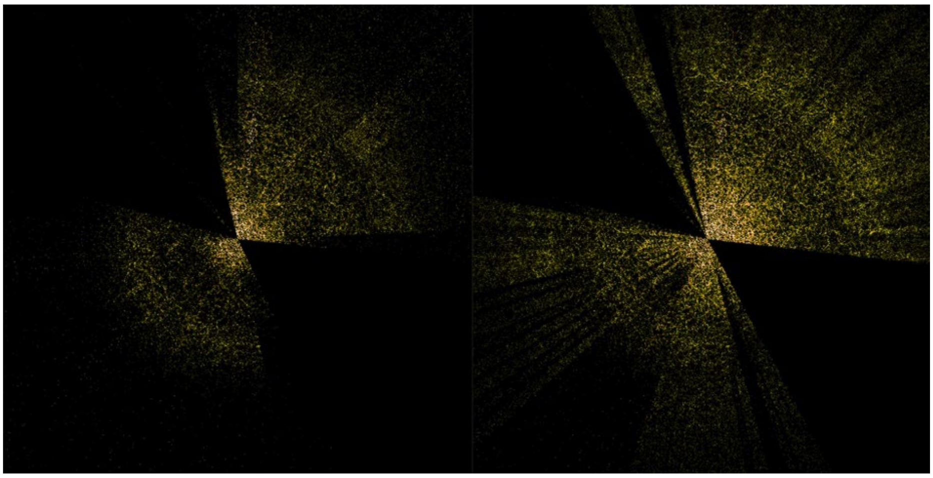
Over the past 20 years cosmology has made the transition to a precision science. Synergies between cosmology and particle physics have been pivotal in this progress and in the theoretical interpretation of the experimental evidence. The standard cosmological model (the LCDM model) has been established and its parameters are now measured with unprecedented precision. This relatively simple model successfully describes observations from widely different epochs of the Universe, from the early Universe all the way to the present day. The "unreasonable effectiveness" of the LCDM model offers challenges and opportunities.

Firstly, precision is not enough: accuracy is also crucial. In addition, there is a big difference between modelling and understanding. This is further complicated by the fact that cosmology only makes observations not experiments, so virtually every inference is heavily model dependent.

This brings to mind what Feynman said: "The first principle is that you must not fool yourself and you are the easiest person to fool."

The next decade will see the era of large surveys; a large coordinated effort of the scientific community in the field is on-going to map the cosmos producing an exponentially growing amount of data. I will explore some examples of how I think we can proceed as not to fool ourselves in the interpretation of forthcoming data.



A slice through the 3-D map of galaxies from the completed Sloan Digital Sky Survey (left) and from the first few months of the Dark Energy Spectroscopic Instrument (DESI; right). The earth is at the center, with the furthest galaxies plotted at distances of 10 billion light years. Each point represents one galaxy. This preliminary version of the DESI map shows only 400,000 of the 35 million galaxies that will be in the final map. **Credit:** D. Schlegel/Berkeley Lab using data from DESI.

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High precision spectroscopy in astrophysics: implications on fundamental physics and the characterization of Earth-like planets

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New high-resolution astronomical spectrographs designed for ultra-high radial velocity precision and extreme spectral fidelity are leading to significant advances in exoplanet research and allow to perform astrophysical experiments on gravitational redshift and stability of the fundamental physical constants with unprecedented precision and accuracy. Progress on laser frequency combs, as new calibration systems, was essential to achieve few cm s^{-1} Doppler precision as required to measure masses of Earth-like planets in solar-type stars and sub-Earth mass planets around low-mass stars. For planets eclipsing their host stars, the radius is known and determination of masses provide densities which set constrains and give insight on the overall chemical composition of these exoplanets.

I will review recent observations of terrestrial planets with ultra-stable spectrographs, new progress on the measurement of the solar gravitational redshift and on-going efforts to measure any variations in the value of the fine-structure constant on cosmological timescales via observations of absorption systems towards high redshift quasars.