Winter Meeting 2023

Report of Contributions

Contribution ID: **3** Type: **not specified**

Microscopic contributions to the entropy production: from nonequilibrium steady states to global equilibrium

Monday, 6 February 2023 12:00 (25 minutes)

Entropy production was originally a phenomenological concept and quantifies irreversibility by accounting for all changes in entropy, which is positive by virtue of the second law of thermodynamics. Afterwards, entropy production was derived microscopically, and its derivations date back to Boltzmann, von Neumann, and others. Nowadays, small open quantum systems far from equilibrium have been attracting attention, and entropy productions in nonequilibirum systems have been discussed. Recently, entropy production has been reexpressed in terms of precise information theoretic quantities and computed in a microscopic model. Following this previous work, we study the relative importance of these quantities. We go beyond it by looking at the long-time regime, where finite size effects are important, and by using a slightly different splitting. Our findings could be useful to optimize nanoscale heat engines by identifying the main contributions to entropy production, and give insights into the fundamental nature of entropy production.

Presenter: USUI, Ayaka (ICCUB)

Contribution ID: **4** Type: **not specified**

The cosmological gravitational wave background: from theoretical modelling to detection prospects

Monday, 6 February 2023 11:05 (25 minutes)

One of the main targets for upcoming gravitational wave observatories is the detection of a cosmological stochastic gravitational wave background (SGWB). Such a signal has the potential to shed light on part of the cosmological history not accessible by other means as well as to probe new physics at energy scales beyond the reach of terrestrial experiments.
A stochastic background, for instance, can provide information on inflation at scales much smaller than the ones probed by CMB and Large Scale Structure surveys.
In this context, I will introduce the quest for primordial features in the SGWB, theoretical modelling and challenges in scenarios generating entrancing backgrounds and part of the current data analysis effort to reconstruct a stochastic signal with the Laser Interferometer Space Antenna (LISA).

Presenter: FUMAGALLI, Jacopo (ICCUB)

Contribution ID: **5** Type: **not specified**

The Gaia4Sutainability project

Tuesday, 7 February 2023 16:25 (25 minutes)

Gaia4Sustainability is a Proof-of-Concept project granted by the Ministerio de Ciencia e Innovación in the 2021 call. The project aims to develop a robust, reliable, and straightforward framework for estimating the natural brightness of the sky. High quality photometry provided by the ESA Gaia satellite allows the computation of the contribution of the integrated star light to the sky brightness. The project consists of a set of implementations (web service, stand-alone program and open-source measurement device) devised for any interested stakeholder to accurately evaluate the impact of light pollution on, for example, environmental activities.

The presence of excessive artificial lighting at night and the consequent disruption of the natural day-night cycle has a pernicious effect on many species. To obtain reliable measurements of the light pollution levels, it is mandatory to know the natural night sky brightness including the integrated star light, zodiacal light, the galactic and extragalactic background light, and the airglow. This together with a model of the terrestrial atmosphere extinction and scattering provides a realistic image of the night sky for a given place and time. The resulting model can, then, be used as a reference value of the natural sky brightness (in cloudless nights), or to know the expected natural levels of sky brightness at pristine areas.

The project also includes the design and construction of a cheap and easy-to-build photometer, named FreeDSm, based on open software and low-cost hardware. It will include several connectivity options and the ability to collect positioning information and measure light pollution, with the capacity to share data on the platform, if desired.

This twofold methodology (modelling and low-cost measuring) proposed by Gaia4Sustainability, intends contributing 1) to widely spread the acquisition of measurements; 2) achieve a greater engagement of social agents; and 3) raise generalised awareness on the light pollution problem.

Primary author: MASANA, Eduard (Institut de Ciències del Cosmos (ICCUB-IEEC))

Co-authors: BALAGUER, Lola (ICCUB-IEEC); CARRASCO MARTÍNEZ, Josep Manel (Institut d'Estudis Espacials de Catalunya); Dr DAFONTE, Carlos; Dr JORDI, Carme (Institut de Ciències del Cosmos (ICCUB-IEEC)); LURI, Xavier (ICCUB); Dr MANTEIGA, Minia (Universidade de A Coruña); Dr RIBAS RUBIO, Salvador (Parc Astronòmic Montsec); Dr ULLA-MIGUEL, Ana (Universidade de Vigo)

Presenter: MASANA, Eduard (Institut de Ciències del Cosmos (ICCUB-IEEC))

Contribution ID: **7** Type: **not specified**

Physics beyond the Standard Model: flavour and Dark Photons

Monday, 6 February 2023 16:15 (25 minutes)

In this talk I outline the motivation for BSM physics, and focus on the opportunity that flavour physics offers for new physics searches. After the introduction and motivation we look at a concrete BSM model, the Dark Photon. We perform an analysis for 2-body meson and baryon decays which allows to set bounds on the flavour-changing couplings of the model.

Presenter: FOLCH, Jordi (TU Dortmund/University of Barcelona)

Contribution ID: **8** Type: **not specified**

Recent insights on novae explosions at gamma rays

Tuesday, 7 February 2023 10:25 (25 minutes)

A nova is a thermonuclear runaway explosion that takes place at the surface of a white dwarf in a binary system. The detection of novae at high-energy gamma rays (HE, E>100 MeV) in 2010 unveiled the extreme conditions that take place when a nova outburst occurs. At the same time, these detections posed a number of questions on the hadronic or leptonic origin of the gamma-ray emission, on the particle acceleration mechanisms at act, and on the maximum energies attainable in these explosions. Further insights into these questions have been recently obtained following the first-detection ever of a nova explosion at very-high energy gamma rays (VHE, E>100 GeV), the source RS Ophiuchi. In this talk I will review the latest results on novae explosions at VHEs and the implications of their detection in this energy range. I will also provide updated perspectives for current and future Cherenkov facilities to detect new novae explosions occurring in our Galaxy in the next years.

Presenter: AGUASCA-CABOT, Arnau

Contribution ID: **9** Type: **not specified**

Revisit the Three-Zone model of PBH formation

Monday, 6 February 2023 12:25 (25 minutes)

At first, the primordial black hole formation in a spherically symmetric model of density perturbation will be introduced, known as Three-zone model. And then I would like to explain some shortages regarding to this model. Finally, a more realistic scenario will be shown.

Presenter: LI, Aichen (University of Barcelona, ICCUB)

Contribution ID: **10** Type: **not specified**

Binary black holes: from formation to coalescence

Monday, 6 February 2023 15:20 (25 minutes)

Almost 100 binary black holes (BBH) have been detected by the LIGO-Virgo detectors, and the field of gravitational wave astronomy and astrophysics is rapidly growing. I will present recent result from the ICCUB Virgo group, which tries to understand the mechanism of BBH formation in the Universe and how the properties of the ones that eventually coalesce can be used to shed light on their origin.

Primary author: GIELES, Mark (ICC)

Presenter: GIELES, Mark (ICC)

Contribution ID: **11** Type: **not specified**

Instrumentation activities of the ICCUB Tehcnology Unit

Tuesday, 7 February 2023 11:45 (25 minutes)

The Technological Unit of the ICCUB is currently providing several groups of ICCUB with services, such as instrumentation and software development, in order to support their contributions to international collaborations. Many developments on instrumentation are related to sensitive photosensor readout technology with key contributions in international projects such as LHCb, CTA, HERD, LISA and IAXO. Furthermore, this technology is also being applied in medical imaging technology in cooperation with academic and industrial partners.

Primary author: GASCON FORA, David (ICCUB. Universitat de Barcelona)

Presenter: GASCON FORA, David (ICCUB. Universitat de Barcelona)

Contribution ID: **12** Type: **not specified**

The Milky Way's Stellar Halo

Monday, 6 February 2023 14:30 (25 minutes)

The discovery of a large highly radially anisotropic kinematic structure dominating the vast majority of the stellar halo of the Milky Way (better known as the Gaia-Sausage-Enceladus merger debris, GSE) has prompted several studies in the recent years to report discoveries of other debris. Whilst evidence in favour of the GSE merger has continued to grow, the consensus around the origins of these lesser debris groups is highly debated. I will present results from our group at the ICCUB interpreting some of these new results through the lens of tailored and fully cosmological numerical simulations and discuss the implications of the GSE for the search of the most metal-poor and ancient stars in the MW.

Co-authors: Dr AMARANTE, João (ICCUB); Dr ORKNEY, Matthew (ICCUB); LAPORTE, Chervin (ICCUB-IEEC)

Presenter: LAPORTE, Chervin (ICCUB-IEEC)

Contribution ID: **13** Type: **not specified**

Presentation of the Planes Complementarios at the Technology Unit

Tuesday, 7 February 2023 10:00 (25 minutes)

Co-authors: LURI, Xavier (ICCUB); GASCON FORA, David (ICCUB. Universitat de Barcelona); PORTELL DE MORA, Jordi (ICCUB); JULIÁ-DÍAZ, Bruno (Universitat de Barcelona)

Presenters: LURI, Xavier (ICCUB); GASCON FORA, David (ICCUB. Universitat de Barcelona); PORTELL DE MORA, Jordi (ICCUB); JULIÁ-DÍAZ, Bruno (Universitat de Barcelona)

Contribution ID: **14** Type: **not specified**

Putting together the puzzle of common envelope evolution

Tuesday, 7 February 2023 15:20 (25 minutes)

Common Envelope Evolution (CEE) is a critical phase in the evolution of binary stars. It is required to shrink the orbits of stars born in pairs towards much tighter configurations, with final orbital periods of days, hours, or even minutes. Many high-energy astrophysical phenomena are created this way: type Ia supernovae, X-ray binaries, or gravitational wave sources among others. Unfortunately, the CEE phase is also one of the most complex problems in modern-day stellar astrophysics. In my talk, I will explain what are the main pieces of the puzzle of CEE and how observations can help to put them together.

Primary author: BLAGORODNOVA, Nadia (Univeristat de Barcelona)

Presenter: BLAGORODNOVA, Nadia (Univeristat de Barcelona)

Contribution ID: **15** Type: **not specified**

PhotSat: The first IEEC astrophysics cubesat

Tuesday, 7 February 2023 12:35 (25 minutes)

Photsat is the first astrophysics observatory being prepared by the catalan institute of space studies (IEEC) to be allocated in a cubesat mission. The mission aims to survey the full sky during 2-3 years, obtaining photometric lightcurves for V<12-15 mag in several photometric filters, covering the optical and the ultraviolet range. This will provide information of the transient sky at the bright end, that other projects are not able to provide. The preparation of this mission will also be the first step to create a collaborative network needed among the different catalan universities and institutes to be able to plan future missions of this kind.

Co-authors: CARRASCO MARTÍNEZ, Josep Manel (Institut d'Estudis Espacials de Catalunya); GOMEZ CAMA, Jose Maria

Presenters: CARRASCO MARTÍNEZ, Josep Manel (Institut d'Estudis Espacials de Catalunya); GOMEZ CAMA, Jose Maria

Contribution ID: **16** Type: **not specified**

Neutron stars –the natural nuclear physics laboratories

Monday, 6 February 2023 14:55 (25 minutes)

Neutron stars are natural laboratories for studying strongly correlated matter in extreme conditions. In such an environment, exotic components, such as hyperons can appear. Their impact is significant on the mass-radius relation for the cold neutron stars but also on the thermal quantities that are essential for describing violent phenomena such as supernovae explosions or binary neutron star mergers. In this talk I will present a finite temperature equation of state for hypernuclear matter, and I will discuss the influence of hyperons on the neutron star observables such as mass, radius and gravitational waves emitted from merging events.

Presenter: KOCHANKOVSKI, Hristijan (Departament de Fisica Quantica i Astrofisica and Institut de Ciencies del Cosmos, Universitat de Barcelona, Marti i Franques 1, 08028, Barcelona, Spain)

Contribution ID: **17** Type: **not specified**

Software and data processing activities of the ICCUB Technology Unit

Tuesday, 7 February 2023 12:10 (25 minutes)

The ICCUB Technological Unit is contributing to the software development and data processing of several projects. The most important one is Gaia, both on its data processing and on its catalogue validation and data mining aspects, but we are progressively increasing our contributions to other projects such as Virgo, ET, PLATO, nanosatellites, and soon LISA. In this talk I will present and briefly describe these software engineering and data processing activities at the ICCUB.

Primary author: PORTELL DE MORA, Jordi (ICCUB)

Presenter: PORTELL DE MORA, Jordi (ICCUB)

Contribution ID: **18** Type: **not specified**

Preceding CME effects on gradual SEP events: Modeling the 2013 March 15 event with EUHFORIA and PARADISE

Tuesday, 7 February 2023 17:15 (25 minutes)

During solar maximum, the frequency of CMEs being expelled from the Sun is in the order of a few events per day. If an event is capable of driving a shock strong enough to accelerate particles, then we might be able to register a gradual SEP event at Earth's location. But what happens when we have a highly disturbed interplanetary medium at the time of the SEP event? How do preceding CMEs affect the profiles we register at Earth? And more importantly, are we capable of reproducing and forecasting these events before they arrive?

In this work, we model the gradual solar energetic particle (SEP) event that was observed by near-Earth spacecraft on March 15, 2013. This is done by using the model PARADISE (PArticle Radiation Asset Directed at Interplanetary Space Exploration), which simulates the transport of SEPs through non-nominal solar wind configurations generated by the magnetohydrodynamic (MHD) model EUHFORIA (EUropean Heliospheric FOrecast Information Asset).

Several CMEs occurred in the days prior to the solar eruption of March 15. These proceeding CMEs disturbed the solar wind, which may have affected the interplanetary transport of the SEPs, potentially explaining the delayed onset of the SEP event at Earth. To investigate this effect with the PARADISE model, also the preceding CMEs were included in the EUHFORIA simulation. Two different scenarios were explored, using different CME models to simulate the state of the heliosphere at the time of the SEP event. This work aims at showing how different solar wind configurations affect the SEP time-intensity profiles with in-depth analysis of the SEP event simulations.

Primary author: ESTEBAN NIEMELA, Antonio (Universitat de Barcelona)

Co-authors: Dr WIJSEN, Nicolas (NASA Goddard Space Flight Center, University of Maryland College Park); Dr ARAN, Angels (Universitat de Barcelona); Prof. JASMINA, Magdalenic (KU Leuven, Royal Observatory of Belgium); Dr RODRIGUEZ, Luciano (Royal Observatory of Belgium); Prof. POEDTS, Stefaan (KU Leuven, University of Maria Curie-Skłodowska)

Presenter: ESTEBAN NIEMELA, Antonio (Universitat de Barcelona)

Contribution ID: **19** Type: **not specified**

Quantum field theory from entanglement

Tuesday, 7 February 2023 16:50 (25 minutes)

Growing evidence suggests that vacuum entanglement entropy (EE) may provide a universal description of QFT (in general dimensions), alternative to correlation functions. In this talk I will review the set of known axioms satisfied by EE in QFT and some of its successes in the direction of uniquely characterising the different models. Then, I will argue that such set of axioms is at present incomplete by explicitly showing that certain models which satisfy all the axioms do not correspond to any actual QFT.

Primary author: BUENO, Pablo (Universitat de Barcelona)

Presenter: BUENO, Pablo (Universitat de Barcelona)

Contribution ID: **20** Type: **not specified**

Holography in the Gravitational-Wave Era

Tuesday, 7 February 2023 14:30 (25 minutes)

The discovery of gravitational waves has opened a new experimental window into the Universe. The fact that the relevant physics is often out of equilibrium offers a golden opportunity for holography to make a unique impact on cosmology and astrophysics. I will illustrate this through the dynamics of first-order phase transitions in the early Universe and in neutron star mergers. If time permits, I will briefly mention possible applications to thermal inflation and baryogenesis.

Primary author: MATEOS, David (ICREA & U Barcelona)

Presenter: MATEOS, David (ICREA & U Barcelona)

Contribution ID: **21** Type: **not specified**

Quantum droplets in Bose-Einstein condensates

Tuesday, 7 February 2023 10:50 (25 minutes)

Quantum fluctuations can stabilize bosonic mixtures and Bose-Einstein condensates (BECs) with dipolar interactions against the collapse predicted by the mean-field theory. This stabilization mechanism allows for two new states of matter to arise: self-bound quantum droplets and dipolar supersolids. When dipolar interactions between the atoms are present, these droplets can self-assemble into arrays and form a supersolid, which presents both a crystalline structure and superfluid properties.

In 3D bosonic systems, the formation of droplets has been studied in non-dipolar binary mixtures within the miscible regime and in single-component dipolar gases with highly magnetic atoms, where the dipolar interactions (long-range and anisotropic) dominate over the contact interactions (short-range and isotropic). We will first focus on non-dipolar binary mixtures to explore the main ground state properties of self-bound droplets and the excitation of the monopole breathing mode.

As opposed to non-dipolar mixtures, dipolar mixtures can form droplets when the two species are immiscible since the droplets remain self-bound due to the dipole-dipole interactions between the two components. Also, a self-bound droplet may bind a second component that would be unstable by itself. In the context of dipolar binary mixtures, the orientation of the dipoles of each component plays a crucial role in the ground state physics of the system. In particular, we will study mixtures with antiparallel dipoles, which present a wider immiscibility region and a different phase separation as observed with parallel dipoles.

Primary author: ARAZO, Maria (Universitat de Barcelona)

Presenter: ARAZO, Maria (Universitat de Barcelona)

Contribution ID: **22** Type: **not specified**

The Effective Field Theory below the Electroweak Scale

Monday, 6 February 2023 10:40 (25 minutes)

The low energy effective theory (LEFT) provides a general framework for the analysis and interpretation of any experimental data at energies below the electroweak scale. This includes most of the data we have today in particle physics, e.g. lepton and hadron decays and mixing, electric and magnetic dipole moments, cross sections in GeV-scale collisions and other particle properties.
In this presentation we will introduce the LEFT and its main features, and discuss some recent developments in precision calculations.

Presenter: MORELL FERRER, Pol (Institut de Ciències del Cosmos (ICCUB))

Contribution ID: **23** Type: **not specified**

Heavy quarkonium in the quark-gluon plasma as an open quantum system

Monday, 6 February 2023 12:50 (25 minutes)

The quark-gluon plasma (QGP) is a new state of matter that appears at extremely large temperatures and densities. This phase appeared in the early universe and, nowadays, we can recreate it in the laboratory using ultrarelativistic heavy ion collisions. However, it is very challenging to obtain information about the matter created in these collisions as the medium only exists for a very small time.
Heavy quarkonium is a good probe of the medium. On one hand, the production of heavy quark pairs involves large energies and does not depend on the medium. On the other hand, the formation of bound states is affected by the medium. Therefore, measuring the production of quarkonium states we can deduce the properties of the medium.
In the last decade, we have understood that three mechanism modify the yield of quarkonium in heavy ion collisions: the screening of chromoelectric fields, the medium-induced decay width and recombination. It is challenging to include all these effects in a consistent way, specially when thermal effects are not a perturbation and we cannot use the semi-classical approximation.
A promising approach put forward in the last years is to understand quarkonium as an open quantum system. I will report recent advances in this approach, from the derivation of the Lindblad equation to the phenomenological application. I will show how we can make predictions for a wide range of observables, obtaining results compatible with observations.

Presenter: ESCOBEDO ESPINOSA, Miguel Ángel (Universitat de Barcelona)

Contribution ID: **26** Type: **not specified**

How can we help?

Monday, 6 February 2023 10:10 (30 minutes)

The manager of the Institute is going to explain the different services the secretariat provides for the researchers.

Primary author: PALLARES, Esther

Presenter: PALLARES, Esther

Contribution ID: **27** Type: **not specified**

Welcome!

Monday, 6 February 2023 10:00 (10 minutes)

Presenter: LURI, Xavier

Contribution ID: **28** Type: **not specified**

Thermal Relic Dark Matter in the Modern Era

Tuesday, 7 February 2023 14:55 (25 minutes)

Thermal relic of massive stable particles, which are often called Weakly Interacting Massive Particles (WIMPs), has been one of the most fascinating candidates for cosmological dark matter (DM). WIMP DM can be tested directly and indirectly at terrestrial experiments, namely high-energy colliders, direct detection with elastic DM-nucleon scattering and indirect detection with extra cosmic-ray flux from present DM annihilation or decay. In the meantime, the sensitivity of the direct detection experiments has grown a lot in recent years, albeit without any affirmative signals thus far, and the resulting cross section limits start to exclude many well-motivated WIMP DM models. This tendency motivates us to take a new direction in DM model building.

In this presentation, I will talk about a recent effort in model building of thermal relic WIMP DM by presenting some example models where DM-nucleon scattering is naturally suppressed while the DM abundance is thermally produced.

Primary author: OKAWA, Shohei (ICCUB)

Presenter: OKAWA, Shohei (ICCUB)

Contribution ID: **29** Type: **not specified**

QCD medium in relativistic heavy-ion collisions

Monday, 6 February 2023 17:05 (25 minutes)

Heavy-ion collision experiments are essential to the goal of characterizing QCD matter properties at different conditions of temperature and density. From the theoretical side, the determination of the QCD phase diagram is only possible at very particular regions, and effective models provide useful, but not definite results. In this talk I will elaborate on how heavy-ion experiments allow to probe different regions of the QCD phase diagram, and how the time evolution of the produced system can be numerically simulated. Finally, I will show how our group can provide theoretical input for these simulations. The comparison of the latter to experimental results serves as a test for the microscopic assumptions on the strong interaction.

Presenter: TORRES-RINCON, Juan (ICCUB)

Contribution ID: **30** Type: **not specified**

Radiation from stellar bow shocks

Monday, 6 February 2023 16:40 (25 minutes)

Early-type OB stars are hot and have strong radiation fields that accelerate supersonic winds that can reach velocities of a few thousands of km/s. Most of these stars are part of binary systems, and some are kicked away from their orbits by a supernova explosion of their companion or because of tidal gravitational disruptions. The ejected star is denominated runaway and has typical supersonic velocities of tens of km/s or more. A subclass of runaway stars called hypervelocity-stars can reach velocities of thousands of km/s. Winds of runaway stars interact with their surrounding media injecting energy and generating an arc-shaped structure called a bow shock, which consist of two shock waves: a forward shock that propagates through the interstellar medium and a reverse shock that propagates through the stellar wind. Shocked interstellar gas and dust are heated and compressed, producing thermal free-free emission. Electrons and protons can also be accelerated up to relativistic energies in the reverse shock through diffusive acceleration mechanisms, and can then interact with local electromagnetic and matter fields emitting broadband non-thermal radiation. In this talk, I will address the main features of massive stars and stellar bow shocks. Additionally, I will present predictions about non-thermal radiation in the bow shocks of hypervelocity stars and preliminary results about radiation at radio wavelengths in the bow shocks of some detected runaway stars.

Presenter: RODRIGO MARTÍNEZ, Javier (Universitat de Barcelona)

Contribution ID: **51** Type: **not specified**

Winter Meeting Concerto

Tuesday, 7 February 2023 16:10 (15 minutes)

Winter Meeting Concerto