ENAA 2022 – XXXII Encontro Nacional de Astronomia e Astrofísica

Abstract Book

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Talk Abstracts

Monday 9:00 - 10:45 - Planets and Planetary Systems, part 1

Atmospheric evolution and the search for species of astrobiological interest in the Solar System

João A. Dias[1], Pedro Machado[1], José Ribeiro[1], Constança Freire[1]

[1] Instituto de Astrofísica e Ciências do Espaço (IA) - Faculty of Sciences of the University of Lisbon

We used the Planetary Spectrum Generator (PSG) [1] a radiative transfer suite, with the goal of simulating spectra from observations of Venus, Mars and Jupiter, searching for minor chemical species. For Venus, sulphur dioxide (SO2) absorption lines were detected and its abundance constrained, by comparing simulations with observations by the Texas Echelon Cross Echelle Spectrograph (TEXES) spectrograph, around 7.4 μm [2]. The mean abundance of SO2 was constrained to 120 ppb, using the Optimal Estimation Method [3] and a line-depth ratio method [2] independently, in agreement with 50-175 ppb obtained by Encrenaz et al [2]. For Mars, both a positive and a negative detection of methane were reanalyzed using PSG simulations with the goal of constraining the methane abundance. The related spectra observations in the IR, around 3.3 μm, report, respectively, to the Mars Express (MEx) [5] and ExoMars [6] space-probes. For Jupiter, the detection of ammonia, phosphine, deuterated methane and methane was studied, by comparing simulations with IR observations by the Infrared Space Observatory (ISO), around 7-12 μm. [7]. The next step is focused in the determination of the abundances of the previous species. Independent simulations were performed using PSG and the NEMESIS state-of-the-art radiative transfer suite [8]. Funding: This research was funded by the Portuguese Fundacao Para a Ciencia e Tecnologia under project P-TUGA Ref. PTDC/FIS-AST/29942/2017 through national funds and by FEDER through COMPETE 2020 (Ref. POCI-01-0145 FEDER-007672). Aknowledgments: We credit Thérèse Encrenaz, from LESIA, Observatoire de Paris, for all the support and fruitful discussion; Geronimo Villanueva, from NASA-Goddard Space Flight Center, for discussing issues regarding PSG; Marco Giuranna, PI of the PFS instrument of Mars Express (ESA), Alejandro Cardesín, from ESAC-ESA, Ann Carine Vandaele, PI of the NOMAD instrument of ExoMars (ESA) and Séverine Robert, from the ExoMars team,

for all the support regarding Mars dedicated research; Gabriella Gilli (IAA), for the collaboration regarding the LMD-VGCM model; Patrick Irwin, from the University of Oxford (UK), for the collaboration under the NEMESIS radiative transfer code; Asier Munguira, from the University of the Basque Country, for his availability to discuss atmospheric research methods in the context of the present work. References [1] Villanueva et al. 2018, Journal of Quantitative Spectroscopy and Radiative Transfer [2] Encrenaz et al. 2012; Astronomy & Astrophysics [3] C. D. Rodgers. Inverse methods for atmospheric sounding: theory and practice. World Scientific, 2008 [4] Encrenaz et al. 2020; Astronomy & Astrophysics. [5] Giuranna et al. 2019; Nature [6] Korablev et al. 2019.; Nature [7] Encrenaz et al. 1999 ; Planetary and Space Science [8] Irwin et al. 2008 ; Journal Of Quantitative Spectroscopy And Radiative Transfer

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Identification and Characterization of Morphological evidence associated with Fluvio marine Environments on Mars

Rodrigues F.[1], Reis E.[2], Machado P.[3], Brasil F.[3], Espadinha D.[4]

[1] Institute of Geography and Spatial Planning, University of Lisbon; [2] Centre for Geographical Studies, Institute of Geography and Spatial Planning, Universidade de Lisboa, Associated Laboratory TERRA; [3] Institute of Astrophysics and Space Sciences; [4] Institute of Astrophysics and Space Sciences, Reis J., Institute of Geography and Spatial Planning, University of Lisbon

Mars is the most Earth-like planet in the Solar System, due to its formation, structure and composition, but also due to the characteristics of its surface. These particularities point to the fact that, some time in its geological past, the planet was potentially habitable (Baker, V. R. 1981). Two such indicators are the morphological evidence that reveals an active hydrosphere with liquid water flow and the probable ocean existence. The deltaic lobes record possible interactions between watercourses and a potential giant water body on Mars (Achille, G., & Hynek, B. M. 2010). The goal of this study is to identify and characterise erosion and deposition processes, dominated by watercourses and littoral dynamics, through high-resolution imaging to characterise the shapes on the surface. Through its morphological features the environmental behaviour of the Borealis Ocean at its interface with the coast was determined, establishing the parallelism with the dynamics observed on Earth. Based on the literature review, a region of interest was selected that brought together fluvial phenomena and was in a strong dichotomous line. Two geographically close deltas were selected (Abus Vallis and Isara Vallis) that exhibit similar morphological characteristics, revealing that they were formed in the same environment (Toffoli et al. 2021). Abus Vallis appears to be of extreme importance, given its easy dating, as it is covered by units dating to the Late Hesperian (3.6 - 3.3 million years) permitting to temporally locate the Isara delta, which is given special focus. Subsequently, spectral images were used, obtained through the equipment orbiting Mars, specifically Mars Express- ESA, which has an instrument for storing high-resolution images and topographic data - HRSC (K. Gwinner et al, 2016); Context Camera CTX and High Resolution Imaging Experiment (HiRISE) - Mars Reconnaissance Orbiter (Malin at al, 2007). To identify and characterise the erosion and deposition processes, the high-resolution images were processed in GIS environment (ArcGIS pro), and the morphology of the study area was identified, characterised and mapped. The results show that the Isara delta is located at the boundary between the northern lowlands and the southern highlands (potential ocean-continent boundary) in the Memnonia (Coles et al, 2019); . There are two giant promontories (Amazonis Mensae and Gordii Dorsum) with a northwest - southeast orientation in the area, which may have been formed by tectonic movements and massive flood events that filled the Amazonis Planitia basin with water, which widens and deepens towards the northern plains (E. Fuller & J. Head 2002). This phenomenon was triggered by deformation of the Martian crust by tectonics and hydrothermalism during the development of the Tharsis volcanic shield (Michael H. Carr, 1974; Citron et al., 2018) . According to the analysis of the HRSC images, it was found that the Isara

Vallis delta comes from a valley created by groundwater sapping, from aquifers that come from Tharsis. The high-resolution images and digital terrain models reveal that the studied delta is a Gilbert- type, stepped, shallow-water delta (Rees et al., 2018) with a dug main fan channel, which witnesses different mean water levels from the receiving basin. This allowed us to reconstruct the fluvial and marine dynamics of Mars during the formation of this delta. The satellite images allowed the production of very detailed cartography, enabling a better reading of the delta's shapes and characteristics, through which it will be possible to understand the hydrological cycle of Mars, at a regional and global level. References Achille, G., & Hynek, B. M. (2010). Ancient ocean on Mars supported by global distribution of deltas and valleys. Nature Geoscience, 3(7), 459–463. https://doi.org/10.1038/ngeo891; Baker, V. R. (1981). The geomorphology of Mars. Progress in Physical Geography, 5(4), 473–513; Citron, R. I., Manga, M., & Hemingway, D. J. (2018). Timing of oceans on Mars from shoreline deformation. Nature, 555(7698), 643–646. https://doi.org/10.1038/nature26144; Coles, K. S., Tanaka, K. L., & Christensen, P. R. (2019). The Atlas of Mars. Cambridge University Press. Elizabeth R. Fuller and James W. Head (2002): Amazonis Planitia: The role of geologically recent volcanism and sedimentation in the formation of the smoothest plains on Mars. Journal of Geophysical Research, Vol.107, No. E10, 5081, doi:10.1029/2002JE001842; K. Gwinner, R. Jaumann, E. Hauber, H. Hoffmann, C. Heipke, J. Oberst, G. Neukum, V. Ansan, J. Bostelamann, A. Dunke, S. Elgner, G. Erkeling, F. Flueten, H. Hiesinger, N.M. Hoekzema, E. Kersten, D. Zoizeauu, K. D. Matz, K. Willner, (2016): The High Resolution Stereo Camera (HRSC) of Mars Express and its approach to science analysis and mapping for Mars and its satellites. ELSEVIER, Vol. 126, pp: 93-138, doi: https://doi.org/10.1016/j.pss.2016.02.014 Michael C. Malin, James F. Bell III, Bruce A. Cantor, Michael A. Caplinger, Wendy M. Calvin, R. Todd Clancy, Kenneth S. Edgett, Lawrence Edwards, Robert M. Haberle, Philip B. James, Steven W. Lee, Michael A. Ravine, Peter C. Thomas, and Michael J. Wolff, (2007): Context Camera Investigation on board the Mars Reconnaissance Orbiter, Journal of Geophysical Research, Vol,112, doi:10.1029/2006JE002808 Michael H. Carr, (1974): Tectonism and Volcanism of the Tharsis Region of Mars. Journal of Geophysical Research, Vol. 79, No. 26, doi:10.1029/jb079i026p03943; Rees, C., Palmer, J., & Palmer, A. (2018). Gilbert-style Pleistocene fan delta reveals tectonic development of North Island axial ranges, New Zealand. New Zealand Journal of Geology and Geophysics, 61(1), 64–78. https://doi.org/10.1080/00288306.2017.1406377 Toffoli, B., Plesa, A. C., Hauber, E., & Breuer, D. (2021). Delta Deposits on Mars: A Global Perspective. Geophysical Research Letters, 48(17). https://doi.org/10.1029/2021GL094271;

Stellar occultation campaign for (65 803) Didymos in Portugal

João F. Ferreira[1], Kleomenis Tsiganis[1], Paolo Tanga[2], Damya Souami[2]

[1] Aristotle University of Thessaloniki; [2] Observatoire de la Côte d'Azur

Context: As we approach the date of the impact of the DART mission (September 26th 2022), it becomes increasingly important to obtain accurate astrometry of its target binary asteroid system, (65 803) Didymos and its satellite, Dimorphos. One of the best astrometric measurement methods in the field of asteroids are stellar occultations. Campaigns have been made to register positive chords, including one in Portugal on August 25th. Method: The ACROSS team has been making predictions for occultations by this binary system, including events in the US and Japan earlier this year, as well as campaigns in Portugal less than a month from the impact, and in Asia in the days prior. Thanks to a collaboration with the RECON team, several telescopes will be deployed across a large area to maximize the odds of registering at least one positive occultation. Results: Prior to this campaign, several attempts have been made to observe a stellar occultation by Didymos. However, due to there not being prior events from this asteroid, and to its small size (0.78 km of diameter), pinning down the orbit is a complex endeavour. Multi-station campaigns have been organized in the United States (June 25th, July 24th) and in Japan (July 29th), so far without positive chords registered. Conclusion: The campaign in Portugal is of the upmost importance in order to improve the astrometry of Didymos prior to the DART impact, and any positive results will greatly impact our knowledge of this system's orbit. The clock is ticking for events prior to the impact, and Portugal is home to the best campaign left to obtain one.

Detection of Barium in the atmospheres of ultra-hot gas giants

Tomás de Azevedo Silva[1]
[1] IA-CAUP/FCUP

High-resolution spectroscopy studies of ultra-hot Jupiters have been key in our understanding of exoplanet atmospheres. Observing into the atmospheres of these giant planets allows for direct constraints on their atmospheric compositions and dynamics while laying the groundwork for new research regarding their formation and evolution environments. Two of the most well-studied ultra-hot Jupiters are WASP-76b and WASP-121b, with multiple detected chemical species and strong signatures of their atmospheric dynamics. We take a new look at these two exceptional ultra-hot Jupiters by re-analyzing the transit observations taken with ESPRESSO at the VLT and attempt to detect the presence of additional species. We add a novel detection of Ba+ to the known atmospheric compositions of WASP-76b and WASP-121b, the heaviest species detected to date in any exoplanetary atmosphere, with additional new detections of Co and Sr+ and tentatively Ti+ for WASP-121b. We also confirm the presence of Ca+, Cr, Fe, H, Li, Mg, Mn, Na and V on both WASP-76b and WASP-121b, with the addition of Ca, Fe+ and Ni for the latter. Finally, we also confirm the clear asymmetric absorption feature of Ca+ on WASP-121b, with an excess absorption at the bluer wavelengths and an effective planet radius beyond the Roche-Lobe, hinting that the signal may arise from planetary atmospheric escape

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PoET: a solar telescope for planet hunters

Nuno C. Santos[1], Alexandre Cabral[2], and the PoET team
[1] IA/U. Porto; [2] IA/U. Lisboa

High resolution spectroscopy plays a key role in the effort to detect and characterise other Earths. This objective remains, however, challenged by astrophysical noise from the host stars, whose oscillations, granulation, and magnetic activity distort the observed spectra. Existing methods usually tackle the problem without a detailed understanding of the individual sources of variability and are insufficient to reach the required precision levels. A new approach is needed. In this talk I will present the concept of PoET, the Paranal Solar Espresso Telescope. PoET will connect to the "planet hunter" ESPRESSO spectrograph (ESO-VLT) and provide the unique capability to point to any region of the solar disk and obtain ultra-high resolution (>200 000), precisely wavelength calibrated spectra of the resolved solar disk and covering the full optical domain (380-780 nm) in one single shot. Using the Sun as a proxy for other solar-type stars, data will allow to map our star and understand in unprecedented detail the contribution of each solar feature to spectral variability that affect the detection and characterisation of exoplanets. The potential of PoET for the national solar and stellar community will also be discussed. The PoET project was recently funded though an ERC Advanced Grant.

Monday 11:15 - 13:00 - Galactic and Extragalactic Astronomy

Mass loss in Open Clusters

Duarte Almeida[1]
[1]FCUL

Mass is the main quantity driving the formation, structure, and evolution of stars but it also governs the dynamics of stellar systems such as Open Clusters (OCs) that provide crucial information about the dynamical evolution of the Galactic disk where they are formed. In recent years, several large-scale OC studies have been published, however high quality and systematic mass determinations for OCs are not available so, in our work, we performed homogenous mass determinations for 1743 OCs from the state-of-the-art catalogue of Milky Way OCs (W. Dias et al., 2021). Mass errors were assessed using two mass determination methods as well as with bootstrapping techniques and are typically between 2 and 5%. Using the resulting mass distribution, we attempted to constraining the mass loss fraction experienced by clusters along their life by simulation the mass evolution using the dissolution equation derived by Lamers et al., 2005. We recover the same disruption parameter values obtained in the literature when considering the age distribution, but it does not provide a good match when considering the mass distribution. To improve the agreement between the simulated and observed masses, a different Cluster Initial Mass Function (CIMF) was used which led to better results.

Galactic potentials and stellar orbits in AEssence

Claudio Llinares[1]
[1] IA/FCUL

The knowledge of the different classes of stellar orbits that can be accommodated in a given galactic potential is a prerequisite when building self-consistent models using for instance the Schwarzschild technique. Furthermore, observational properties of galaxies depend on what these classes of orbits are and in particular, on the presence of chaos in the systems. In the realistic case in which our starting point is not a galactic potential, but a density distribution, we will require a gravitational theory to make the connection between the stars that we see and the movement these stars may be having. Here we study orbits predicted by AEssence, which is the latest extension of the MOND phenomenology into the relativistic world. We find that thanks to the presence of a mass term in the field equations, the theory can allocate new classes of orbits that do not exist in both Newtonian gravity or MOND. We discuss consequences that these new families of orbits can have in non-linear cosmological structure formation as well as explore a possible alternative model for galactic structure.

Scale Height Evolution of the Galactic Disk

Sandro Moreira[1], André Moitinho[1]
[1] CENTRA - FCUL

Observations seem to imply that the thickness of the Galactic disk traced by old stellar clusters is larger than that defined by young clusters. Different mechanisms have been proposed in the literature. Here, we explore a different approach. Perhaps, the reported evolution of the disk scale height is an effect of a selective disruption of open clusters closer to the galactic plane. In a previous work, a computational model that combined effects of star cluster birth and dissolution rates for the encounters with giant molecular clouds, successfully recreated the evolution of the disc scale height. However, it featured a discrepancy in the number of clusters surviving at each age between the simulations and the observational data. This was possibly due not considering the effects of cluster masses in the model. In this work, we upgrade the model with mass dependent disruption by the Galactic tidal field and internal (secular) dissolution. We reproduce not only the evolution of the disc scale height but also the cluster numbers and age distributions found by the Gaia mission.

An investigation of the star-forming main sequence considering the nebular continuum emission at low-z

Henrique Miranda[1,2], Ciro Pappalardo[1,2], Polychronis Papaderos[1,2], José Afonso[1,2], Israel Matute[1,2], Catarina Lobo[1,3], Ana Paulino-Afonso[1,3], Rodrigo Carvajal[1,2], Silvio Lorenzoni[1], Duarte Santos[1,2]

[1] Instituto de Astrofísica e Ciências do Espaço e Departamento de Física; [2] Faculdade de Ciências da Universidade de Lisboa; [3] Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto

Galaxy evolution has been studied through the interpretation of the spectral energy distribution of galaxies using spectral synthesis codes and this method has been crucial in discovering different pillars of modern galaxy evolution theories. However, this analysis has been mostly carried out using spectral synthesis codes that assume a negligible nebular contribution to the total continuum. FADO is the first publicly available population spectral synthesis tool that treats self-consistently, the contribution from ionised gas to the observed emission. This is expected to be particularly influential when considering star-forming (SF) galaxies. In this talk, I will present the results of the study of the impact of the nebular contribution in the determination of the star formation rate (SFR), stellar mass and consequent effect on the star-forming main sequence (SFMS), at low redshift for a sample of SF galaxies. We considered the application of FADO to the spectral database of SDSS to derive physical properties of galaxies. As a comparison, we used the data in the MPA-JHU catalogue, which contains the properties of SDSS galaxies derived without considering the nebular contribution. The results show that the SFR estimates, derived from the extinction-corrected Hα luminosity, are similar between FADO and MPA-JHU (difference of 0.01 dex). The stellar mass estimates are in average slightly higher (0.11 dex) for FADO than for MPA-JHU. However, considering the uncertainties, the differences are negligible. With similar SFR and stellar mass estimates, the derived SFMS is also similar between FADO and MPA-JHU (difference of 0.02 dex). Our results show that for SDSS normal SF galaxies the additional modelling of the nebular contribution does not affect the retrieved fluxes and consequentially also does not influence SFR estimators based on the extinction-corrected Hα luminosity. For the stellar masses the results point to the same conclusion. These results are a consequence of the fact that the vast majority of normal SF galaxies in SDSS have a low nebular contribution. However, the obtained agreement might only hold for local SF galaxies whereas higher redshift galaxies could show different physical properties when using FADO, as an effect of the expected increased nebular contribution.

Ensemble Machine Learning for the Extraction of High-Redshift Radio Galaxies

R. Carvajal[1], I. Matute[1], J. Afonso[1], S. Amarantidis[2], D. Barbosa[3]

[1] IA-Universidade de Lisboa; [2] IRAM; [3] IA-Universidade de Lisboa.

Understanding the conditions in which Active Galactic Nuclei (AGN) grow and interact with their host galaxies is one of the main steps into obtaining a full picture of the overall evolution of galaxies and their environment. This is markedly relevant in the context of the Epoch of Reionisation (EoR), for which observations of AGN might be the only way to access the processes occurring in high-redshift galaxies. In particular, observations in radio and X-ray wavelengths, which are not obscured or by the material present in host galaxies, can help characterising some of the properties of the central engines of AGN. Up to this moment, $\sim$400 AGN have been detected, optically, close to the EoR with only a fraction of them being observed in radio wavelengths. This is in stark with current models and simulations, which have determined that, given the conditions of current and future radio surveys (e.g. EMU, MIGHTEE, SKA, LoTSS, etc.), the number of detected AGN should be, at least, one order of magnitude larger. In view of the need to detect, observe, and study more high-redshift AGN, new techniques have been used in parallel to traditional AGN detection and redshift determination methods. One family of procedures is that of Machine Learning (ML), which can leverage the large data volumes from existing catalogues in order to extract correlations among their properties and be used to predict the characteristics of new sources. As part of this effort to obtain new high-redshift, radio-detected, AGN (Radio Galaxies, RG), we have developed an ensemble ML pipeline that, using multi-wavelength photometry of NIR-detected objects, can predict the detection of RG and their corresponding redshift values. We will present the results of training this pipeline with photometry from sources the Hobby-Eberly Telescope Dark Energy Experiment Spring (HETDEX) field and applying it to non-fully characterised sources in the Stripe 82 field.

FADO and galaxy classification

Duarte Santos[1], Ciro Pappalardo[2], Henrique Miranda[1]
[1] FCUL, IA; [2] IA

From the spectra of galaxies, we are able to extract several physical properties, such as the star-formation rate, stellar mass and metallicity. However, to calculate these, one must first understand what is the driving mechanism of the emission lines in these galaxies. Baldwin, Phillips & Terlevich (1981) found that comparing the flux ratio of specific emission lines organized galaxies in four distinct areas, due to different excitation mechanisms. These diagrams were named the BPT diagrams. Kaufmann et al. (2003) and Kewley et al. (2006) found that galaxies could be divided in three types: star-forming (SF), galaxies with Active Galactive Nuclei (AGNs) and galaxies with a mixture of both, Composite. To extract the emission line flux of these galaxies, models such as the Stellar Population Synthesis (SPS) models are implemented in their observed spectra. However, a problem with these models is that they only consider the stellar contribution, neglecting the nebular emission. FADO (Fitting Analysis using Differential evolution Optimization), developed at the Institute of Astrophysics and Space Sciences, is the first SPS model that self-consistently adds nebular emission to its code. The purpose of this work is to compare the MPA-JHU analysis (Brinchmann et al., 2004) with the FADO analysis (Cardoso et al, accept.) of the spectra of the Data Release 7 of the Sloan Digital Sky Survey (SDSS DR-7, Abazajian et al., 2009) galaxies, to understand if the nebular contribution affects galaxy classification through the standardised BPT diagrams, with galaxies in the Local Universe. We have found that the self-consistent addition of nebular emission does not affect galaxy classification through emission line diagnostic diagrams, i.e., BPT, SII and OI. The same is true of the galaxies in the Main Sequence, where the galaxies in FADO and MPA-JHU fall in the same regions of the parameter space, which is in line with previous research (Miranda et al. sumbitted). Furthermore, 10% of the galaxies that are classified as SF by the BPT diagram are classified as AGN by either the SII or OI diagram, and of these galaxies, up to 71% have low stellar masses ($< 10^9$ $M_\odot$) and sub-solar metallicites ($12 + \log \mathrm{O/H} < 8.69$). This implies a bias in classification in the BPT diagram, where these galaxies most likely have an AGN component that the BPT diagram is unable to detect. Finally, we have also found that comparing the equivalent width of either Hα and Hβ with the ratio of the equivalent widths of [OIII]λ5007 and Hβ separates galaxies in two types: SF and AGNs. Although they are unable to distinguish the Composite population, these diagrams are useful in the case we do not have the four emission lines to plot the BPT diagram, allowing us to have a preliminary outlook into the properties of a galaxy. This simple classification could be used in future large spectroscopic surveys, such as MOONS, where at redshift above 2 the Hα and [NII]λ6584 emission lines fall outside the coverage of this instrument. In the future, we plan on further analysing galaxies that are misclassified by more than one diagram to understand if they truly have an AGN in their cores. We will do this by modelling their SEDs through a wide range of wavelengths (from the NED database) and then by seeing if the fit is better with our without AGN contribution, using the χ^2 test.

A Sample of Dust Attenuation Laws for DES Galaxies

João Duarte[1], Santiago González-Gaitán[1], Ana Mourão[1], Ana Paulino-Afonso[2]
[1] CENTRA/IST; [2] IA/UP

Type Ia supernovae (SNe Ia) are useful distance indicators in cosmology, provided their luminosity is standardized by applying empirical corrections based on light-curve properties. One of these corrections, expressed as a color-luminosity relation, accounts for the effect of dust extinction. As the role of dust in both supernova and extra-galactic astronomy is still not fully understood, this color-luminosity relation is usually assumed to be universal, which can potentially introduce systematics into the standardization. The Hubble residuals step observed between SNe originating in low and high mass galaxies has been suggested as one such systematic. In this work we seek to obtain a more complete view of dust attenuation for a sample of 162 SN Ia host galaxies and to ascertain whether the "mass-step" is linked to dust properties. We fit Composite Stellar Population models to both the global and local (4 kpc) Dark Energy Survey photometry for these galaxies, which are used to map dust properties. We observe a large variation of dust reddening levels and confirm that these change with host galaxy properties, such as the stellar mass and age. We recover a well documented relation between the attenuation slope and the optical depth, best explained by the variation of star to dust geometry with galaxy orientation. This relation is shown to differ significantly from the extinction slope/optical depth relation found directly for SNe. Analyzing the usual SN standardization, we find evidence of a two dimensional "dust-step", which, although comparable, is not completely analogous to the "mass-step". We find both steps to be more pronounced for red SNe. We conclude that dust attenuation varies greatly with galaxy properties such as the stellar mass, meaning a universal Rv = 3.1 or a universal SN Ia correction should ideally not be assumed. We also conclude that the global and local environmental dust values for the hosts seem to be a poor representation of SN extinction. Additionally, the "mass-step" cannot be fully accounted for using host galaxy attenuation and a "dust-step" approach.

Monday 14:00 - 15:30 - Galactic and Extragalactic Astronomy (cont.); Cosmology and Gravitation, part 1

The 3D motion of the ISM with ESO and ESA telescopes

João Alves[1]
[1]U.Vienna

The current model for the structure of the local Milky Way is in crisis. Data from the ESA Gaia mission has overthrown the 150-year-old paradigm for the gas distribution in the local Milky Way, a 500 pc ring known as Gould's Belt. In the newly emerging view, local star-forming regions are connected by lower-density gas. They are part of a new organizational unit: undulating, coherent, and linear Galactic-scale gas structures. What is the origin of these kpc-long structures, how do star-forming regions form and disperse inside them, and are they related to the traditional view of spiral arms?

Underpinning these questions lies a critical measurement currently beyond reach: tracing the Galactic gas flow in 3D. Gas flow is a fundamental physical property of the ISM. Knowing it is to know the past and future path of the gas in the Galaxy, measure momentum and infer the external forces acting on the star-forming gas. Achieving this measurement for the local kpc would constitute a breakthrough in ISM, star formation, and spiral structure formation research. The goal of ISM-FLOW is to see the local Milky Way gas in 3D motion for the first time and make sense of it. The project will use a dedicated large observational campaign in the near-infrared at ESO (VISIONS, PI: Alves) and upcoming ESA Gaia data. We will measure the local Galactic gas flow for the first time, derive the local molecular gas trajectory from the past and into the future (-20 to 20 Myr), and be in a position to make significant advances in the field.

Interstellar dust indicators from Integral Field Spectroscopy

Sabyasachi Goswami[1]
[1]CENTRA

Extinction in the line of sight towards supernovae affects the determination of its explosion properties and progenitor characteristics, as well as its distance estimation when used in cosmology. The host galaxies where supernova occurs contain a wealth of information largely unexplored at resolved scales in the context of supernovae. With the integral field spectroscopy of nearby galaxies that have hosted supernovae from The All-weather MUse Supernova Integral field Nearby Galaxies (AMUSING) survey, we are in a unique position to investigate in detail the dust properties near and far from the explosion site for a variety of galaxies and supernova types. Resonant lines from ions like sodium (Na I D), potassium (K I), magnesium (Mg II) etc. are abundant in the interstellar medium(ISM) and can be observed in the optical spectra of galaxies to obtain valuable information about dust and gas. We compare the characteristics of the observed spectra to the ISM absorption features and make maps of various galaxy properties which allows a detailed study of the origin and nature of narrow absorption lines, leading to strong constraints on progenitor systems and host galaxy extinction.

Extinction curves of type Ia supernovae from the Dark Energy Survey

João Gonçalves[1]
[1] IST/CENTRA

Although they are not strictly standard candles, type Ia supernovae can still be used as such if their luminosity is corrected with the luminosity-lightcurve width relation and the luminosity-color relation. This latter takes into account the effects of interstellar dust, namely extinction and reddening, quantified by the supernova's dust parameters: Av and Rv. However, Rv and the slope of the luminosity-color relation are routinely assumed universal for all supernovae. In this work, we set out to analyse observations of 207 type Ia supernovae from the Dark Energy Survey covering the redshift range 0-0.8. Our aim is to obtain individual dust parameters for each supernova. We do this by fitting their griz lightcurves with SN(oo)Py, a Monte Carlo Markov Chain lightcurve fitter. We investigate the fitting methodology by first fitting simulated supernovae, studying the effects that different parameter priors have on the results. We then fit the DES data, analysing correlations between different parameters, comparing the results obtained using SN(oo)Py with those previously obtained using different fitters and retrieving extinction parameters, notably Rv. We find that, as expected, Rv is difficult to constrain with just four filters, and we thus perform additionally an analysis of color populations. Our preliminary results show indications for several different Rv populations within type Ia supernovae, which should be taken into account when correcting luminosities for cosmology.

A designer approach to f(Q) gravity and cosmological implications

Inês Albuquerque[1]
[1]IA/FCUL

The current standard cosmological scenario, described by the Lambda-Cold-Dark-Matter (LCDM) model, relies on both the validity of General Relativity (GR) and the existence of a dark sector. However, in addition to the still unanswered questions surrounding the latter, a growing number of accurate cosmological surveys has also been reporting observational tensions within LCDM. As a consequence, alternatives beyond the standard model have been extensively explored, including large-scale modifications of the gravitational interaction known as Modified Gravity (MG) theories. Among the latter is f(Q) gravity, a MG theory belonging to the Symmetric Teleparallel Gravity in which gravitational phenomena are attributed to non-metricity instead of curvature and where f(Q) is a general function of the non-metricity scalar, Q. In this talk I will present a designer approach to f(Q) gravity, where the form of the f(Q) function is designed to match specific expansion histories based on different choices for the evolution of the effective dark energy equation of state. I will present the investigation of the evolution of linear cosmological perturbations in this model by studying the behavior of the effective gravitational coupling and providing theoretical predictions for related physical quantities such as the product of the growth rate and the root mean square of matter fluctuations and the sign of the cross-correlation power spectrum of galaxy distribution and Cosmic Microwave Background (CMB) anisotropies.

Testing f(Q) gravity with redshift space distortions

Tiago Barreiro[1], Bruno Barros[2], Tomi Koivisto[3], Nelson Nunes[4]
[1] IA-FCUL and ULHT; [2] Cape Town U.; [3] Tartu, Inst. Phys.; [4] IA-FCUL.

A cosmological model with Symmetric Teleparallel Gravity is constrained with redshift space distrotions data. The cosmological background for the model mimics a ΛCDM evolution but differences arise in the perturbations. The linear matter fluctuations are numerically evolved and the study of the growth rate of structures is analyzed in this cosmological setting. The best fit parameters reveal that the σ_8 tension between Planck and Large Scale Structure data can be alleviated within this framework.

Monday 16:00 - 17:45 - Cosmology and Gravitation, part 1, cont.

Generalising conformal time

José Pedro Mimoso[1]

[1] Dept. Física FCUL & Instituto de Astrofísica e Ciencias do Espaço

Conformal time is a time coordinate often used in the investigation of Friedmann-Lemaitre-Robertson-Walker (FLRW) cosmological models. It defines the time measured by a comoving observer, and is simply related to the comoving distance travelled by light rays, and hence to cosmological horizons. In the present work, I analyse how to generalise this useful coordinate to models that are more general than the spatially homogeneous and isotropic Friedmann-Lemaitre-Robertson-Walker (FLRW). In particular I consider the cases either of anisotropic or of inhomogeneous models, as well as the case of cosmological models built in the framework of extended gravity theories. We show that the crucial point supporting the generalization of conformal time is the requirement of vanishing shear.

Adventures in automatic differentiation

Justin Feng[1]

[1]Instituto Superior Tecnico

In this talk, I discuss automatic differentiation, which refers to a collection of numerical methods for efficiently differentiating arbitrary functions to machine precision. In the Julia language, robust libraries exist which can differentiate numerical ODE solutions with respect to problem parameters. I discuss some of the applications I have explored so far, as well as some potential uses for these techniques in gravitation and astrophysics.

Forecasting F(Q) cosmology with standard sirens

José Ferreira[1], Tiago Barreiro[1], José Mimoso[1], Nelson Nunes[1]
[1] IA/FCUL

Forecast constraints for a Symmetric Teleparallel Gravity model with a ΛCDM background are made using forthcoming ground and space based gravitational waves observatories. A Bayesian analysis resorting to generated mock catalogs shows that LIGO is not expected to be able to distinguish this model from ΛCDM, while both LISA and the ET will, with the ET outperforming LISA. We also show that low redshift events are favored in order to improve the quality of the constrains.

Particle production processes in f(R,T) gravity

Miguel A. S. Pinto[1], Tiberiu Hark[2], Francisco S.N. Lobo[3]

[1] Institute of Astrophysics and Space Sciences, University of Lisbon; [2] Department of Physics, Babes-Bolyai University; [3] Institute of Astrophysics and Space Sciences, University of Lisbon

We investigate the possibility of gravitationally generated particle production in the scalar-tensor representation of f(R,T) gravity. As happens with any modified theory of gravity with a nonminimal curvature-matter coupling, the divergence of the matter energy-momentum tensor does not vanish identically. We explore the physical and cosmological implications of this non-conservation by using the formalism of irreversible thermodynamics of open systems in the presence of matter creation/annihilation. The particle creation rates, pressure, temperature evolution and the expression of the comoving entropy are obtained in a covariant formulation and discussed in detail. Applied together with the gravitational field equations, the thermodynamics of open systems lead to a generalization of the standard ΛCDM cosmological paradigm, in which the particle creation rates and pressures are effectively considered as components of the cosmological fluid energy-momentum tensor. We also consider specific models, and we compare the scalar-tensor f(R,T) cosmology with the ΛCDM scenario, and if it additionally gives rise to particle creation rates, creation pressures, and entropy generation through gravitational matter production in both low and high redshift limits.

Testing GR in collapsing spacetimes

V. Cardoso[1], D. Hilditch[1], K. Marouda[1], J. Natario[1], U. Sperhake[2]
[1] IST Lisbon; [2] Cambridge UK

It is expected that GR breaks down near a Planck mass black hole. We explore whether this may also be true during the dynamical formation of a finite mass black hole. We consider solutions to the Einstein field equations in order to examine departures from general relativity that would be induced by the potential dominance of higher derivative curvature invariants on the dynamics. These arise naturally in effective field theory. In this talk, I will provide numerical results from classical collapsing spacetimes, in an attempt to address this intriguing topic.

Linearized General Relativity in hyperboloidal slices

Inês Rainho[1]

[1]Instituto Superior Técnico

Waveforms are the main deliverable of numerical relativity for gravitational wave astronomy. The precision of the theoretical waveforms is critical for recovering the correct properties of the systems that emitted the signal. These waveforms are obtained by evolving the system (usually a coalescing compact binary) using the Einstein field equations and extracting the emitted signals. Gravitational radiation is only unambiguously defined at future null infinity. A problem that remains unsolved is the computation of the waveforms all the way out to future null infinity from first principles. In this talk I will present an approach to solve this problem resorting to hyperboloidal slices. They are spacelike and smooth everywhere, and they reach future null infinity, which allows us to unambiguously extract gravitational waves there. Evolving on hyperboloidal slices requires writing the Einstein field equations in a new set of coordinates adapted to outgoing waves. By performing this coordinate transformation, infinity is brought to a finite coordinate distance. This introduces infinities in the equations themselves, but they can be overcome by considering the rate of decay of the fields as we approach future null infinity.

Cosmological constraints on a simple model for varying alpha

Nelson J. Nunes[1], Vitor da Fonseca[1], Tiago Barreiro[1]

[1] Instituto de Astrofísica e Ciências do Espaço - U. Lisbon

We use quasars spectra measurements, including the latest ESPRESSO data point, as well as Planck observations of the cosmic microwave background to constrain a simple parametrization of scalar field dark energy also responsible for the possible variation of the fine structure constant. We combine them with local results from atomic clocks and the MICROSCOPE experiment. The constraints placed on the parameters of the model are consistent with a null variation of the field.

Tuesday 9:00 - 10:45 - Planets and Planetary Systems, part 2; Solar and Stellar Physics

Venus Atmospheric Dynamics: Akatsuki UVI and TNG HARPS-N observations

Daniela Espadinha[1], Pedro Machado[1], Javier Peralta[2], José Silva[1], Francisco Brasil[1]

[1] Institute of Astrophysics and Space Sciences, Observatório Astronómico de Lisboa, Portugal; [2] Departamento de Física Atómica, Molecular y Nuclear, Universidad de Sevilla: Sevilla, Andalucía, Spain

As the closest planet to Earth, it should be expected Venus to be the most Earth-like planet we know. Both Earth and Venus share almost the same radius, mass and density and were formed from the same available ingredients, at the same time and location in the Solar System. Yet, Venus has undoubtedly ended up with an extreme climate, with a dense carbon dioxide dominated atmosphere responsible for a runaway greenhouse effect and high surface temperatures. Because of these similarities and differences, Venus is a key planet in the understanding of planetary evolution to which the study of the atmospheric dynamics is indispensable. For Venus, the better understanding of cloud circulation can yield important results such as the possibility to explain and describe one of its most fascinating characteristics: the superrotation of Venus' atmosphere. To accurately describe the atmospheric circulation of Venus, this work employed the use of two distinct methods (described below) to obtain wind velocities on specific layers of the Venusian atmosphere: The Doppler velocimetry for fibre-fed spectrographs was initially developed by Thomas Widemann (Widemann et al., 2008) and was later evolved by Pedro Machado who also developed and fine-tuned a Doppler velocimetry method for long slit spectrographs (Machado et al., 2012, 2014). This technique is based on solar light scattered on Venus' dayside and provides instantaneous wind velocities measurements of its atmosphere. The sunlight is absorbed by cloud particles in Venus' top clouds and then re-emitted in Earth's direction in a single back-scatter approximation (Machado et al., 2012, 2014, 2017). The cloud-tracking method consists of a simple analysis of a pair of navigated and processed images, provided that the time interval between both is known. It is possible to analyse the motion of cloud features between the initial and second image, either by matching specific points or areas in both images. This matching process allows us to measure displacements and velocities of cloud features and deduct an average velocity for a certain cloud layer of the atmosphere, selected in the wavelength range of the observations (Peralta et al. 2018). The use of an evolved tool of cloud tracking based on phase correlation between images and other softwares (Hueso et al. 2010) allows to explore Venus' atmospheric dynamics based on space and ground observations including data from Akatsuki UVI instrument and TNG/HARPS- N. The images used were navigated and processed for optimal identification of cloud features which help with the processes described above. In short, the main goal of this work was to build wind profiles in different wavelengths which allow us to

analyse several layers of the Venusian atmosphere. Some results of this study are presented following the works of Sánchez-Lavega et al. 2008, Hueso et al. 2013 and Horinouchi et al. 2018. Another goal of this study is connected to the detection and characterisation of atmospheric gravity waves also using Akatsuki/UVI images. These waves are oscillatory disturbances on an atmospheric layer in which buoyancy acts as the restoring force. They can only exist in stably stratified atmospheres, that is, a fluid in which density varies mostly vertically (Silva et al. 2021). It is possible that the exploration of these waves can lead to a better understanding of the mechanisms that drive the state of superrotation of the Venusian atmosphere. References [1] Hueso et al., The Planetary Laboratory for Image Analysis (PLIA). Advances in Space Research, 46(9):1120–1138, 2010. [2] Sánchez-Lavega et al., Variable winds on Venus mapped in three dimensions. Geophysical Research Letters, 35 (13), 2008 [3] Hueso et al., Venus winds from ultraviolet, visible and near infrared images from the VIRTIS instrument on Venus Express. 2013. [4] Horinouchi et al., Mean winds at the cloud top of venus obtained from two-wavelength UV imaging by Akatsuki. Earth, Planets and Space, 70:10, 2018. [7] Machado et al., Characterizing the atmospheric dynamics of Venus from ground-based Doppler velocimetry, Icarus, Volume 221, p.248-261, 2012. [6] Machado et al., Wind circulation regimes at Venus' cloud tops: Ground-based Doppler velocimetry using CFHT/ESPaDOnS and comparison with simultaneous cloud tracking measurements using VEx/VIRTIS in February 2011, Icarus, 2014. [7] Machado et al., Venus Atmospheric Dynamics at Two Altitudes: Akatsuki and Venus Express Cloud Tracking, Ground-Based Doppler Observations and Comparison with Modelling. Atmosphere 2021, 12, 506. [8] Machado et al., Venus cloud-tracked and Doppler velocimetry winds from CFHT/ESPaDOnS and Venus Express/VIRTIS in April 2014. Icarus, vol. 285, p. 8-26, 2017. [9] Peralta et al., Nightside Winds at the Lower Clouds of Venus with Akatsuki/IR2: Longitudinal, Local Time, and Decadal Variations from Comparison with Previous Measurements. The American Astronomical Society. The Astrophysical Journal Supplement Series, Volume 239, Number 2, 2018 [10] Widemann et al., Venus Doppler winds at cloud tops observed with ESPaDOnS at CFHT, Planetary and Space Science, Volume 56, p. 1320-1334, 2008. [11] Silva et al., Characterising atmospheric gravity waves on the nightside lower clouds of Venus: a systematic analysis, A&A 649 A34, 2021. Acknowledgements We thank the JAXA's Akatsuki team for support with coordinated observations. We gratefully acknowledge the collaboration of the TNG staff at La Palma (Canary Islands, Spain) - the observations were made with the Italian Telescopio Nazionale Galileo (TNG) operated on the island of La Palma by the Fundación Galileo Galilei of the INAF (Istituto Nazionale di Astrofisica) at the Observatorio del Roque de los Muchachos of the Instituto de Astrofisica de Canarias. We acknowledge support from the Portuguese Fundação Para a Ciência e a Tecnologia (ref. PTDC/FIS-AST/29942/2017) through national funds and by FEDER through COMPETE 2020 (ref. POCI-01-0145 FEDER-007672) and through a grant of reference 2020.06389.BD.

Atmospheric Gravity Waves on Mars using OMEGA/Mars Express images – novel results from systematised study

F. Brasil[1,2], P. Machado[1,2], G. Gilli[3,1], A. Cardesin-Moinelo[4,1], J. E. Silva[1,2], D. Espadinha[1,2], R. Rianco-Silva[2]

[1] Instituto de Astrofisica e Ciencias do Espaco, Lisbon, Portugal; [2] Faculdade de Ciencias da Universidade de Lisboa, Lisbon, Portugal; [3] Instituto de Astrofisica de Andalucia (IAA-CSIC), Granada, Spain; [4]European Space Astronomy Centre, Spain

Atmospheric gravity waves are mesoscale atmospheric oscillations in which buoyance acts as the restoring force, being a crucial factor in the circulation of planetary atmospheres since they transport momentum and energy, which can dissipate at different altitudes and force the dynamics of several layers of the atmosphere [1]. The source of these waves can be associated with the surface's topographic features (orographic gravity waves) or with jet streams and atmospheric convection (non-orographic gravity waves). Recent modelling studies showed the strong role of gravity waves on diurnal tides on Mars atmosphere [2], however, their characteristics are still not well constrained by observations. Here we report follow-up results from the detection and characterisation of atmospheric waves on Mars' atmosphere, using data from the OMEGA spectrometer on board the Mars Express (MEx) space mission [3]. We used image navigation and processing techniques based on contrast enhancement and geometrical projections to characterise the morphological properties of the detected waves. Our observations include the MEx nominal mission of the OMEGA instrument for the Martian years 27 and 28 (from January 2004 – January 2006 and from June – July 2007), constituted by 27 orbits and 4072 hyperspectral data QUBES. Every image was navigated and processed in order to optimise the detection of the wave packets and accurate characterisation of the wave properties such as the horizontal wavelength, packet width, packet length and orientation. The characterised wave packets present a wide range of properties over a broad region of Mars' globe, especially in the evolution of gravity waves. We also found that the detected waves occur at solar longitudes between 240-250º and 330-340º, almost corresponding to the beginning and the end of the dust storm seasons. This preliminary result suggests a relationship between the presence of atmospheric waves and the dust storm events, already mentioned by Gondet et al. (2019). Acknowledgements: We acknowledge support from the Portuguese Fundação Para a Ciência e a Tecnologia of reference PTDC/FIS-AST/29942/2017, through national funds and by FEDER through COMPETE 2020 of reference POCI-01-0145-FEDER-007672, and through a grant of reference 2021.05455.BD. Funded by ESA Faculty research contract and Science Exchange Programme in the frame of MWWM - Mars Wind and Wave Mapping project. We would like to thank the late Dr Brigitte Gondet for her considerable help that made this work possible. References [1] Fritts, D. C.; Alexander, M. J. Gravity wave dynamics and effects in the middle atmosphere. Reviews of geophysics, 2003, 41.1. [2] Gilli, G., et al. Impact of gravity waves on the middle atmosphere of Mars: A non-orographic gravity wave parameterization based on global climate modeling and MCS observations. Journal of Geophysical Research: Planets, 2020, 125.3: e2018JE005873. [3] Brasil, Francisco, et al. Characterising Atmospheric Gravity Waves on Mars using Mars Express OMEGA

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Saturn atmosphere's winds with VLT/UVES Doppler velocimetry

Pedro Machado[1], Miguel Silva[2], Agustin Sánchez-Lavega[3], José Silva[2], Daniela Espadinha[2], Francisco Brasil[2], and José Ribeiro[4]

[1] Institute of Astrophysics and Space Sciences, IA-FCUL, Lisboa, Portugal (machado@oal.ul.pt); [2] Institute of Astrophysics and Space Sciences; [3] Departamento de Física Aplicada, Escuela de Ingeniería de Bilbao, Spain; [4] Institute of Astrophysics and Space Sciences.

We present Doppler wind velocity final results of Saturn's zonal flow at cloud level. Our aim is help to constrain the characterization of the equatorial jet at cloud level and the latitudinal variation of the zonal winds, to measure its spatial and temporal variability, to contribute to monitor the variability in order to achieve a better understanding of the dynamics of Saturn's zonal winds (Sánchez-Lavega et al. 2003, 2007, 2016); Finally, the complementarity with Cassini, providing an independent set of observations. The study of the planet's global system of winds at the 0.7 bar region is based on high resolution spectra from the UV-Visual Echelle Spectrograph (UVES) instrument at ESO's Very Large Telescope (VLT). Under the assumption of predominantly zonal flow, this method allows the simultaneous direct measurement of the zonal velocity across a range of latitudes and local times. The technique, based on long slit spectroscopy combined with the high spatial resolution provided by the VLT, has provided the first ground-based characterization of the latitudinal profile of zonal wind in the atmosphere of Saturn and the first zonal wind field map in the visible. It promises to improve the characterization of the equatorial jet and the latitudinal variation of the zonal winds, as well the measurement (and monitorization) of its spatial and temporal variability, achieving a better understanding of the dynamics of Saturn's zonal winds (which Sánchez-Lavega have found to have changed in recent years). A complete characterization of the dynamical behaviour of Saturn atmosphere is crucial for understanding its driving mechanisms. Finally, the complementarity with Cassini, has provided an independent set of observations to compare with and help validate the method. The zonal wind profile retrieved is consistent with previous spacecraft measurements based on cloud tracking, but with non-negligible variability in local time (longitude) and in latitude. The UVES/VLT instrument has been used, which simultaneously achieves high spectral resolving power and high spatial resolution. The field has been derotated in order to have the aperture aligned perpendicularly to Saturn's rotation axis. In this configuration, spatial information in the East-West direction is preserved in a set of spectra in the direction perpendicular to dispersion. Our Doppler velocimetry method is based on the technique of absolute accelerometry (Connes, 1985) which has been applied to the backscattered solar spectrum in order to determine the Doppler shift associated with the zonal circulation. Our measurements have been made in the wavelength range of 480-680 nm. Previously we successfully adapted and fine tuned this Doppler velocimetry technique for measuring winds at Venus cloud tops (Machado et al. 2012, 2014,2017, 2021; Gonçalves et al., 2020). In the present study we will show the adaptation of this method for Saturn's case. We will use coordinated observations from the Cassini's Visible and Infrared Mapping Spectrometer (VIMS),

in order to compare with the Doppler winds obtained from the UVES/VLT high-resolution spectra. The observations consisted of 4 blocks of 15 exposures of 90 sec, plus two shorter blocks of 9 exposures, totaling 7.3 hours of telescope time. In order to cover the whole disk the aperture has been offset by 1 arcsec in the North-South direction between consecutive exposures. Most of the northern hemisphere was covered by the rings. Saturn's diameter was 17.4 arcsec, and the slit aperture was 0.3x25 arcsec. The aperture offset between consecutive exposures was 1 arcsec. Two shorter observations blocks of 9 exposures only covered the central part of the disk, and four others covered the whole disk. The sub-terrestrial point was at -26.1° S. The presence of the rings lead to severe order superposition. The dark region between the rings and the disk may or may not be present, depending on the slit position. On the other hand, defects in the response of the UVES slit in the upper part preclude its use for accurate Doppler measurements such as these. For these reasons only the central part of the aperture has been considered for the measurements. It can be easily noticed that we were able to reproduce with a significant agreement the amplitudes of the wind velocities previously observed in a vast range of latitudes and that they are highly consistent with the cloud tracking measurements from almost simultaneous Cassini data. References: Connes, P., Absolute Astronomical Accelerometry, Astrophysics and Space Science (ISSN 0004-640X), volume 110, no. 2, p.211-255, 1985. Goncalves, R., Machado, et al., Icarus, 335, article id. 113418, 2020. Machado, P., Luz, D.Widemann, T., Lellouch, E.,Witasse, O, , Icarus, Volume 221, p. 248-261, 2012. Machado, P., Widemann, T., Luz, D., Peralta, J., Icarus, 2014. Machado, P., Widemann, T., Peralta, J., Gonçalves, R., Donati, J-F., Luz, D., Icarus, 285, 8-26, 2017 Machado, P., et al., Atmosphere, 12, 506, 2021. Sánchez-Lavega, A., et al., Nature, 423, 623-625, 2003. Sánchez-Lavega, A., Hueso, R.; Pérez-Hoyos, S., Icarus, 187, 510-519, 2007. Sánchez-Lavega, A., et al., Nature Communications, 7, id. 13262, 2016.

Preliminary atmospheric study of Jupiter using ISO/SWS data

José Ribeiro[1], Pedro Machado[1], Santiago Pérez-Hoyos[2], João Dias[1], Patrick Irwin[3]
[1] Instituto de Astrofísica e Ciências do Espaço; [2] Universidad del País Vasco; [3] University of Oxford

The study of the thermal spectrum of Jupiter gives us the possibility to study the elements that constitute the Jovian atmosphere, allowing us to infer the formation history and conditions of the giant planet (Taylor et al., 2004). Determining the abundance of chemical species and isotopic ratios is fundamental in this regard. For this, we reanalyse 1997 Jupiter data obtained by the ESA mission Infrared Space Observatory (ISO) (Kessler et al., 1996) in the 793.65-3125 cm−1 (3.2-12.6 μm) region using the Short-Wave Spectrometer (SWS) (de Graauw et al., 1996). Despite the age of this data, we argue that it warrants a revisit and reanalysis since it was an important step in the study of Jupiter's atmosphere and there have since been advancements in atmospheric models and line data. In this work we used the NEMESIS radiative transfer suite (Irwin et al. 2008) to reproduce the observations from Encrenaz et al. (1999), which will also work as a validation of our method. Using the Cassini/CIRS model as a starting point, we adapted the template for the ISO/SWS data. We compiled correlated k-tables from the spectral line database from Fletcher et al. (2018) for a NH3, PH3, 12CH3D, 12CH4, 13CH4, C2H2, C2H6, C2H4, C4H2, He and H2 atmosphere. We first compare the spectrum obtained by ISO/SWS with the a priori model in order to find discrepancies between them as well as how each molecule individually impacts the forward model. Our current work is focused on the 793.65-1500 cm-1 (6.7-12.6 μm) region of the spectrum, for comparison reasons between the CIRS and ISO-SWS data, with the 793.65-1200 cm−1 (8.3-12.6 μm) region showing the best fit. We present here our preliminary results of the study of abundances of 12CH3D, 12CH4, 13CH4, C2H2 and C2H6 of Jupiter's atmosphere as well as our study of the pressure temperature profile of Jupiter obtained using NEMESIS retrievals. We also compare our results with the profiles and abundances from Neimann et al. (1998) and Fletcher et al. (2016) with the aim of constraining the number of possible best fit profiles. As consequence of the former study, we also present our initial study of the H/D and 12C/13C isotopic ratio of the Jovian atmosphere from the abundances of 12CH3D, 13CH4 and 12CH4 following the methodology from Fouchet et al. (2000). We hope with this work to advance the understanding of the atmosphere of Jupiter and the physical and chemical processes that occur, as well as better determining its vertical distribution of chemical species and thermal profile. As future work, we expect to extend our frequency domain to the full range of ISO/SWS observations, study the 15N/14N ratio and compare our finding with other relevant results. References: de Graauw et al., Observing with the ISO short-wavelength spectrometer, A&A 315, L49-L54,1996; Encrenaz et al., The atmospheric composition and structure of Jupiter and Saturn form ISO observations: a preliminary review, Planetary and Space Science 47, 1225-1242, 1999; Fletcher et al., Mid-infrared mapping of Jupiter's temperatures, aerosol opacity and chemical distributions with IRTF/TEXES, Icarus 278, 128–161, 2016; Fletcher et al., A hexagon in Saturn's northern stratosphere surrounding the emerging summertime polar vortex, Nature Communications, Volume 9, 2018; Fouchet

et al., ISO-SWS Observations of Jupiter: Measurement of the Ammonia Tropospheric Profile and of the 15N/14N Isotopic Ratio, Icarus 143, 223–243, 2000; Irwin et al., The NEMESIS planetary atmosphere radiative transfer and retrieval tool, Journal of Quantitative Spectroscopy & Radiative Transfer 109, 1136–1150, 2008; Kessler et al., The Infrared Space Observatory (ISO) mission, A&A 315, L27, 1996; Neimann et al., The composition of the Jovian atmosphere as determined by the Galileo probe mass spectrometer, Journal of Geophysical Research Atmospheres 103(E10):22831- 45, 1998; Taylor et al., Jupiter, The Planet, Satellites and Magnetosphere, Ch.4, Cambridge Planetary Science, Eds. Bagenal, Dowling, McKinnon, 2004; Acknowledgements: We thank Thérèse Encrenaz, from LESIA, Observatoire de Paris, for providing the data for this work, Patrick Irwin, from the University of Oxford (UK), for the help with the NEMESIS radiative transfer suite and Maarten Roos-Serote for guidance and help in analysing the data and retrieval results. We acknowledge support from the Portuguese Fundação Para a Ciência e a Tecnologia (ref. PTDC/FIS-AST/29942/2017) through national funds and by FEDER through COMPETE 2020 (ref. POCI-01-0145 FEDER-007672) and through a grant of reference 2021.04584.BD.

Jupiter's atmosphere dynamics with Doppler Velocimetry - Exploring the capabilities of VLT/ESPRESSO

José E. Silva[1], Pedro Machado[2], Francisco Brasil[2], Ruben Gonçalves[2], Miguel Silva[2]

[1] Instituto de Astrofísica e Ciências do Espaço - U.Porto; [2] Instituto de Astrofísica e Ciências do Espaço - U.Lisboa

The thousands of exoplanets that have already been discovered launched an unprecedent drive towards the exploration of these new worlds, particularly their atmospheres. Many of these new planets fit the profile of a gas giant, although with a wide range of characteristics. To study these far away objects, we often use the Solar System as a starting point, thus a good knowledge of the atmospheres of these objects is paramount to understand these other worlds. In this regard, Jupiter often serves as model gas giant, due to its size and mass combination, among other parameters. However, despite numerous interplanetary and orbiting spacecraft combined with a long record of Earth-based observations, some fundamental questions regarding dynamical processes in Jupiter's atmosphere remain [Fletcher et al. (2020)]. The vertical structure of the colourful clouds we see with a small-sized telescope and their circulation mechanisms are still elusive [Sanchez-Lavega (2011)]. Also, to study the atmosphere dynamics of solar system planets, particularly its behaviour and evolution with time, continuous observations are required [Hueso et al. (2020)]. Multiple records of detailed observations span across more than 30 years, from first analysis of the zonal winds [Limaye et al. (1986), Vasavada et al. (1998)] using Pioneer and Galileo data, to more detailed views from the Cassini flyby [Porco et al. (2003), Salyk et al. (2006), Garcia-Melendo et al. (2011), Galperin et al. (2014)]. The most recent efforts in this regard are attributed to the Juno mission, which contributes with very high spatial resolution images [Hansen et al. (2017)], supported by observation campaigns from the Hubble Space Telescope [Garcia-Melendo et al. (2001), Tollefson et al. (2017), Hueso et al. (2017), Johnson et al. (2018)]. Although an impressive volume of data, winds at tropospheric levels have mostly been obtained with cloud-tracking techniques, which follow large patterns moving in the observable atmosphere of Jupiter. Recent efforts in studying the dynamics of the tropospheric region of Jupiter with other techniques such as high-resolution spectroscopy are gaining momentum, with the improvement of facilities which enable increased spectral resolution [Gaulme et al. (2018), Goncalves et al. (2019)]. Different techniques, such as high resolution spectroscopy applied to planetary atmospheres of the Solar System to study dynamics, can be complementary to the usually employed cloud-tracking method, by targeting slightly different levels of the atmosphere [Machado et al. (2021)], with the possibility therein to study the vertical wind shear. The technological capabilities of modern facilities that were designed to discover exoplanets can also be taken advantage of to observe Solar System atmospheres, achieving unprecedent levels of precision from the ground [Gonçalves et al. (2020)]. One such facility is ESPRESSO, assembled on the Very Large Telescope, at ESO. ESPRESSO is able to get two simultaneous spectra in a wavelength range between 378.2 and 788.7 nm with a resolving power that ranges from 70,000 in the Medium Resolution mode (MR) to more than 190,000 in the Ultra

High Resolution mode (UHR) [Pepe et al. (2021)]. ESPRESSO was originally designed for exoplanet hunting and atmospheric characterisation, however, just as was demonstrated in [Gonçalves et al. (2020)] for HARPS-N, using these very high resolution spectrographs on solar system atmospheric characterisation can open new horizons on what is possible to achieve with ground-based instruments to study large objects in our cosmic vicinity. We present an optimised Doppler velocimetry method, originally used to retrieve winds on Venus' cloud top region in the visible part of the spectrum [Widemann et al. (2008), Machado et al. (2012), Machado et al. (2014), Machado et al. (2017)]. With its successful application to Venus, this work presents an exploration of other targets within the solar system with our method. It is also an opportunity to investigate the effectiveness of ESPRESSO in the study of Solar System atmospheres, since it was used for this purpose for the first time. We show zonal wind speeds at equatorial latitudes using all the lines in the visible spectrum, from solar radiation backscattered on Jupiter's atmosphere. These results are compared with the plethora of wind velocity data already retrieved in Jupiter's troposphere for validation, finding consistency between both methods, despite our limited spatial and temporal coverage. This work promotes another step in the exploration of other Solar System targets with ground-based observations, to fill the gap left by the limited availability of interplanetary space missions, ensuring continuous monitoring of the evolution of the atmospheric circulation on those planets at high spectral resolutions. References 1) Fletcher, L.N., et al. (2020), PSJ, 216, article id. 30, DOI: 10.1007/s11214-019-0631-9; 2) Galperin, B., et al. (2014), Icarus, 229, pp. 295-320, DOI: 10.1016/j.icarus.2013.08.030; 3) Garcia-Melendo, E., Sanchez-Lavega, A., (2001), Icarus, 152, pp 316-330, DOI: 10.1006/icar.2001.6646; 4) Gaulme, P., et al. (2018), A&A, 617, article id. A41, DOI: 10.1051/0004-6361/201832868; 5) Gonçalves, I., et al. (2019), Icarus, 319, pp. 795-811, DOI: 10.1016/j.icarus.2018.10.019; 6) Gonçalves, R., et al. (2020), Icarus, 335, article id. 113418, DOI: 10.1016/j.icarus.2019.113418; 7) Hansen, C.J., et al., (2017), Spc. Sci. Rev., 243, pp. 475-506, DOI: 10.1007/s11214-014-0079-x; 8) Hueso, R., et al. (2017), Geophys. Res. Lett., 44, pp. 4669-4678, DOI: 10.1002/2017GL073444 9) Johnson, P.E., et al. (2018), Nat. Lett., 155, pp. 2-11, DOI: 10.1016/j.pss.2018.01.004; 10) Limaye, S.S., (1986), Icarus, 65, pp. 335-352, DOI: 10.1016/0019-1035(86)90142-9; 11) Machado, P., et al. (2012), Icarus, 221, pp. 248-261, DOI: 10.1016/j.icarus.2012.07.012; 12) Machado, P., et al. (2014), Icarus, 243, pp. 249-263, DOI: 10.1016/j.icarus.2014.08.030; 13) Machado, P., et al. (2017), Icarus, 285, pp. 8-26, DOI: 10.1016/j.icarus.2016.12.017; 14) Machado, P., et al. (2021), Atmosphere, 12, nº506, DOI: 10.3390/atmos12040506; 15) Pepe, F., et al. (2021), A&A, 645, A96, DOI: 10.1051/0004-6361/202038306; 16) Porco, C., et al. (2003), Science, 299, nº1541, DOI: 10.1126/science.1079462; 17) Salyk, C., et al. (2006), Icarus, 185, pp. 430-442, DOI: 10.1016/j.icarus.2006.08.007; 18) Sanchez-Lavega, A. (2011), CRC Press, 1st E., Taylor & Francis Group; 19) Tollefson, J., et al. (2017), Icarus, 296, pp. 163-178, DOI: 10.1016/j.icarus.2017.06.007; 20) Vasavada, A.R., et al. (1998), Icarus, 135, pp. 265-275, DOI: 10.1006/icar.1998.5984; 21) Widemann, T., et al. (2008), Planet. Space Sci., 56, pp. 1320-1334, DOI: 10.1016/j.pss.2008.07.005.

Spectral Characterization of Young Free-floating Planetary-mass Objects

Lara Piscarreta[1], Kora Muzic[1], Víctor Almendros-Abad[1]
[1] CENTRA - FCUL

Surveys in star forming regions (SFRs) reveal the existence of the so-called planetary-mass objects (PMOs) that overlap in mass with giant exoplanets but, contrarily to planets, do not orbit a star, and seem to float freely in-between stars. These objects are one of the biggest challenges in star and planet formation. However, a detailed spectral characterization is lacking, due to their intrinsic faintness and significant extinction present in young environments. Moreover, at these low luminosities, there is a large contamination coming from background field objects, making it imperative to build methods that efficiently separate these two populations. With that in mind, we have built a dataset of about 60 publicly available near-infrared spectra from the X-Shooter instrument at the Very Large Telescope. Our data encompass young ultracool dwarfs (brown dwarfs and PMOs) in nearby young moving groups and nearby SFRs with spectral types M8 or later. These regions are ideal for this type of study due to their proximity and low to negligible extinction, which enables near-infrared spectroscopy. We derived fundamental parameters such as spectral types and extinction for our dataset, by recurring to direct comparison with spectral templates, and inspected several spectral features that help in spectral typing and distinguishing young late-type objects from field contaminants. This is important as observations with the James Webb Space Telescope will uncover large datasets of spectra from objects in this temperature range, which were previously non-detectable.

The Enigma of Li-Rich Giants and its Relation with Stellar Activity

Inês Rolo[1], Elisa Delgado Mena[2]

[1] Faculdade de Ciências da Universidade do Porto ; [2] Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP

Magnetic activity, in particular the phenomena usually associated with it much like spots and plages, and the lithium abundance of stars, are in general thought to be connected. However, as of today it is unclear just how. Do they increase the amount of lithium in reducing its depletion? Or are they a source of bias for the measurements? There is evidence provided in quite a few works, that indeed stellar activity signals correlate with the variations noted in the lithium abundance of stars. This has been found especially in young active dwarfs, and magnetically peculiar stars. This work focus on looking for, and studying correlations such as these that might arise between the lithium abundances and stellar activity but in a sample of young but evolved intermediate mass red giants for which atypically high lithium abundances have been observed, that is, lithium rich giants. These stars are inhabitants of stellar clusters, which are ideal laboratories for the study of their lithium enhancement given that they span a narrow mass range, and composition. But, much of what makes them lithium rich is still unclear, namely, it is unclear if this enhancement is due to internal production of lithium incited by certain mechanisms, or if it is due to external contamination. The goal here is thus, to determine variations in the lithium abundances of these stars, variations of their stellar activity indicators and variations in their effective temperature, and look for correlations, as well as study their temporal variations. The results of this study put in evidence that there could be an inclination for active young but evolved stars to have more significant lithium abundances.

Tuesday 11:15 - 13:00 - Astronomical Technology: instrumentation, methods and codes

ELT-ANDES, the High Resolution Spectrograph for the ELT and the design of the Instrument Front End

Alexandre Cabral[1], Bachar Wehbe[1], Manuel Abreu[1], Manuel Monteiro[2], Nuno Santos[2]

[1] Instituto de Astrofísica e Ciências do Espaço, Universidade de Lisboa (Portugal); [2] Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP (Portugal)

ANDES is a high-resolution spectrograph to me mounted on one of the Nasmyth foci of the ESO Extremely Large Telescope in Chile. ANDES consists of three fiber-fed spectrographs (UBV, RIZ, YJH) providing a spectral resolution of ∼100,000 with a minimum simultaneous wavelength coverage of 0.4-1.8 μm with the goal of extending it to 0.35-2.4 μm with the addition of a K band spectrograph. It operates both in seeing- and diffraction-limited conditions and the fiber feeding allows several, interchangeable observing modes including a single conjugated adaptive optics module and a small diffraction-limited integral field unit in the NIR. Its modularity will ensure that ANDES can be placed entirely on the ELT Nasmyth platform, if enough mass and volume is available, or partly in the Coudé room. In this talk, the preliminary design of ANDES, and in particularly of its Front End (FE), will be presented. The FE will be composed by a structure, a cable derotator and four benches: two for the seeing limited observation modes and two for the adaptive optics IFU+SCAO. The preliminary optical and optomechanical design of the seeing limited mode arm will be detailed also showing the techniques used to maximize the modularity of the four sub-Front End modules.

An overview of ELT Line Calibrations WG activities

C.J.A.P. Martins[1]
[1] CAUP

In September 2019, the ELT Programme Scientist at ESO created a set of Working Groups (WGs) that have as main goal to improve critical aspects that are needed for the ELT to do transformative science and for the telescope and instruments to be operated smoothly. These WGs bring together expertise from within ESO, the instrument consortia, and the wider community. One of these, the Line Calibrations WG, is coordinated by me. I will introduce the goals and composition of the team, summarize our activities so far (focusing on recommendations for ANDES and for novel space/drone-based calibration systems for astronomical telescopes), and outline pathfinder experiments being set up at ESPRESSO to validate ELT and ANDES calibration strategies.

Adaptive Optics Telemetry

Nuno Morujão[1,2], Carlos Correia[1,2], Johann Kolb[3], Paulo Andrade[2,4], Paulo Garcia[2,4]

[1] Departamento de Física e Astronomia, Faculdade de Ciências da Universidade do Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal; [2] Center for Astrophysics and Gravitation, Instituto Superior Técnico, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal; [3] European Southern Observatory, Alonso de Córdova 3107, Vitacura, Región Metropolitana, Chile; [4] Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal

Objectives: Estimating atmospheric turbulence parameters is essential for assessing the performance of an adaptive optics (AO) system aiming to correct the effects of Earth's atmosphere on the seeing of an observed astronomical object. One such system is the adaptive op-tics system of the Auxiliary Telescopes of the VLTI, NAOMI. Making use of a Shack-Hartmann (SH) wavefront sensor coupled with a deformable mirror (DM) and control loop, a dynamic correction of the wavefront deformations caused by atmospheric turbulence can be achieved. Treatment of the telemetry data, associated with the correction, is used to achieve a reconstruction of the Fried parameter and outer-scale allowing for an estimation of the performance of the AO system. Methods: The performance of the NAOMI system was first estimated through simulation of the response of the SH sensor to an atmosphere, based on the von-Kármán model of turbu-lence. A reconstruction of the original atmosphere was achieved from the response of the arti-ficial sensor, through the use of a fitting algorithm [1] which accounts for the effects of the non-orthogonality of the derivative of the modal Zernike basis, known as cross-talk, as well as the measurement noise from various sources (ex: photon noise). Real data analysis followed the simulation work, turbulence parameters were once again obtained from fitting of the mod-al coefficients, which were produced from the coupled response of the wavefront sensor and DM. The data from the 4 sensors of NAOMI was compared to find agreement between the estimations. Results: Estimates for the system simulation point to a convergence of the Fried parameter to the screen generating values within 8 seconds of evolution, with an error of 0.51 % to the introduced parameter. The outer scale never shows a convergence to the desired threshold of error, steadily decreasing in error to 21 % error in a 20-minute frozen flow simulation. Real data estimates shows a convergence of the Fried parameter in the 60 second data sam-ples, as predicted by the simulation, these results were compared with the DIMM estimates, showing a median error of 0.28% between the two. Agreement in the estimation of the Fried parameter between the various sensors was observed, allowing for the simultaneous coupling of the 4 sensors in turbulence estimations, reinforcing the validity of the calculated values. The outer-scale never approaches the mean value of the outer-scale at the Paranal observatory, for data points spreading 3 years of observation. These results point to an insufficient diameter of the Auxiliary Telescopes (1.8 meters in diameter), making the telescope effectively blind to this second parameter and as such correspond to a measured turbulence more closely related to the Kolmogorov model. References [1] P. Andrade, P. J. Garcia, C. M. Correia, J. Kolb, and M. I. Carvalho, "Estimation of atmospheric turbulence parameters from

shack-hartmann wavefront sensor mea- surements," Monthly Notices of the Royal Astronomical Society, vol. 483, pp. 1192–1201, 2 2019.

VIS/NIR Illumination System for the OGSE of ARIEL Space Mission

Cédric Pereira[1], Manuel Abreu[1], Alexandre Cabral[1]

[1] Faculdade de Ciências da Universidade de Lisboa/Instituto de Astrofísica e Ciências do Espaço

Transit spectroscopy and multi-band photometry has been so far conducted using general-purpose, space-based instruments. These measurements however suffer from a high level of systematic error due to issues such as pointing jitter, thermal and opto-mechanical stability, wavelength and photometric calibration, and detector stability. Testing and calibration of high precision photometers for the detection of planetary transits requires a light source which photometric stability must be better than the goal stability of the photometer to be tested. In case test, integration and calibration of these sensors, it will be required highly radiometrically stable light sources, both in flux and spectra. The proposed project aims to research and develop an illumination system, able to fulfil the calibration and characterization requirements from new space missions, a truly impressive challenge when stabilization levels of few ppm are required up to several hours of observation.

The Atmospheric Dispersion Compensator of NIRPS, the Near Infra Red Planet Searcher

Bachar Wehbe[1], Alexandre Cabral[1], João Coelho[1], Manuel Abreu[1], Nuno Santos[2]

[1] Instituto de Astrofísica e Ciências do Espaço, Universidade de Lisboa (Portugal); [2] Instituto de Astrofísica e Ciências do Espaço, Universidade do Porto, CAUP (Portugal)

NIRPS, the Near Infra-Red Planet Searcher, is part of a new generation of Adaptive Optics fiber-fed spectrographs. It was recently installed in the ESO La Silla 3.6 m telescope and will be operated individually or jointly with HARPS. NIRPS aims at spectroscopic observations of stellar objects in the NIR, from 970 nm to 1800 nm (with the option for later extension to 2400 nm). The instrument is assisted by an AO system, whose sensing bandwidth will be from 700 nm to 950 nm. Even if telescope pointing and guiding is perfect at a given reference wavelength, atmospheric dispersion will shift the image centroid at different wavelengths, with impact on fiber injection. Moreover such effect will vary during acquisition with the observation zenith angle. Therefore an Atmospheric Dispersion Corrector (ADC) is mandatory to achieve the instrument requirements. In this talk we will present the design, integration and test results for the NIRPS ADC, the subsystem under the responsibility of Portugal at the Institute of Astrophysics and Space Sciences.

Polarization sky patterns

Beatriz Pereira[1], Ana Mourão[1], Santiago Gonzalez[1]
[1] IST-CENTRA

Polarimetry reveals details of the physics of astronomical objects that would otherwise be hidden in standard imaging or spectroscopic observations. However, reliable measurement of the polarization requires a good understanding of all contamination sources in the system. As the main light source in our night sky, the Moon and its sky polarization patterns are the focus of this study. Using VLT's FORS2 instrument, we observed blank fields during full Moon to analyze these polarization patterns and their influences on polarimetric measurements. We compare our observations to known analytical models of single and multiple scattering of moonlight in the night sky and study the effects of depolarization by the atmosphere. We find increasing agreement with single scattering for smaller wavelengths, and larger depolarization effects for redder wavelenghts.

Photometric redshift-aided classification using ensemble learning

P. A. C. Cunha[1], A. Humphrey[2]

[1] Faculdade de Ciências da Universidade do Porto/Instituto de Astrofísica e Ciências do Espaço, University of Porto, CAUP; [2] Instituto de Astrofísica e Ciências do Espaço, University of Porto, CAUP

We present SHEEP, a new machine learning approach to the classic problem of astronomical source classification, which combines the outputs from the XGBoost, LightGBM, and CatBoost learning algorithms to create stronger classifiers. A novel step in our pipeline is that prior to performing the classification, SHEEP first estimates photometric redshifts, which are then placed into the data set as an additional feature for classification model training; this results in significant improvements in the subsequent classification performance. SHEEP contains two distinct classification methodologies: (i) Multi-class and (ii) one versus all with correction by a meta-learner. We demonstrate the performance of SHEEP for the classification of stars, galaxies, and quasars using a data set composed of SDSS and WISE photometry of 3.5 million astronomical sources. The resulting F1-scores are as follows: 0.992 for galaxies; 0.967 for quasars; and 0.985 for stars. In terms of the F1-scores for the three classes, SHEEP is found to outperform a recent RandomForest-based classification approach using an essentially identical data set. Our methodology also facilitates model and data set explainability via feature importances; it also allows the selection of sources whose uncertain classifications may make them interesting sources for follow-up observations.

Tuesday 14:15 - 15:15 - Astronomy and Society; Cosmology and Gravitation, part 2

The power of collaboration in Astronomy Education

Rosa Doran[1]

[1] NUCLIO

This presentation is intended to present the high impact and importance of international collaboration in Astronomy Education.

Removing barriers from publishing and accessing scientific research: The Astronomy and Astrophysics transition to open access and publishing policies

André Moitinho[1]

[1] CENTRA - Faculdade de Ciências da Universidade de Lisboa

In April 2022 Astronomy & Astrophysics (A&A), one of the world's leading peer-reviewed astronomical journals, became fully open access (OA). While OA makes the results of scientific research freely accessible to all, OA publishing is normally sustained through hefty "article processing charges" authors must pay to publish their work. This in effect shifts the barrier to delivering scientific articles from reading to publishing, and is recurrently an object of criticism. In this talk I will give an overview of the astronomical publishing lansdcape, the options offered by the different journals the supporting financial models. I will then detail the A&A OA model without charges to authors, its evolution and publishing policies.

Latest results of the GRAVITY experiment on the Galactic Centre supermassive black hole

Paulo Garcia[1], Gravity Collaboration
[1] FEUP/CENTRA

[1]We will present the status of the GRAVITY experiment on the Galactic Centre supermassive black hole. GRAVITY is the most advanced optical-infrared instrument in a ground-based observatory. It sharpens the light of four giant 8 m telescopes with advanced adaptive optics and combines it interferometrically, achieving exquisite precision. It was central for the experimental breakthrough justifying part of the 2020 Physics Nobel Prize. We will conduct a review of past achievements since the last Workshop: a) the deep imaging of the galactic centre and detection of several stars (S29, S38, and S55) further to S2, orbiting the immediate environment of the black hole; b) new constraints on the extended mass component inside the S2 apocenter of less than 0.1% of the supermassive black hole mass; c) new significance $+7\ \sigma$ of the Schwarzschild precession detection. The detection of many stars in the close environment of the black hole and the new upgrade of the GRAVITY experiment to GRAVITY+ bring renewed hope to detect a star in orbit close enough to probe the black hole's spin.

Tuesday 15:45 - 17:20 - Cosmology and Gravitation, part 2, cont.

The discovery potential of black holes

Vitor Cardoso[1]

[1] CENTRA-IST, Niels Bohr Institute

One of the most remarkable possibilities of General Relativity concerns gravitational collapse to black holes, leaving behind a geometry with light rings, ergoregions and horizons. These peculiarities are responsible for uniqueness properties and energy extraction mechanisms that turn black holes into ideal laboratories of strong gravity, of particle physics (yes!) and of possible quantum-gravity effects. I will discuss ways to build a community to explore strong-gravity and black hole physics, in particular via ERC grants and european COST Actions.

Optimization of Spectroscopic Tests of Fundamental Physics: from ESPRESSO to the ELT

C.M.J. Marques[1], C.J.A.P. Martins[1], C.S. Alves[2]
[1] CAUP; [2] U.C.L.

Studying the Dark Universe and Fundamental Physics is one of the science and design drivers of the ArmazoNes high Dispersion Echelle Spectrograph (ANDES). We have developed computational tools that can optimize the scientific return of Fundamental Physics tests using redshift drift and fine-structure constant measurements for this instrument, separately or in combination, and also quantify the scientific impact of possible instrument configurations. This is an important result for the ANDES Phase B, making it possible to identify the key parameters for the necessary scientific trade-offs, and will ultimately lead to the definition of an optimized observing strategy. We will illustrate our analysis with some representative examples.

Euclid Cluster Abundances as a probe of Non-homogeneous models and the Cosmological Principle

Ana Carvalho[1]

[1] IA-FCUL

Galaxy cluster number counts are a sensitive probe of cosmology that critically depends on the halo mass function and the survey selection function. With the advent of the Euclid space mission, cluster counts can also be used to test the Cosmological Principle and investigate if the non-homogeneous Lambda Lemaitre-Tolman-Bondi (LLTB) model, featuring both dark energy and cold dark matter, is able to provide a better description of cosmological data. However, this non-homogeneous model has cosmological functions that take longer to compute, slow down MCMC inference methods, and lead to constraints that are harder to converge (due to the increased size of the parameter space). In this communication, I will present how cluster abundances can be used to constrain cosmology in the scope of non-homogeneous models and discuss how Laplace's method can help to obtain constraints.

Constraints on extended Bekenstein models from cosmological, astrophysical, and local data

João F. Dias[1], Léo Vacher[2], C. J. A. P. Martins[1], Nils Schöneberg[3], Samy Vinzl[4], Savvas Nesseris[5], Guadalupe Cañas-Herrera[6], Matteo Martinelli[7]

[1] CAUP; [2] IRAP; [3] ICCUB; [4] Université de Toulouse; [5] UAM-CSIC; [6] Lorentz Institute for Theoretical Physics; [7] INAF.

Searching for variations of nature's fundamental constants is a crucial step in our quest to go beyond our current standard models of fundamental physics. The Bekenstein model and its extensions introduce such a scalar field in a purely phenomenological way, allowing for couplings to other sectors of the Universe, such as baryons, dark matter, and the cosmological constant, inducing a variation of the fine-structure constant on cosmological scales. In this work, different versions of the Bekenstein model are constrained by confronting the full cosmological evolution of the field with an extensive set of astrophysical, cosmological, and local measurements. We show that couplings of the order of parts per million (ppm) are excluded for all the cases considered, imposing strong restrictions on theoretical frameworks aiming to deal with variations of the fine-structure constant.

Low redshift constraints on a Modified Gravity Model

A.M.M. Vieira[1], C.J.A.P. Martins[1]
[1] CAUP

In the search for a model that explains the observed acceleration of the Universe, it has recently been proposed that fractional calculus is used to modify Einstein's field equations; in doing so, the age of the universe is also changed. We constrain the model using low redshift background cosmology data from Type Ia supernovas, Hubble parameter and CMB temperature data. We find that the model does not adequately describe all such data, and is therefore observationally ruled out.

Poster Abstracts

Optical design for a prototype of a cross dispersed echelle spectrograph

Nuno M. Gonçalves[1], A. Cabral[2], M.Abreu[3]

[1] Instituto de Astrofísica e Ciências do Espaço; [2] Instituto de Astrofísica e Ciências do Espaço ; [3] Instituto de Astrofísica e Ciências do Espaço

High resolution spectroscopy has a fundamental contribution for modern astronomy. Cross dispersed echelle spectrographs (CDES) are the vanguard of ultra and High Resolution (HR) spectroscopy, being the ESPRESSO instrument in the Very Large Telescope, the current state off the art in terms of spectral resolution. Currently, HR CDES designs for high performances are a demanding challenge to build since they are bulky, costly, and complex instruments. Nowadays, due to the standardization and the developments in the fabrication of optical components, it is simple to obtain off-the-shelf high-quality parts. This paves the way for a variety of high-performance optical instruments to be constructed with such off-the-shelf components. This opens the possibility to build an affordable HR spectrograph in the visible band with a spectral resolution above the one available in the marketplace with a comparatively smaller cost. In this work we present the design of a prototype of HR CDES with off-the-shelf components. For that reason, we performed a trade-off analysis of commercially available optical components to understand how to maintain a low cost and a high enough spectral resolution that it can be applied for astronomy science cases. The main goal for this design is to give the firsts steps towards miniaturization in the visible range, and then extrapolate the requirements for the UV band. The resulting optical design is for a ground-based spectrograph that has a spectral resolution of R$\approx 10^4$ and a band of (350 – 700) nm. The achievable resolution was heavily influenced by the usage of off-the-shelf components, limiting the optical components sizes and characteristics.

Symmetry restoration in the vicinity of neutron stars with a nonminimal coupling

Masato Minamitsuji[1], Shinji Tsujikawa[2]
[1] CENTRA, IST; [2] Waseda University

We propose a new model of scalarized neutron stars (NSs) realized by a self-interacting scalar field nonminimally coupled to the Ricci scalar. The scalar field has a self-interacting potential and sits at its vacuum expectation value far away from the source. Inside the NS, the dominance of a positive nonminimal coupling over a negative mass squared of the potential leads to a symmetry restoration with the central field value close to 0. This allows the existence of scalarized NS solutions connecting two vacua whose difference is significant, whereas the field is located in the vicinity of VEV for weak gravitational stars. The Arnowitt-Deser-Misner mass and radius of NSs as well as the gravitational force around the NS surface can receive sizable corrections from the scalar hair, while satisfying local gravity constraints in the Solar system. Unlike the original scenario of spontaneous scalarization induced by a negative nonminimal coupling, the catastrophic instability of cosmological solutions can be avoided. We also study the cosmological dynamics from the inflationary epoch to today and show that the scalar field finally approaches the asymptotic value without spoiling a successful cosmological evolution. After the field starts to oscillate about the potential minimum, the same field can also be the source for cold dark matter.

Statistical analysis of different dark energy and modified gravity type models

Samuel R. Pinto V. [1], Adrian M. Cabral[1], Carlos J. A. P. Martins[2]
[1] FCUP/CAUP; [2] CAUP

In this work, we study 3 different dark energy and modified gravity type models: Lifshitz cosmology model; Infinite statistics model; Regge Teitelboim model. In each model, we identify the relevant free parameters and obtain the corresponding modified Friedman equations. We use the data from the Type Ia supernova and Hubble parameter to constrain the free parameters that describe these models with different techniques for maximum likelihood analysis and study their limits where the ΛCDM model applies. For the Lifshitz and infinite statistics models it was possible to determine values for their free parameters that fit the data. In contrast, the Regge Teitelboim model seemed to underfit the data that was used.

A Complete Characterisation of Ultra Steep Spectrum Sources in the COSMOS Field

Davi D. Barbosa[1], J. Afonso [1], I. Matute[1], R. Carvajal[1], S. Amarantidis[1], C. Papalardo[1], I. Whittam[2], I. Heywood[3]

[1] IA-Lisboa; [2] University of Oxford; [3] University of Oxford.

Studies of the high redshift Universe have relied on a number of methods to identify increasingly distant and, consequently, younger galaxies. Radio selection has been reborn as one of the most promising methods, as powerful radio active galactic nuclei (AGN) can potentially be detected at radio frequencies at essentially any redshift. Using the next generation of deep radio surveys, pathfinders to the Square Kilometre Array (SKA), these searches are now being pushed to new sensitivity levels, to find radio AGN at the highest distances and at the earliest formation stages, presumably well within the Epoch of Reionization. Ultra steep spectrum (USS) radio sources have been successfully used to select powerful radio sources at high redshifts (Saxena+2018). Using sources from the Very Large Array (at 3GHz) and MeerKat Radio Telescope (at 1.28GHz, Heywood+2021), we are selecting a comprehensive and extensive sample of USS sources. Finding for the first time an almost complete sample ($>5\sigma$) with optical and infrared counterparts. This study will act as a stepping stone for similar studies over the entire sky, which will soon become possible in the Square Kilometer Array era.

Distribution of young stars observed by the ESA Gaia mission

Gonçalo Fernandes[1], André Moitinho[1]
[1] CENTRA-FCUL

Using the Gaia Data Release 3 dataset, we select a high-quality sample of O- and B- type stars to obtain an improved view of the spatio-kinematic distribution of the spiral structure in the vicinity of the Sun, by deriving both spatial density and velocity maps constructed with a kernel density estimation algorithm.

Observations of the (1-0) band of CO in Venus using VIRTIS-H aboard Venus Express

Constança Freire[1], Thomas Widemann[2], Thérèse Encrenaz [2], Pedro Machado[1], João Dias[1]

[1] Instituto de Astrofísica e Ciências do Espaço Portugal; [2] Paris Observatory - LESIA France

We have used infrared spectra of the dark side of Venus, recorded by the VIRTIS-H spectrometer (Drossart et al. Proc. SPIE 5543, 175, 2014) aboard Venus Express (Svedhem et al. JGR 113, E00B33, 2008), to analyze the CO (1-0) band around 4.7 µm. The resolving power of VIRTIS-H (about 1200) is sufficient to separate the individual lines of CO. We have selected two sets of spectra, the first one at mid-latitude (43°S) and the other in the polar collar (69-83°S). The CO individual lines appear in absorption in the first case, and in emission in the second case, as a consequence of a temperature inversion occurring at high latitude at the level of the upper cloud top. Synthetic models have been calculated using the Planetary Spectrum Generator (Villanueva et al. JQSRT 217, 86, 2018). Information is retrieved on the thermal vertical profile and the CO vertical distribution at both latitudes. This work illustrates the capabilities of high-resolution infrared spectroscopy for monitoring minor atmospheric species in the mesosphere of Venus, in the perspective of the EnVision mission (Helbert et al. Proc. SPIE 11128, A1112804, 2019). We acknowledge support from the Portuguese Fundação Para a Ciência e a Tecnologia (ref. PTDC/FIS-AST/29942/2017) through national funds and by FEDER through COMPETE 2020 (ref. POCI-01-0145 FEDER-007672)

Stellar characterization for the Ariel space mission

Andreas W. Neitzel[1], Diego Bossini[1], Tiago Campante[1]

[1] Instituto de Astrofísica e Ciências do Espaço

With the discovery of various transiting and eclipsing exoplanets, planetary science is taking a step further with the European Space Agency's Atmospheric Remote-sensing Infrared Exoplanet Large-survey (Ariel). Ariel's purpose, the first one of its kind, is the study of the chemical compositions and thermal structures of a large sample of known exoplanets. A crucial step towards the characterization of exoplanets however is the accurate and precise determination of the ages and masses of their host stars, which falls under the purview of the Ariel Stellar Age/Mass/Radius sub-workgroup. These stellar parameters are usually found in the literature in a case-by-case analysis performed by different teams using different methodologies. The field of stellar oscillations, named Asteroseismology, can further constrain the estimation of fundamental stellar parameters. To this aid, satellites such as CoRoT and Kepler have been providing a growing wealth of high-quality stellar oscillation data to work with. The aim is the combination of asteroseismic data with spectroscopic and photometric data into a pipeline that makes use of Bayesian methods to estimate the ages, masses, radii and other fundamental parameters of the stellar targets. PARAM is the pipeline used in this work and it functions by matching a set of observational constraints to a pre-computed grid of stellar evolutionary models. The result will be a catalog of ages and masses of exoplanet-host stars that can be used as a benchmark for calibrating age in non-seismic targets.

Testando o parâmetro de mistura com binários estelares de eclipse

Victória Da Graça Samboco[1], João M. Fernandes[2], Dinelsa Machaieie[3], Fernando J.G. Pinheiro[4]

[1] Universidade de Rhodes e Departamento de Física, Universidade Eduardo Mondlane, Maputo, Moçambique; [2] CITEUC, Departamento de Matemática, Universidade de Coimbra, Coimbra, Portugal e CITEUC, Observatório Geofísico e Astronómico, Universidade de Coimbra, Coimbra, Portugal; [3] Departamento de Física, Universidade Eduardo Mondlane, Maputo, Moçambique; [4] CITEUC, Departamento de Física, Universidade de Coimbra, Coimbra, Portugal e CITEUC, Observatório Geofísico e Astronómico, Universidade de Coimbra, Coimbra, Portugal

Frequentemente, a modelização de estrelas de tipo solar (classe espectral F, G e K) envolve a utilização de um parâmetro, dito de comprimento de mistura, o qual descreve a eficácia do processo covectivo nas camadas superiores deste tipo de estrelas. No caso do Sol, o valor do parâmetro de mistura é calculado criando modelos que se ajustam as propriedades solares conhecidas: massa, composição química, idade, luminosidade e temperatura efectiva. No entanto, diversos resultados apontam a que este valor não se aplique a todas as estrelas de tipo solar. Nesta apresentação pretendemos mostrar como é possível testar a universalidade deste parâmetro de mistura utilizando para tal binários estelares de eclipse.
