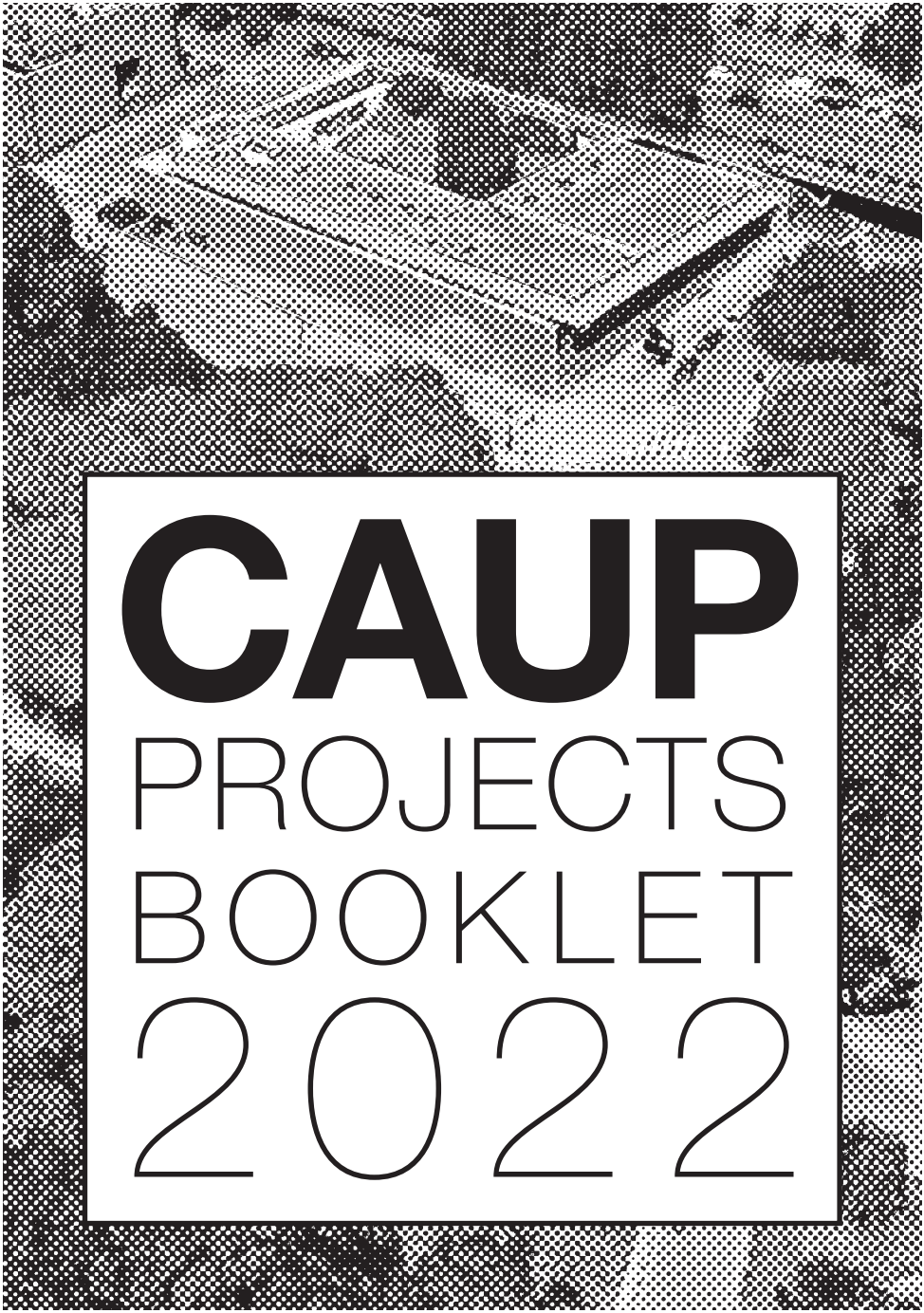

CAUP

PROJECTS BOOKLET 2022

Introduction

CAUP has a strong commitment to providing training opportunities for the next generation of astrophysicists, and we are the only research center in the country with a training activities portfolio that spans all levels from Secondary School to Doctoral Programmes, and entails significant amounts of funding and human resources. As part of our commitment to leadership and excellence, we hereby release a list of research projects offered by CAUP members, for various training levels, in the academic year 2022-23.

We start by listing PhD/MSc projects within our participation in ESA and ESO consortia, which is one of our key strategic priorities. These are followed by other astrophysics PhD/MSc projects, and then by junior (undergraduate) projects and education & outreach projects. These tend to represent more specific interests of individual members, although in some cases they also involve non-CAUP collaborations and external co-supervision. At the PhD level, many of these projects are eligible for funding through doctoral programs such as IDPASC as well as through regular FCT PhD grants. In the latter two cases some projects are listed in Portuguese, since they are mainly offered through the PEEC internship program. In each section the projects are listed alphabetically by title. As an appendix we also list the current CAUP team, including both the researchers and the PhD and younger students.

The project contact person's e-mail is listed, and should be approached for any enquiries on the project. The list is representative of current interests and priorities, but it is not exhaustive. Many CAUP members have sufficiently broad interests and expertise to be able to supervise other projects. Potentially interested students are encouraged to contact us to explore further possibilities.

Carlos Martins
(Head of the CAUP Training Unit)
Abril 2022

CAUP PROJECTS BOOKLET 2022

INDEX

ESA and ESO related projects

Other astrophysics projects

Undergraduate projects

Education and outreach projects

Appendix

ESA and ESO related projects

Fundamental cosmology from precision spectroscopy: The ESPRESSO road to ANDES

Level: PhD or MSc
Supervisor: Carlos.Martins@astro.up.pt

ESPRESSO is a latest-generation spectrograph, combining the efficiency of a modern Echelle spectrograph with extreme radial velocity and spectroscopic precision, and including improved stability thanks to a vacuum vessel and wavelength calibration done with an LFC. A key science driver of ESPRESSO is to improve tests of the stability of nature's fundamental couplings such as the fine-structure constant. In this thesis the student will be directly involved in the analysis and scientific exploration of the ESPRESSO fundamental physics GTO.

Apart from its obvious direct (and very significant) impact on cosmology and fundamental physics, the ESPRESSO data is also important as the first reliable precursor of the analogous Extremely Large Telescope spectrograph, ANDES (in whose Phase B the supervisor is the Chair of the Cosmology and Fundamental Physics WG). A second goal of the thesis is to use the ESPRESSO data for detailed realistic simulations to assess the cosmology and fundamental physics impact of ANDES, including tests beyond the sensitivity of ESPRESSO, such as redshift drift measurements and molecular tests of composition-dependent forces.

Thus the thesis will address two grand-challenge questions: 1) Are the laws of physics universal? and 2) What makes the universe accelerate? The student, who should have a genuine interest and previous experience in experimental spectroscopy and astrophysical data analysis, will be working within the general framework of the ESPRESSO and ANDES science teams.

Key relevant references are Alves et al. MNRAS 488 (2019) 3607, Esteves et al. MNRAS 508 (2021) L53, Martins Rep.Prog.Phys. 80 (2017) 126902 & A&A 646 (2021) A47, Martins et al. PRD 94 (2016) 043001 & PLB 827 (2022) 137002, Martins & Vacher PRD100 (2019) 123514, Murphy et al. A&A 658 (2022) A123, Schmidt et al. A&A 646 (2021) A144, and Vilas Boas et al. A&A 635 (2020) A80.

New Maps of the Dark Side: Euclid and beyond

Level: PhD or MSc
Supervisor: Carlos.Martins@astro.up.pt

The growing amount of observational evidence for the acceleration of the universe demonstrates that canonical theories of cosmology and particle physics are incomplete (if not incorrect) and that new physics is out there, waiting to be discovered. The most fundamental task of forthcoming astrophysical facilities is to search for, identify and ultimately characterise this new physics. The acceleration is seemingly due to a dark component whose low-redshift gravitational behaviour is very similar to that of a cosmological constant. However, currently available data provides very little information about the high-redshift behaviour of this dark sector or its interactions with the rest of the degrees of freedom in the model. It is clear that tackling the dark energy enigma will entail significantly extending the redshift range where its behaviour can be accurately mapped.

A new generation of ESA and ESO facilities, such as Euclid, the ELT, and the SKAO have dark energy characterization as a key science driver, and in addition to significantly increasing the range and sensitivity of current observational probes will allow for entirely new tests of the key assumptions underlying LambdaCDM. The goal of this thesis will be to carry out a systematic exploration of the landscape of physically viable dark energy paradigms and provide optimal discriminating observational tests. The work will initially focus on Euclid (whose launch is fast approaching) and will gradually broaden to explore synergies and probe combination with the SKAO and ANDES. More specifically, the work will be done in the framework of the Euclid TWG, with the student being a member of Euclid.

Key relevant references are Alves et al. MNRAS 488 (2019) 3607, Amendola et al. LRR21 (2018) 2, Faria et al. A&A 625 (2019) A127, Marques & Martins, Phys. Dark Univ. 27 (2020) 100416, Martinelli et al. A&A 644 (2020) A80 & A&A 654 (2021) A148, Martins et al. PRD 94 (2016) 043001 & Phys.Dark Univ. 35 (2022) 100964, Martins & Vacher, PRD 100 (2019) 123514, Tavares & Martins PRD103 (2021) 023525.

Other astrophysics projects

Abundance patterns in star-forming galaxies with machine learning

Level: MSc
Supervisor: Jean Gomes (jean@astro.up.pt)
Co-supervisor: P. Lagos

The abundance of heavy elements in the star-forming galaxies reflects the history of star-formation, chemical enrichment and the effects of the environment, i.e. gas inflow and outflow. Metallicity traces the cycle of baryons within galaxies. We currently have two main approaches to determine abundances in the interstellar medium of galaxies: the direct method and strong line methods.
The direct method employs the auroral flux ratio to strong lines to measure the electron temperature and density. The electron temperature is a vital function of metallicity for the Direct Method. The electron temperature determination in most cases dominates the uncertainty in metallicity, since these lines are usually weaker, as the metallicity increase in most star-forming galaxies, preventing us from detecting them. In contrast, strong lines are easily seen, especially in metal-rich galaxies. Consequently, this method span a broader range of metallicities. Another advantage is that we can use it in lower signal-to-noise observations. Therefore, almost all metallicity studies of extensive galaxy surveys apply the Strong Line method. However, despite the convenience of this approach, strong line ratios depend on metallicity in a complex way. In general, they rely on the hardness of the ionising field, gas excitation and ionisation states. Therefore, this method needs to be first calibrated. Unfortunately, they do not produce consistent metallicities with errors commonly reaching the order of 1 dex. Also, they generally are valid only in specific metallicity ranges with particular conditions.
In this MSc project, the student will study, implement and test distinct model predictions from the literature in order to develop a robust technique for determining gas-phase chemical abundances. Then, we will intercompare these predictions using a newly developed abundance module employing machine learning (ML) techniques. For instance, training sample with theoretical models using a different set of lines (observables) can lead to an alternative abundance classification diagnostic by the ML. Moreover, the lack of auroral lines, such as [OIII] 4363 for the direct method, could be in principle compensated if we extract the hidden information embedded in other lines. Additionally, spectral synthesis codes could easily incorporate this standalone module, such as FADO (Gomes & Papaderos 2017).

Finally, the new prescription developed will be tested to real star-forming galaxies from the SDSS to test possible biases on the recovered abundance patterns in star-forming galaxies. Preferable computing languages are Fortran and Python.

Analytic Methods for Astrophysical Defect Fingerprinting

Level: PhD or MSc
Supervisor: Carlos.Martins@astro.up.pt

Cosmic strings arise naturally in many proposed theories of new physics beyond the standard model unifying the electroweak and strong interactions, as well as in many superstring inspired inflation models. In the latter case, fundamental superstrings produced in the very early universe may have stretched to macroscopic scales, in which case they are known as cosmic superstrings. If observed, these objects thus provide a unique window into the early universe and possibly string theory. Recent progress in CMB and gravitational wave observations shows how some of these scenarios can in principle be constrained by high-resolution data, but also highlight several bottlenecks which make current constraints unreliable. To fully exploit the potential of facilities such as the SKAO and LISA, one needs matching progress both in high-resolution HPC numerical simulations of defect networks and in the analytic modelling of key physical mechanisms underlying their evolution, especially additional degrees of freedom on the defect worldsheets.

This thesis will address the latter, using a series of novel mathematical and statistical techniques, informed by the world's most accurate defect simulations (being done by the supervisor's team) to build upon the successes of the canonical VOS model of Martins & Shellard to develop a new generation of accurately calibrated analytic models for general defect evolution as well as for their astrophysical fingerprints, which is able to match the sensitivity of ongoing and future observational searches and yield reliable constraints. The student will join a recently approved Paris-Porto-Cambridge collaboration grant.

A recent introduction to the field can be found in Martins, Defect Evolution in Cosmology and Condensed Matter: Quantitative Analysis with the Velocity-Dependent One-Scale Model (Springer, 2016). Other relevant references are Almeida & Martins PRD 104 (2021) 043524, Correia & Martins PRD 100 (2019) 103517 & PRD 104 (2021) 063511, Martins & Cabral PRD 93 (2016) 043542, Martins et al. PRD103 (2021) 043538 & PRD 104 (2021) 103506, Rybak et al. PRD96 (2017) 103535 & PRD99 (2019) 063516, and Vieira et al. PRD 94 (2016) 096005.

Coding the Cosmos: Simulating Superstrings in the GPU Era

Level: PhD or MSc
Supervisor: Carlos.Martins@astro.up.pt

Cosmic strings arise naturally in many proposed theories of new physics beyond the standard model unifying the electroweak and strong interactions, as well as in many superstring inspired inflation models. In the latter case, fundamental superstrings produced in the very early universe may have stretched to macroscopic scales, in which case they are known as cosmic superstrings. If observed, these objects provide a unique window into the early universe and possibly string theory. Recent progress in CMB polarization and gravitational wave detection highlights how some of these scenarios could be constrained by high-resolution data. However, they also show that the current bottleneck is the lack of accurate high-resolution simulations of defect networks that can be used as templates for robust statistical analysis, implying that none of the current constraints is reliable. This will be an even bigger problem for next-generation facilities such as the SKAO and LISA. Moreover, most numerical simulations so far have been performed for the simplest Abelian-Higgs (or Nambu-Goto) model, while realistic cosmic strings will have non-trivial internal structure, including charges and currents.

The scientific goal of the thesis is to fill this gap, continuing the deployment of a new generation of high-scalability defect evolution codes that will match the sensitivity of ongoing and forthcoming observational searches, and using them to develop and calibrate suitable analytic models. It will use both CAUP computational resources (including a GPU donated by NVIDIA) and world-leading HPC facilites accessed through PRACE/EuroHPC. The student should have an interest and relevant previous experience in computational physics, data analysis and visualisation. Experience of parallel and/or GPU programming would also be highly beneficial. The student will join a recently approved Paris-Porto-Cambridge collaboration grant.

A recent introduction to the field can be found in Martins, Defect Evolution in Cosmology and Condensed Matter: Quantitative Analysis with the Velocity-Dependent One-Scale Model (Springer, 2016). Other relevant references are Achucarro et al. Phil. Trans. Roy. Soc. Lond. A 377 (2019) 2161.0004, Almeida & Martins PRD 104 (2021) 043524, Correia & Martins PRD100 (2019) 103517, PRD102 (2020) 043503, Astron. Comput. 34 (2021) 100438 & PRD 104 (2021) 063511, Martins et al. PRD103 (2021) 043538 & PRD 104 (2021) 103506, and Rybak et al. PRD 96 (2017) 103535.

Exploring new ways of extracting cosmological information in HI intensity mapping experiments

Level: MSc

Supervisor: Jose.Fonseca@astro.up.pt

HI (neutral hydrogen) intensity mapping is a new and challenging way of using radio telescopes, such as the SKAO, to map the large-scale distribution of matter in the universe. The calibrated maps contain not only the neutral hydrogen emission but also residual emission from galactic and extra-galactic sources. Traditional approaches use blind foreground subtractions methods to clean the observed signal. While successful in recovering the cosmological information on sub-horizon scales, these cannot reconstruct the large angular scales, important to probe the very early universe.

This project aims to explore new approaches in dealing with residual foreground contamination. In particular study how feasible is to jointly infer the cosmology together with foreground parametrisations. We aim to learn when and how such an approach can be taken with future datasets using simulations and standard MCMC. No prior knowledge of astronomy is required. The student should be an enthusiast in bayesian statistical techniques and programming (Python or/and C/C++ and/or Fortran).

Extending the modelling of galactic and extra-galactic HI intensity mapping foregrounds

Level: MSc

Supervisor: Jose.Fonseca@astro.up.pt

Future radio surveys, such as the SKAO and its pathfinders, will map the distribution of neutral hydrogen (HI) in the universe. But galactic and extra-galactic radio emission contaminate the cosmological HI signal. It is, therefore, crucial to have a full physical and spatial understanding of such foregrounds.

The project aims to review the landscape of foreground modelling both in frequency and position in the sky. In addition, we wish to update the parametrisations of Santos et al. 2005 (https://arxiv.org/abs/astro-ph/0408515v2), as well as to explore different models with data, and understand the angular structure of each foreground component. The student should have a background in physics and have basic programming knowledge (Python or/and C/C++ and/or Fortran).

Mitigating the effects systematic redshift errors in future photometric Galaxy Surveys

Level: MSc
Supervisor: Jose.Fonseca@astro.up.pt
Co-supervisor: A. Afonso

Forthcoming cosmological surveys such as Euclid, or current ones such as DES, will map the tridimensional position of millions of galaxies by providing estimates of their redshifts using photometry. Using galaxies' positions one can estimate how matter is clustered in the universe, which we then used to infer cosmological parameters. This is a powerful probe of the the composition, formation, and evolution of the universe. Notwithstanding, any systematic error in the redshift estimation will affect the best fit values of the cosmological parameters.

In this project, we aim to understand the entire process of photometric redshift estimation using thousands of simulated spectral energy distributions, from which photometric catalogs will be derived. The student will understand how a catalogue of galaxies' positions is used to compute the galaxy power spectrum, and how this power spectrum is used to constrain cosmological parameters. The final goal is then to characterise the effect of systematic redshift errors in the angular power spectrum, and ultimately its impact on cosmological parameter estimations. We also aim to establish mitigation strategies to be applied in future surveys. The student should have minimal knowledge in extra-galactic astronomy, and basic programming (Python or/and C/C++ and/or Fortran) experience.

SOAP+: modelling active region evolution

Level: MSc
Supervisor: Joao.Faria@astro.up.pt

The SOAP code allows us to simulate the effects of stellar activity in radial velocity and transit observations. It was developed to understand the impact of stellar noise in the data we use to search for exoplanets. This project aims to extend SOAP with an important missing feature: the ability to simulate the evolution of active regions during the magnetic cycle of the star. The inclusion of this
effect will allow us to create realistic simulations of Sun-like stars and M dwarfs, to study how stellar activity can be corrected in order to allow for the detection of low-mass planets like the Earth.

We are looking for a candidate who is enthusiastic about learning and has good communication and organization skills. The project does not require prior knowledge of astronomy and/or exoplanets. The candidate is expected to have good knowledge of a scientific programming language such as Python or C/C++. A relevant reference is SOAP2: A tool to estimate the photometric and radial velocity variations induced by stellar spots and plages. Dumusque, Boisse, Santos 2014, https://arxiv.org/abs/1409.3594

Spatial distribution of active regions and its signature in stellar brightness variations

Level: MSc
Supervisor: Angela.Santos@astro.up.pt
Co-supervisors: J. Faria, M. Cunha

Sunspots are the most evident manifestation of the magnetic activity in the Sun. Other low-mass stars, known as solar-like, are also magnetically active and spots emerge at their surfaces in active regions. For stars other than the Sun, one cannot resolve their surface and discern individual spots. Nevertheless, sunspots and starspots are magnetic features that are cooler and darker than the surroundings. Therefore, as they co-rotate with the surface of the star, spots lead to quasi-periodic brightness variations.

The characteristics of such activity-related brightness variations depend on a number of observational, stellar, and spot properties. The spatial distribution of spots, both in longitude and latitude, leave an in-print in the brightness variations, which is not fully understood. In this project, the student will investigate how the different properties impact the observed solar/stellar brightness and how one can use brightness variations to learn about those properties. To that end, the student will use high-precision space-based photometric data (e.g. VIRGO, Kepler, TESS). The results are expected to be worth publication in an international Journal and/or presentation in a workshop/conference in the field.

Undergraduate projects

A física de outros universos

Orientador: Carlos.Martins@astro.up.pt

Perfil do candidato:
O aluno deve ter interesse em astrofísica observacional e análise de dados. Experiência de programação, análise e visualização de dados é essencial. Experiência anterior com projectos deste tipo é valorizada. Espera-se uma dedicação ao projecto de pelo menos 6 horas de trabalho por semana, parcialmente presenciais. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e actividades:
O aluno será integrado num projecto internacional que usa o espectrógrafo ESPRESSO para testar o modelo cosmológico padrão e procurar indícios da presença de nova física para além deste. Em particular, pretende-se estudar a possibilidade de as leis da física que conhecemos não serem válidas em regiões ou épocas diferentes do universo. O aluno contribuirá para alguns dos testes já em curso e para a definição e prioritização de testes futuros. Possíveis actividades incluem:
1) Exploração dos testes de física fundamental feitos pelo ESPRESSO como ferramentas para testes mais precisos de modelos de energia escura e do Princípio de Equivalência de Einstein;
2) Análise das restrições a classes específicas de modelos, impostas pelo ESPRESSO e por outros dados observacionais contemporâneos;
3) Planeamento e design experimental de futuros testes mais precisos, no contexto do ESPRESSO e dos instrumentos previstos para o ELT, incluindo a criação de catálogos de dados simulados para optimizaçao de estratégias observacionais;
4) Organização e apresentação dos resultados obtidos. O estágio poderá incluir visitas de trabalho a colaboradores externos e/ou deslocações a conferências para apresentação dos resultados.

Exemplos de bibliografia relevante para este projecto (alguma da qual resultou de estágios anteriores) incluem:
https://arxiv.org/abs/1709.02923
https://arxiv.org/abs/1801.08089
https://arxiv.org/abs/1911.10821
https://arxiv.org/abs/2012.10505
https://arxiv.org/abs/2112.05819
https://arxiv.org/abs/2203.02781

Impacto cosmológico da observação da expansão do universo em tempo real

Orientador: Carlos.Martins@astro.up.pt

Perfil do candidato:
Experiência de programação, análise e visualização de dados é essencial. Experiência anterior com projectos deste tipo é valorizada. Espera-se uma dedicação ao projecto de pelo menos 6 horas de trabalho por semana, parcialmente presenciais. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e actividades:
O aluno será integrado num projecto internacional que desenvolve estratégias observacionais optimizadas para a caracterização das propriedades da energia escura. Em particular, pretende-se utilizar para esse fim medições em tempo real da taxa de expansão do universo (designado redshift drift) que serão pela primeira vez feitas pelo instrumento ANDES, cuja Fase B de construção está a decorrer. Actividades específicas incluem:
1) Estudo semi-analítico de modelos com campos escalares para a aceleração do universo e das suas consequências observacionais;
2) Desenvolvimento de ferramentas estatísticas de comparação desses modelos com os dados observacionais actualmente existentes;
3) Desenvolvimento de catálogos simulados de observações do redshift drift e outras observáveis, e optimização das respectivas estratégias observacionais;
4) Organização e apresentação dos resultados obtidos. O estágio poderá incluir visitas de trabalho a colaboradores externos e/ou deslocações a conferências para apresentação dos resultados.

Exemplos de bibliografia relevante para este projecto (alguma da qual resultou de estágios anteriores) incluem:
https://arxiv.org/abs/1606.07261
https://arxiv.org/abs/1709.02923
https://arxiv.org/abs/1902.01783
https://arxiv.org/abs/1907.05151
https://arxiv.org/abs/2108.10739

O que nos diz a distribuição de galáxias no céu: O caso da correlação angular de dois pontos

Orientador: Jose.Fonseca@astro.up.pt

Perfil do candidato:
O/a aluno/a deve ter interesse em Cosmologia e como se utiliza a distribuição das galáxias para compreender o universo em que vivemos. O/a aluno/a deve ter um bom background em matemática e ter algum conhecimento de programação em Python.

Objectivos e actividades:
O/a aluno/a começará por rever as várias quantidades usadas para quantificar a distribuição de galáxias no universo. Em especial ira derivar como é que a correlação angular de dois pontos está relacionada com outros estimadores. Para além disso irá rever como é que a correlação angular de dois pontos pode ser estimada observacionalmente usando o estimado de Landy-Szalay.

Simulação computacional e visualização de supercordas com GPUs e CUDA

Orientador: Carlos.Martins@astro.up.pt

Perfil do candidato:
O aluno deve ter interesse em programação, física computacional e data science. Experiência de programação, análise e visualização de dados é essencial. Experiência de programação paralela e/ou em GPUs será útil (em particular, o aluno terá acesso a GPUs de última geração, através de um projecto financiado pela NVIDIA). Experiência anterior com projectos deste tipo é valorizada. Espera-se uma dedicação ao projecto de pelo menos 6 horas de trabalho por semana, parcialmente presenciais. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e actividades:
O aluno será integrado num projecto internacional, em colaboração com as universidades de Cambridge e Paris, que estuda a evolução de vários tipos de defeitos topológicos, incluindo paredes de domínio, cordas cósmicas e supercordas. Estes objectos formaram-se necessariamente no universo primitivo, e a sua caracterização dá-nos pistas cruciais sobre a física fundamental, que serão exploradas pelo SKAO e LISA. O objectivo do estágio á a simulação computacional da evolução de alguns destes modelos cujo comportamento não foi ainda estudado em detalhe, recorrendo a programação em CPUs e/ou GPUs, e o pós-processamento e análise destas simulações. Actividades específicas podem incluir:
1) Estudo de modelos analíticos para a evolução de redes de defeitos topológicos;
2) Desenvolvimento, optimização e/ou validação de códigos numéricos de evolução de redes;
3) Processamento, análise e visualização de resultados de simulações numéricas de alta resolução destas redes (incluindo o desenvolvimento de videos destas simulações);
4) Organização e apresentação dos resultados obtidos. O estágio poderá incluir visitas de trabalho a colaboradores externos e/ou deslocações a conferências para apresentação dos resultados.

Exemplos de bibliografia relevante para este projecto (alguma da qual resultou de estágios anteriores) incluem:
https://arxiv.org/abs/1602.08083
https://arxiv.org/abs/1911.03163
https://arxiv.org/abs/2005.14454
https://arxiv.org/abs/2011.09700
https://arxiv.org/abs/2108.03147
https://arxiv.org/abs/2108.07513

Testes de modelos de energia escura e gravitação modificada

Orientador: Carlos.Martins@astro.up.pt

Perfil do candidato:
Experiência de programação, análise e visualização de dados é essencial. Experiência anterior com projectos deste tipo é valorizada. Espera-se uma dedicação ao projecto de pelo menos 6 horas de trabalho por semana, parcialmente presenciais. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e actividades:
O aluno será integrado num projecto internacional que desenvolve estratégias observacionais optimizadas para a caracterização das propriedades da energia escura. Em particular, pretende-se estudar as consequências observacionais de modelos cosmológicos inspirados em teoria de cordas ou gravitação quântica, usando novos instrumentos como o Euclid, o SKAO, e o ANDES, que alargarão a gama de redshifts para os quais o comportamento gravitacional da energia escura é bem conhecido e possibilitarão testes completamente novos. Actividades específicas incluem:
1) Estudo semi-analítico de modelos de física fundamental baseados em campos escalares ou outros graus de liberdade para a aceleração do universo e das suas consequências observacionais;
2) Desenvolvimento de ferramentas estatísticas de comparação desses modelos com dados observacionais (cosmológicos e astrofísicos) actualmente existentes;
3) Aplicação destas ferramentas a modelos de energia escura e gravitação modificada, e modelação de estratégias observacionais para o estudo estes modelos com instrumentos futuros;
4) Organização e apresentação dos resultados obtidos. O estágio poderá incluir visitas de trabalho a colaboradores externos e/ou deslocações a conferências para apresentação dos resultados.

Exemplos de bibliografia relevante para este projecto (alguma da qual resultou de estágios anteriores) incluem:
https://arxiv.org/abs/1806.07653
https://arxiv.org/abs/1905.02792
https://arxiv.org/abs/1911.08232
https://arxiv.org/abs/2012.10513
https://arxiv.org/abs/2201.12863
https://arxiv.org/abs/2204.08016

Testing the Distance Duality Relationship

Orientador: Jose.Fonseca@astro.up.pt
Co-orientador: P. Avelino

Perfil do candidato:
O/a aluno/a deve ter interesse em Cosmologia e testes cosmológicos da Relatividade Geral. O/a aluno/a deve ter um bom background em física e matemática. O/a candidato/a deve ter algum conhecimento de programação em Python.

Objectivos e actividades:
O/a aluno/a começará rever as distâncias de luminosidade e angular, tal como a relação entre elas, a relação dual de distância. Deverá rever modelos que induzem desvios na relação e compreender como se pode usar a relação para testar a teoria da Relatividade Geral observacionalmente. O/a aluno/a deverá explorar novas possibilidades de testes observacionais.

Education and outreach projects

Astrofísica, programação e análise de dados para o ensino secundário

Orientador: Carlos.Martins@astro.up.pt

Perfil do candidato:
É dada preferência a alunos de mestrado de ensino. Experiência prévia de programação, análise e visualização de dados é útil. Espera-se uma dedicação mínima de 6 horas de trabalho por semana, parcialmente presenciais. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e actividades:
Os estagiários participarão no desenvolvimento de conteúdos de astrofísica e áreas afins apropriados para alunos do ensino secundário (de áreas científicas). Actividades específicas incluem:
1) Pesquisa bibliográfica sobre a área relevante;
2) Desenvolvimento de conteúdos de astrofísica (incluindo programação e análise de dados) apropriados para alunos do ensino secundário, em colaboração com os investigadores e alunos de doutoramento da equipa e com professores de escolas secundárias parceiras do projecto;
3) Implementação destes conteúdos em pequenos grupos de alunos do ensino secundário das escolas parceiras (incluindo visitas a estas escolas);
4) Organização e publicação destes conteúdos, e dos resultados obtidos.

Espera-se que os resultados do estudo sejam apresentados, entre outros locais, no Encontro Nacional de Astronomia 2023.

Citizen science: from an investigative technique to a method of equity in access to astronomy communication and education

Level: MSc or PhD
Supervisor: ilidioandrecosta@astro.up.pt
Co-supervisor: C. Morais (FCUP)

The citizen science (CS) concept is now summarized in a simple common idea: the public engagement in different stages of scientific processes. If the view of CS as a scientific technique is very consensual, its use as a science communication and education (SCE) method is not. However, accomplishing science communication goals is one of the most common purposes of CS, highlighted by both scientists and CS project managers alike. Indeed, the advantages of associating science communication and science education have long been known, namely through CS projects, helping to bridge the gap between scientific research and science education. Thus, engaging teachers in CS processes is a natural path, enhanced by the school effect and the teacher effect in students, but also in the effect these have in student's families and the surrounding school community. This multiplier effect of influences which schools provide is unique and highly positive.

Supported by data of our previous research and in a synergistic context between science education, science communication to non-interested audiences and scientific research in astronomy, that CoAstro: @n Astronomy Condo project emerges. In it we have as objectives: i) to structure, implement and evaluate the effects of a co-designed CS project by primary teachers (from regions with low spontaneous involvement with science), astronomers and science communicators; ii) to evaluate knowledge, attitudes and beliefs towards science, of teachers and its changes, as a result of participation in CoAstro; iii) perceive the impact of CoAstro on the dissemination of astronomy among school communities; iv) to improve a CS design for a public with low interest in astronomy and in regions far away from science centres.

Contributos para a investigação em ensino e divulgação das ciências

Orientador: ilidioandrecosta@astro.up.pt

Perfil do candidato:
Dar-se-á preferência a candidatos com bom domínio da língua inglesa (especialmente escrita) não sendo, contudo, um critério de exclusão a falta de domínio desta língua.

Objectivos e actividades:
O candidato deverá estar motivado para a realização de projetos investigativos exploratórios na área do ensino ou divulgação das ciências (biologia, geologia, matemática, astronomia, física ou química). Estes partirão de dados já coletados pelo Planetário do Porto - Centro Ciência Viva (PP-CCV) ou, em alternativa, poderão resultar denovas propostas investigativas apresentadas pelos candidatos.

Assim propõe-se:
1) Definição do campo de intervenção ou, em alternativa, selecção dos dados, já existentes no PP-CCV, a trabalhar.
2) Tratamento/análise dos dados.
3) Discussão dos resultados e estabelecimento de conclusões.
4) Apresentação do projeto investigativo exploratório, sob a forma de artigo e/ou comunicação em congresso.

Literacia científica e numeracia em Portugal

Orientador: Carlos.Martins@astro.up.pt

Perfil do candidato:
É dada preferência a alunos de mestrado de ensino, e a alunos com experiência prévia de programação, análise e visualização de dados. Espera-se uma dedicação mínima de 6 horas de trabalho por semana, parcialmente presenciais. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e actividades:
Os estagiários participarão na implementação de um estudo sobre literacia científica em geral (e a numeracia em particular) no ensino secundário e superior em Portugal.
Actividades específicas incluem:
1) Pesquisa bibliográfica sobre a área relevante;
2) Planeamento e organização da logística do estudo, nas versões digital (para alunos do ensino superior) e em papel (para alunos do ensino secundário);
3) Implementação do estudo e análise dos resultados;
4) Organização e apresentação dos resultados obtidos.

Espera-se que os resultados do estudo sejam apresentados, entre outros locais, no Encontro Nacional de Astronomia 2023.

Scientific literacy and astronomy teaching

Level: PhD or MSc
Supervisor: Carlos.Martins@astro.up.pt

We have previously carried out a survey of high-school students (from 7th to 12th grade) in Portuguese schools, aiming to determine the degree of understanding of some basic astronomy concepts which are supposedly part of the national schools curriculum. The main result of the survey was that most students do not in fact meet the set national standards.

The goal here is to take advantage of our privileged contacts with schools to extend this study, ideally reaching several tens of thousands of students and possibly also extending it to university students. The increased population will enable a more detailed statistical analysis that should allow meaningful comparisons between different sub-samples.

Although the focus will be on astronomy, in the case of a PhD project we will also aim to quantify the degree of scientific literacy of the students, focusing on contemporary issues such as global warming. These studies can be done either by implementing in Portugal methodologies previously developed in other countries or by designing and implementing our own, optimized to the specific context of Portuguese schools.

Finally we will also seek to quantify the degree of scientific literacy of the school teachers themselves, and how that may impact some of the knowledge (and the possible misconceptions) acquired by the students during their school years. The goal will be to use our findings to propose a detailed and specific actin plan that schools and teachers can implement locally.

APPENDIX

The CAUP Team, April 2022

Researchers [40]
Vardan Zh. Adibekyan
Pedro P. Avelino
Susana C. C. Barros
Diego Bossini
Jarle Brinchmann
Tiago J. L. C. E. Campante
Ilídio André P. M. Costa
Vitor M. M. Costa
Margarida S. Cunha
António C. da Silva
Paulo Maurício de Carvalho
Morgan Deal
Elisa Delgado Mena
Olivier D. S. Demangeon
João P. Faria
Pedro Figueira
Daniel F. M. Folha
José Carlos Fonseca
Jorge Filipe Gameiro
Jean Michel Gomes
João N. T. Gomes da Silva
Andrew J. Humphrey
M. S. Nanda Kumar
Maria Teresa V. T. Lago
Patricio Lagos
João J. G. Lima
Catarina Lobo
Jorge H. C. Martins
Carlos J. A. P. Martins
Mário J. P. F. G. Monteiro
Pedro M. Palmeirim
Ana S. Paulino Afonso
L. Filipe Pereira
Ivan Rybak
ângela R. G. Santos
Nuno C. Santos
Tom C. Scott
Lara G. Sousa
Sérgio A. G. Sousa
Pedro T. P. Viana

Ph.D. Students [23]
Alexandros Antoniadis Karnavas
Rui P. L. Azevedo
Ana F. S. Barros
Thibault Boulet
Abhishek Chougule
Miguel T. Clara
Pedro Alexandre C. Cunha
Tomás de Azevedo Silva
João D. F. Dias
David Gruber
Mara Jacinto
Ana C. O. Leite
Nuno A. M. Moedas
Sandy G. Morais
Sergei Mukovnikov
José Rodrigues
Nuno M. Rosário
André Miguel A. C. V. Silva
Ana Rita Silva
Abderahmane Soubkiou
Renata S. Trintin
Daniel A. D. Vaz
Paulina M. Zaworska

Other Students [22]
Ana Barboza
Adrian H. M. Cabral
João M. A. Custódio
Anselmo J. G. Falorca
Maria Inês M. F. S. Ferreira
Jeanne Gandon
Diogo S. V. B. Gomes
Jorge M. S. B. F. Lopes
Catarina M. J. Marques
José G. B. Matos
Tatiana S. S. Mendes
Bruno H. Morini
Andreas W. Neitzel
Pedro A. A. Nogueira
Francisco C. N. Q. Pimenta
André S. A. Pinheiro
Miguel C. Ralha
Mariana I. C. Reis
Manuel C. Rosa
Pedro Miguel M. Silva
Rodrigo P. Silva
Samuel R. P. Veiga

CAUP

Centro de Astrofísica da Universidade do Porto

Centro de Astrofísica da Universidade do Porto

U.PORTO

Rua das Estrelas
4150-762 Porto, Portugal
T. +351 226 089 830
geral@astro.up.pt

www.astro.up.pt
www.facebook.com/astro.up.pt
www.twitter.com/astro_up
www.youtube.com/cauptv