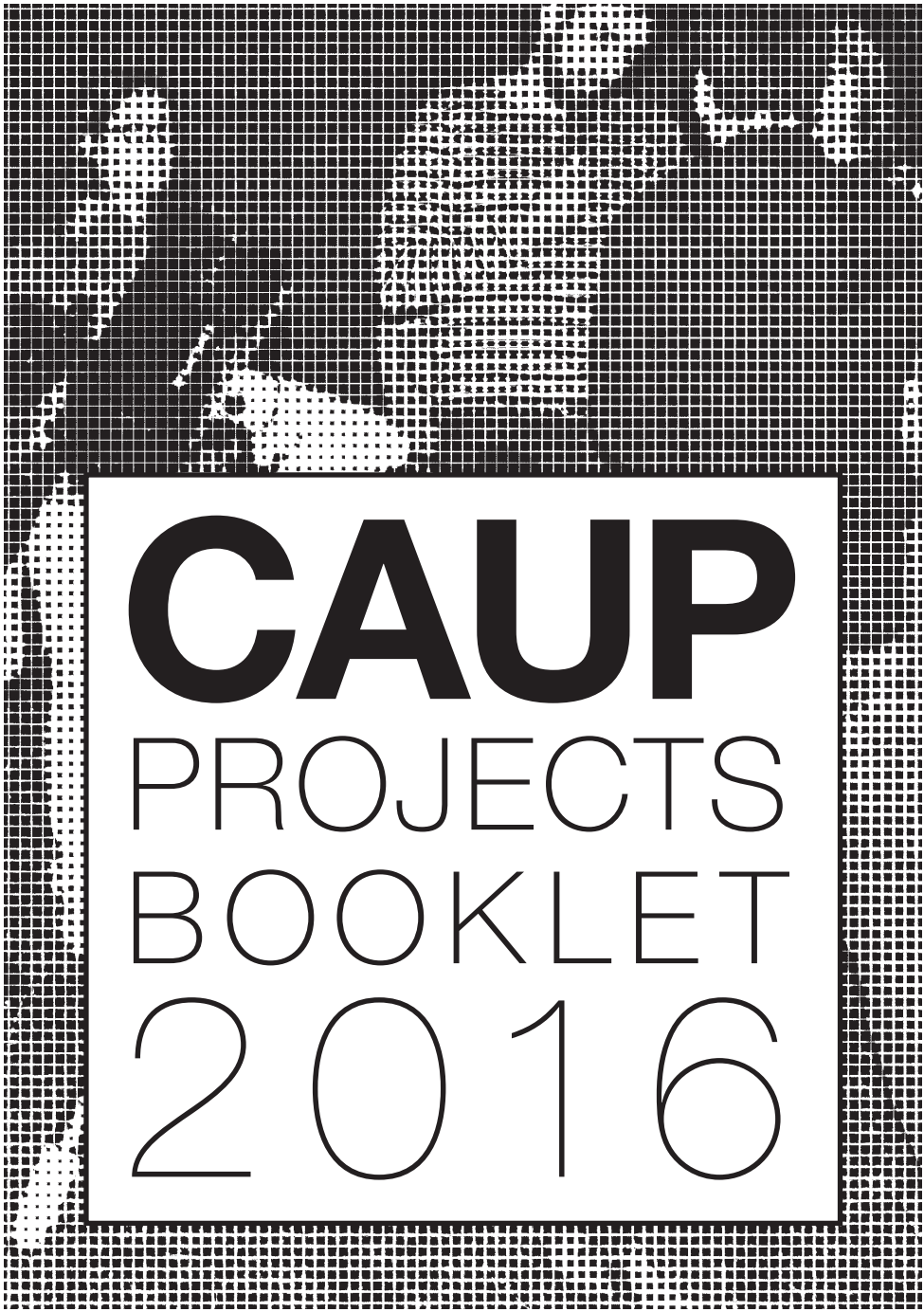

CAUP

PROJECTS BOOKLET 2016

INDEX

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 2016-17.

We start by listing PhD/MSc projects within our participation in ESA and ESO consortia, as leading the national participation in such consortia is one of our key strategic priorities. These are followed by other astrophysics PhD/MSc 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 our PhD::SPACE.

Finally we list education/outreach projects and projects for undergraduate students. In the latter case these are listed in Portuguese, since they are almost always offered through the Faculty of Sciences' PEEC internship program. As an appendix we also list the current CAUP research team and a 'Funding ID' of current research grants.

In the cases where the project has several co-supervisors, the contact person for the project is the one whose e-mail is listed, and you should approach him/her for any enquiries on the project. Although the list is representative of current interests and priorities, it is by no means 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)
March 2016

ESA and ESO related projects

Astrophysical and Local Tests of the Einstein Equivalence Principle

Level: PhD or MSc
Offered in PhD::SPACE: Yes
Supervisor: Carlos.Martins@astro.up.pt

The Einstein Equivalence Principle (EEP, which Einstein formulated in 1907) is the cornerstone of General Relativity (only formulated in 1915) but also of a broader class known as metric theories of gravity. Although they are often confused, the two are conceptually distinct, and different experiments optimally constrain one or the other. Recent developments, including quantum interferometric tests and dedicated space missions, promise to revolutionize the field of local tests of the EEP and dramatically improve their current sensitivity.
In this thesis the student will explore new synergies between these imminent new local tests of the EEP and ongoing or planned astrophysical and cosmological tests: some of these directly test the EEP, while others only test the behaviour of GR on various scales. We will explore relevant paradigms (including scenarios with and without screening mechanisms) and study how they will be further constrained by experiments such as MicroSCOPE and ACES, in combination with astrophysical data. The project may have a theoretical or an observational focus, depending on the student's preference and skills. In any case the work will be directly relevant for the science case of several ELT instruments, and to a lesser extent for ALMA, Euclid and the SKA.

Recent relevant works include arXiv:1403.7377, arXiv:1412.0108, arXiv:1506.03550, arXiv:1508.00765 and arXiv:1508.06157.

Detecting light from other worlds: the high-resolution spectroscopy approach

Level: PhD or MSc
Offered in PhD::SPACE: Yes
Supervisor: Nuno.Santos@astro.up.pt

With the number of exoplanets increasing at a fast pace, the attention of exoplanetology is slowly focusing in their detailed characterization. The detection of exoplanet atmospheres is now a reality for at least the most favourable cases, though in general not in great detail. In the present project we propose to develop a methodology to detect the spectra of exoplanets using high-resolution spectroscopy, and in particular to study the reflectance of the exoplanet as a function of wavelength. The methods will be used with the new ESPRESSO (ESO) instrument that will soon start operating at the VLT. Together with planet atmosphere models, the observations will allow us to probe and understand in unique detail the physical and chemical conditions of the observed planets.

Detecting the atmospheres of exoplanets with CHEOPS: combining theory and observations

Level: PhD or MSc
Offered in PhD::SPACE: Yes
Supervisor: Nuno.Santos@astro.up.pt

With the number of exoplanets increasing at a fast pace, the attention of exoplanetology is progressively focusing in their detailed characterization. This characterization effort will receive a major boost in the coming years, as a number of new telescopes both in space and on the ground become operative. To fully exploit the potential of the data to arrive, it is critical that similar efforts are spent on the development of theoretical tools that will enable the interpretation of observations.
The present project proposes a combined theoretical and observational approach to use data from new instruments to study the atmospheres of exoplanets. In particular, we will focus on the use of CHEOPS high precision photometry to detect and analyse the occultation signals for a variety of planets orbiting stars with different properties. A statistical analysis of the data, coupled with the model predictions, will allow to understand new physical processes in the atmospheres of exoworlds.

New Maps of the Dark Side

Level: PhD or MSc
Offered in PhD::SPACE: Yes
Supervisor: Carlos.Martins@astro.up.pt

The growing amount of observational evidence for the recent acceleration of the universe unambiguously 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 for the next generation of astrophysical facilities is therefore 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 becoming increasing 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 E-ELT, and the SKA 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. 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 (in which the dark side team is more directly involved) and will gradually broaden to explore synergies with the SKA and relevant ELT instruments.

Recent relevant works include arXiv:1311.5841, arXiv:1412.0108, arXiv:1503.05068, arXiv:1505.05529 and arXiv:1601.02950.

Other astrophysics projects

Coding the Cosmos: a New Generation of Superstring Simulations

Level: PhD or MSc
Offered in PhD::SPACE: Yes
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 polarization and gravitational wave detection highlights how some of these scenarios can 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. This is expected to be an even bigger problem for next-generation facilities such as COrE+ and eLisa. This thesis will go significantly beyond the state-of-the-art and develop and implement a new generation of high-scalability HPC defect codes that will be able to match the sensitivity of ongoing and forthcoming observational searches.

Recent relevant works include arXiv:1310.3614, arXiv:1312.2123, arXiv:1405.7722, arXiv:1407.3905 and arXiv:1602.01322.

Galaxy interactions at Infrared wavelengths

Level: MSc
Supervisor: Tom.Scott@astro.up.pt
Co-Supervisor: Catarina Lobo (IA, Porto)

Galaxies, especially in galaxy clusters and galaxy groups, can tidally interact with one another and these interactions produce characteristic distortions in the galaxy's shape, e.g. tidal tails. During their orbits in galaxy clusters, spiral disk galaxies like the Milky Way can also interact with a hot X-ray emitting gas, which pervades galaxy clusters and is known as the intra-cluster medium (ICM). This interaction, known as ram pressure stripping, can remove the galaxy's gaseous interstellar medium. During ram pressure stripping it is only the galaxy's interstellar medium which interacts with the ICM leaving the galaxy's old stellar population unaffected. Ram pressure stripping can however affect the location of young stars. So to distinguish between tidal and ram pressure-stripping interactions we need to understand which wavelength best traces a spiral galaxy's old stellar population. We can then see whether the old stellar population has been disturbed or not by the interaction, thus allowing us to distinguish between tidal and ram pressure interactions. In turn this will help understand how the cluster environment drives the evolution of its galaxies.
In general, infrared wavelengths are better tracers of old stellar populations than optical wavelengths, but there remain questions about which infrared wavelength bands optimally reflect a galaxy's old stellar population. The project's aim is to compare the emission from a sample of spiral galaxies in a few nearby clusters imaged in different infrared wavelength bands and with different telescopes, including the Spitzer space telescope (all data is available and in archives). The study will investigate the differences between emission in different infrared bands and the reasons for these differences based on theories of the emission detectable in each band, with the aim of determining which band best reflects the emission from the old stellar population. Resolving this question is a step in understanding more fundamental issues of galaxy evolution.

Orbital evolution of planetary systems: from formation to today

Level: PhD
Offered in PhD::SPACE: Yes
Supervisor: Vardan.Adibekyan@astro.up.pt
Co-supervisors: Alexandre Correia (U. Aveiro), Pedro Figueira (IA, Porto)

The field of extrasolar planets research is teeming with activity. Last year we celebrated the 20th anniversary of the discovery of the first planet outside our system, and yet we count already over 2000 confirmed planets and hundreds of candidates to confirm. With a fast-growing discovery pace and a bright future ahead guaranteed by large number of ongoing and planned projects, it presents itself as the emerging astronomy topic of the new century. As the planetary zoology continues, recent studies have shown that stellar properties (like, mass evolutionary stage, and metallicity) also play a very important role not only on the formation of planets, but also on the orbital evolution. Several remarkable observational results can be outlined from these studies, that are still waiting for a solid explanation: planets in the metal-poor systems form/evolve differently appear to form farther out from their central star and/or they form later and do not migrate far; low-metallicity stars have a deficit of eccentric planets between 0.1 and 1 AU when compared to their metal-rich counterparts, because of either a less effective planet-planet interactions or due to the self--shadowing of the disk by a rim located at the dust sublimation radius (approx. 0.1 AU). Planet-planet and planet-disk gravitational interactions during the formation process emerge as important orbit-shaping to be explored for a better understanding of the evolution of planetary systems. With this project we propose to study the impact of stellar metallicity on the orbital evolution of planetary systems from the observational point of view and to develop new simulations in which we consider the effect of disk and/or a companion planet's presence on the planetary parameters. A linkage between theory and observations as presented here is uncommon, but crucial to understand our picture of extrasolar system. The different expertise of the supervisors will allow for a more encompassing work than before.

Physical properties of VIPERS' galaxies

Level: MSc
Supervisor: Jean Michel Gomes (jean@astro.up.pt)
Co-Supervisor: Catarina Lobo (IA – Porto)

VIPERS (VIMOS Public Extragalactic Survey http://vipers.inaf.it) has just made its first data release of ~50 000 galaxy spectra in the redshift range $0.5 < z < 1.2$ over a total area of ~24 square degrees. Multi-wavelength ancillary data is available as well. These new data provide the currently unique opportunity to extend to medium redshift, with similar statistics, all the analyses already carried out for SDSS local galaxy spectra, namely by deriving several physical properties of galaxies such as stellar and gas masses, extinction, chemical abundances, mean stellar age and metallicity, star-formation histories, gas ionization parameters, among others. Comparisons with the local sample results will allow us to shed light on how galaxies evolve through time.
In this project, the student is expected to learn how to work with existing spectral synthesis and emission-line analyses tools, and apply them to the already fully reduced VIPERS' spectra to extract the physical properties of galaxies outlined above. During this work, he/she will have to develop some programming routines and achieve a good management of the dataset. The student will then compare his results with the ones already obtained at low redshift, contributing to a better understanding of the possible evolutionary pathways of galaxies. In particular, some astrophysical relations (e.g. the mass-metallicity relation) will be investigated for the first time at higher redshifts with similar statistical significance as already achieved in the local Universe.

Probing Galaxy Evolution & Feedback Using Giant Gaseous Structures Associated with Radio--Loud Galaxies at High Redshift

Level: PhD or MSc
Offered in PhD::SPACE: Yes
Supervisor: Andrew.Humphrey@astro.up.pt

Powerful radio-loud active galaxies at high redshifts (z>2) are often associated with ~100 kpc scale nebulae that emit strongly in the line of Lyman-alpha. Moreover, many also show associated extended Lyman-alpha absorbers that are at least as large. The global properties of these gaseous structures are, at present, poorly understood. This project aims for a substantially improved characterisation of the Lyman-alpha emitting and absorbing gases, making use of new observations from state of the art observing facilities, includng VLT MUSE and Keck.

Stellar noise and stellar 'signals': the role of alpha elements on the formation of planets

Level: MSc
Supervisor: Vardan.Adibekyan@astro.up.pt
Co-Supervisor: Mahmoudreza Oshagh (U. Göttingen/IA, Porto)

Understanding the stellar magnetic activity phenomena (such as spots, faculae, plages) is very important for different fields of stellar and exoplanetary astrophysics, and for planetary climate studies. Studying magnetic activity on stars of different stellar parameters and activity levels provides an opportunity for detailed tests of stellar/solar dynamo models. From the exoplanetary sides, it is well known that stellar active regions combined with the stellar rotation can induce signals in high-precision photometric and radial velocity observations. These activity-induced signals may lead to masking or mimicking exoplanets signal. Moreover, these signals are one of the main limitations for the detection and the precise characterization of low mass/small radii planets, which is the major goal of future instruments.

The ultimate goal of this project is to explore novel ways to estimate the stellar variability (new proxies). By using lines of different excitation and ionization potentials the student will explore the link between photospheric variability and chromospheric activity. It is also of great interest (and part of the project) to study the impact of these variations on the the derivation of stellar parameters and chemical abundances of the stars. This work will be carried out in collaboration with Pedro Figueira (IA, Porto) and other members of the EXOEarths team. The student will join our team that has very strong experience in the studies of stellar activity, planet detection and stellar characterization. There is also possibility for the student to participate in the observational programs of our team with the telescopes in Chile.

Testing the impact of kappa--distributed electron energies in quasar nebulae

Level: PhD or MSc
Offered in PhD::SPACE: Yes
Supervisor: Andrew.Humphrey@astro.up.pt

A long-held assumption is that the electron energies in extrasolar warm ionized nebulae (HII regions, quasar-ionized nebulae, etc.) follow the Maxwell-Boltzmann (MB) distribution. However, direct measurements from a number of plasmas within our Solar system have revealed the presence non-equilibrium electron energy distributions, which have been characterised by the 'kappa-distribution' (KD).
Armed with the MAPPINGS 1e photoionization code (the first to include kappa-distributed electron energies) an extensive exploration of photoionization model parameter space will be conducted, to ascertain the generalized impact of KD election energies on quasar/AGN line spectra, and how this impact depends on various model parameters (e.g., density, metallicity, kappa, ionization parameter, ionizing spectral energy distribution).
Observational tests for the presence of KD in photoionized nebulae will be developed. Moreover, diagnostics of gas physical conditions with the least (or no) dependence on the value of kappa, or on the choice of KD of MB cases, will be developed. The possible impact on BPT diagrams (and similar), and on the spectral classification of emission line galaxies, will also be elucidated.

The role of alpha elements on the formation of planets

Level: MSc
Supervisor: Vardan.Adibekyan@astro.up.pt
Co-Supervisor: Pedro Figueira (IA, Porto)

The correlation between the occurrence of giant planets and the metallicity of host stars is now well established, with metal-rich stars being more likely to harbor gas giants. Interestingly, the same correlation is weakened as one moves toward Neptune-size planets, ultimately vanishing as we enter the regime of terrestrial planets. These correlations lend support to the core-accretion model, where the planet formation starts with the accretion of dust particles and later planetesimals. Latter, if the metallicity of the system is high, the rocky or icy core can form very fast and after accreting a gaseous envelope a massive planet will be formed. If the amount of heavy elements (metals) is not enough the core will grow in a longer timescale and will be no time to accrete enough gas - the planet will be terrestrial. In most of the studies the results were obtained using the iron abundance as a proxy of overall metallicity. However, recent studies showed that metal-poor planet host stars are enhanced by other elements, which means that the total amount of metals in these stars is not small. In this Master project the student will derive chemical abundances of the stars from the Coralie sample using the Cross-Correlation Function, with the ultimate goal to study the correlation between the frequency of planets and "total" metallicity. This work will be carried out with a collaboration of Sergio Sousa (IA, Porto) and other members of the EXOEarths team.

Education / outreach and undergraduate projects

Scientific literacy and astronomy teaching

Level: PhD or MSc
Offered in PhD::SPACE: No
Supervisor: Carlos.Martins@astro.up.pt

We have recently 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. This was also compared to an earlier study in 2009. 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, 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 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.

Cartografando o lado escuro do universo

Orientador: Carlos.Martins@astro.up.pt

Local do Estágio:
CAUP; dependendo do desempenho, o estágio incluirá também visitas de trabalho a colaboradores no estrangeiro e/ou deslocações a conferências para apresentação dos resultados.

Perfil do Candidato:
É dada preferência a alunos de astronomia, física ou engenharia física. Experiência prévia de programação, análise e visualização de dados é essencial. Espera-se uma dedicação ao projecto de 6 horas de trabalho por semana. A experiência anterior com projectos deste tipo é valorizada. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e Actividades:
Os alunos serão integrados em colaborações internacionais cujo objectivo é o desenvolvimento de estratégias observacionais optimizadas para a caracterização das propriedades da energia escura em todo o intervalo de redshifts de 0 a 5, em particular utilizando o satélite Euclid (ESA) e os vários instrumentos previstos para o E-ELT (ESO). Entre outros serão explorados métodos astrofísicos que testam a estabilidade das constantes fundamentais da natureza. Actividades específicas incluem:

1) Estudo (semi-)analítico de alguns modelos cosmológicos para a aceleração do universo e a variação das constantes fundamentais da natureza;
2) Desenvolvimento e análise de simulações numéricas para alguns modelos representativos, e comparação com os dados observacionais já existentes ou futuros;
3) Desenvolvimento de catálogos simulados de observações para os instrumentos em causa (Euclid, ESPRESSO, HIRES e outros), e optimização das respectivas estratégias observacionais;
4) Organização e apresentação dos resultados obtidos.

Exemplos de bibliografia relevante incluem arXiv:1311.5841, arXiv:1412.0108, arXiv:1503.05068, arXiv:1505.05529 e arXiv:1601.02950.

Espectroscopia IFU: Técnicas básicas de redução e análise

Orientador: Patricio.Lagos@astro.up.pt

Local do Estágio:
CAUP

Perfil do Candidato:
Alunos de licenciatura ou primeiro ano de mestrado em física ou astronomia.

Objectivos e Actividades:
A espectroscopia de campo integral ou IFU (do inglês integral field unit) é uma técnica moderna amplamente utilizada no estudo de objetos extensos. As vantagens desta técnica, em comparação com as observações de fenda longa, é a captação simultânea de informação espectral e espacial dos objetos ou campos observados, o que garante a homogeneidade dos dados. A espectroscopia IFU é uma técnica complexa, para a qual cada grupo têm desenvolvido suas próprias ferramentas específicas de análise, o que torna difícil para os usuários à utilização das suas capacidades. Os atuais instrumentos (GMOS, VIMOS, KMOS, MUSE, etc) e a próxima geração de IFUs, em desenvolvimento, para o E-ELT (HARMONI, EPICS, etc) exigirá astrônomos altamente qualificados para utilizar estas instalações modernas. O objetivo por trás deste estágio, é o estudo dos elementos básicos de observação, redução e análise de dados IFU obtidos a partir de observações nos telescópios Gemini e VLT. Neste projeto será também estudado, os aspectos mais relevantes da física do meio interestelar.

Literacia científica e numeracia nas escolas portuguesas

Orientador: Carlos.Martins@astro.up.pt

Local do Estágio:
CAUP; os resultados do projecto poderão ser apresentados no Encontro Nacional de Astronomia de 2017. Poderão também ser úteis algumas deslocações a escolas.

Perfil do Candidato:
É dada preferência a alunos de mestrado de ensino, e em igualdade de circunstâncias às áreas de física, química e matemática. Será dada preferência a candidatos com alguma experiência prévia na àrea. Espera-se uma dedicação ao projecto de 6 horas de trabalho por semana. Experiência em programação, análise e visualização de dados é importante. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e Actividades:
O estagiário participará no desenvolvimento e implementação de um estudo sobre literacia científica em geral (e a numeracia em particular) no ensino secundário em Portugal. Actividades específicas incluem:
1) Pesquisa bibliográfica sobre a área relevante;
2) Planeamento do estudo principal (dirigido aos alunos), e análise da viabilidade de um possível estudo complementar para professores do ensino secundário e/ou para alunos do ensino superior;
3) Implementação do estudo;
4) Organização e apresentação dos resultados obtidos.

Paleontologia cósmica: à procura de fósseis do universo primitivo

Orientador: Carlos.Martins@astro.up.pt

Local do Estágio:
CAUP; dependendo do desempenho, o estágio incluirá também visitas de trabalho a colaboradores no estrangeiro e/ou deslocações a conferências para apresentação dos resultados.

Perfil do Candidato:
É dada preferência a alunos de astronomia, física ou engenharia física. Experiência prévia de programação, análise e visualização de dados é essencial. Espera-se uma dedicação ao projecto de 6 horas de trabalho por semana. A experiência anterior com projectos deste tipo é valorizada. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e Actividades:
Os alunos serão integrados em colaborações internacionais cujo objectivo é o estudo da evolução de supercordas e outras n-branas. Estes objectos formaram-se necessariamente no universo primitivo, e a sua caracterização dá-nos pistas cruciais sobre a física fundamental. O estudo da evolução destes objectos inclui ainda a análise das respectivas consequências observacionais, no contexto dos dados do satélite Planck e de possíveis missões futuras da ESA como o COrE+. Actividades específicas incluem:

1) Estudo de modelos analíticos para a evolução de redes de supercordas e outros defeitos topológicos;
2) Desenvolvimento de novos modelos (analíticos ou numéricos) simplificados para estudar aspectos específicos do problema;
3) Processamento, análise e visualização de resultados de simulações numéricas de alta resolução destas redes ;
4) Organização e apresentação dos resultados obtidos.

Exemplos de bibliografia relevante incluem arXiv:1310.3614, arXiv:1312.2123, arXiv:1405.7722, arXiv:1407.3905 e arXiv:1602.01322.

Testes da universalidade das leis da física

Orientador: Carlos.Martins@astro.up.pt

Local do Estágio:
CAUP; dependendo do desempenho, o estágio incluirá também visitas de trabalho a colaboradores no estrangeiro e/ou deslocações a conferências para apresentação dos resultados.

Perfil do Candidato:
É dada preferência a alunos de astronomia, física ou engenharia física. Experiência prévia de programação, análise e visualização de dados é essencial. Espera-se uma dedicação ao projecto de 6 horas de trabalho por semana. A experiência anterior com projectos deste tipo é valorizada. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e Actividades:
Os alunos serão integrados em colaborações internacionais cujo objectivo é desenvolver novos métodos astrofísicos para testar o modelo cosmológico padrão e procurar indícios da presença de nova física para além deste modelo. Em particular, pretende-se estudar a possibilidade de as leis da física a que estamos habituados não serem válidas em regiões diferentes do universo. Actividades específicas incluem:

1) Estudo do impacto da variação das constantes fundamentais da natureza em vários processos ou objectos astrofísicos, e das suas consequências observacionais;
2) Exploração dos testes astrofísicos da estabilidade das constantes fundamentais como ferramentas para testes mais precisos do Princípio de Equivalência de Einstein;
3) Desenvolvimento de novos testes de consistência do modelo cosmológico padrão, no contexto da instrumentação da próxima geração (incluindo o Euclid e os vários instrumentos previstos para o E-ELT);
4) Organização e apresentação dos resultados obtidos.

Exemplos de bibliografia relevante incluem arXiv:1409.1923, arXiv:1409.3963, arXiv:1412.0108, arXiv:1508.06083 e arXiv:1508.06157.

APPENDIX

The CAUP Team, March 2016

Researchers [40]
Vardan Zh. Adibekyan
Pedro P. Avelino
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António C. da Silva
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Pedro Figueira
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Jean Michel Gomes
Jorge M. C. Grave
Andrew J. Humphrey
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Mathieu Vrard

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Leandro S. M. Cardoso
Leyla Ebrahimpour
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Rui A. A. Fernandes
Andressa C. S. Ferreira
Ana C. O. Leite
Jorge H. C. Martins
Fernando Moucherek
Jason J. Neal
Benard Nsamba
Paola A. Quitral Manosalva
Elsa P. R. G. Ramos
Ana C. S. Rei
Ivan Rybak
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Marckelson S. Silva
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Arlindo M. M. Trindade
Solène C. Ulmer-Moll

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Vasco M. C. Ferreira
Mahmoud Hayati
Elsa M. P. S. Moreira
L. Filipe Pereira
Ana M. M. Pinho
Maria P. L. P. Ramos
Albina C. O. Sá

Funded grants currently active:

Characterizing Earth-like planets around small stars
PI: Pedro Figueira

Doctoral Network in Space Sciences (PhD::SPACE)
PI: Mário Monteiro

Exploitation of Space Data for Innovative Helio- and Asteroseismology (SPACEINN)
PI: Non-CAUP (CAUP contact Mário Monteiro)

Optimization of ESPRESSO Fundamental Physics Tests
PI: Carlos Martins/Ana Catarina Leite

Planet Analysis and Small Transit Investigation Software (PASTIS)
PI: Nuno Santos/Alexandre Santerne

Study of Emission Line Galaxies with Integral Field Spectroscopy
PI: Non-CAUP (CAUP contact Polychronis Papaderos)

The future of Extrasolar Planets: new intrumentation for new science
PI: Pedro Figueira

Understanding the nature of pulsations and the physics of the Ap stars
PI: Margarida Cunha

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