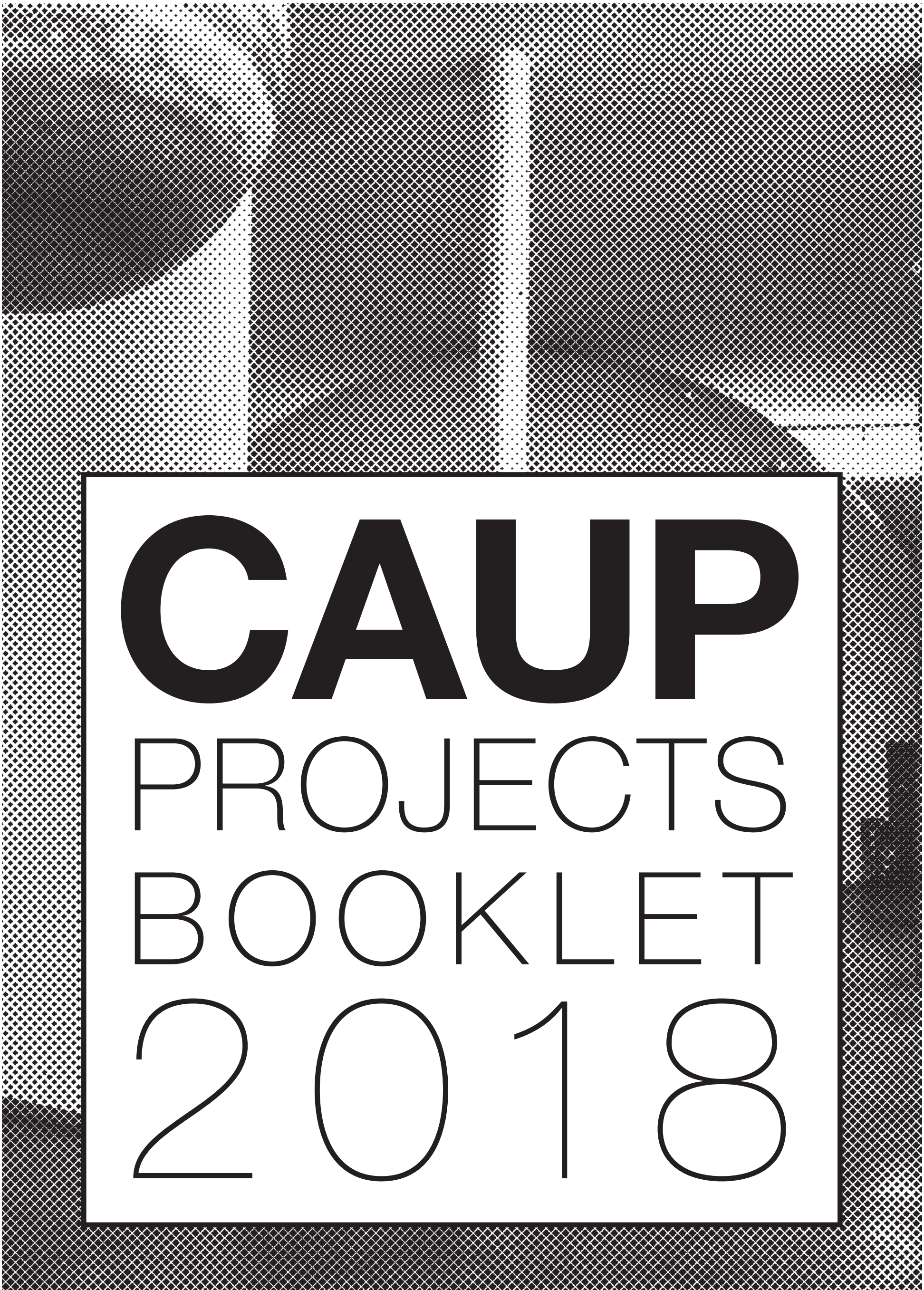

CAUP

PROJECTS BOOKLET 2018

INDEX

Education/outreach and undergraduate projects

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 2018-19.

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 doctoral program in the context of IA as well as through regular FCT PhD grants.

Finally we list education/outreach projects and projects for undergraduate students. In the latter case these are mainly 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 team, including both the researchers and the PhD and younger students.

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 2018

ESA and ESO related projects

Fundamental cosmology from precision spectroscopy: from ESPRESSO to the E-ELT

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

ESPRESSO is the next 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 a Laser Frequency Comb. ESPRESSO has been installed in the Combined Coudé Laboratory of the VLT and linked to the four Unit Telescopes (UT) through optical Coudé trains, allowing operations either with a single UT or with up to four UTs for about a 1.5 magnitude gain. One of the key science drivers of ESPRESSO is to perform improved tests of the stability of nature's fundamental couplings, and in particular to confirm or rule out the recent indications of dipole-like variations of the fine-structure constant, alpha.

In this thesis the student will be directly involved in the analysis and scientific exploration of the ESPRESSO fundamental physics GTO data, as well as in the preparation of any follow-up observations. Apart from its obvious direct - and very significant - impact on cosmology and fundamental physics, the ESPRESSO data will also be important as the first reliable precursor of analogous high-resolution spectrographs for the next generation of Extremely Large Telescopes, and in particular of ELT-HIRES (in whose Phase B we will be directly involved). Thus a second goal of the thesis is to use the ESPRESSO data to carry out detailed realistic simulations to assess the cosmology and fundamental physics impact of ELT-HIRES, inter alia exploring the feasibility of novel tests which are beyond the sensitivity of ESPRESSO, such as redshift drift measurements and molecular tests of composition-dependent forces.

Key relevant references are: Alves et al. PRD97 (2018) 023522, Avgoustidis et al. PRD 93 (2016) 043521, Evans et al. MNRAS 445 (2014) 128, Leite et al. PRD 94 (2016) 123512, Martins Rep.Prog.Phys. 80 (2017) 126902, Martins et al. JCAP 1508 (2015) 047, PRD 93 (2016) 023506, PRD 94 (2016) 043001 and Martins & Pinho PRD 95 (2017) 023008.

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 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 (whose launch is fast approaching) and will gradually broaden to explore synergies and probe combination with the SKA and relevant ELT-HIRES instruments.

Key relevant references are: Amendola et al. Living Rev. Rel. 21 (2018) 2, Calabrese et al. PRD 89 (2014) 083509, Martins et al. PRD 93 (2016) 023506 and Martins et al. PRD 94 (2016) 043001.

Other astrophysics projects

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 polarization and gravitational wave detection shows how some of these scenarios can be constrained by high-resolution data. However, to fully exploit the potential of ESA facilities such as CORE 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. This thesis will address the latter, using a series of mathematical and statistical techniques to develop more accurate analytic models for general defect evolution (building upon the successes of the current canonical VOS model) as well as for their astrophysical fingerprints, which is able to match the sensitivity of ongoing and future observational searches.

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 Correia & Martins PRE96 (2017) 043310, Lazanu et al. PLB B747 (2015) 426, Martins & Cabral PRD 93 (2016) 043542, Martins et al. PRD 93 (2016) 043534 & PRD 94 (2016) 116017, Rybak et al. PRD96 (2017) 103535, and Vieira et al. PRD 94 (2016) 096005.

Are high-mass young stars bloated?

Level: PhD or MSc

Supervisor: Nanda Kumar (nanda@astro.up.pt)

Almost two decades ago, using classical stellar structure physics, theoreticians predicted that the young high-mass (O and B type) stars should be swollen up to 400 Rsun. This is because a high-mass stars grows by gulping very fast, large amounts of high entropy material. The high internal entropy then drives the star to swell and cool off for a while until its internal system is stabilized and contracts to the main-sequence values. We have discovered a very enigmatic object which holds many characteristics of such a swollen young star and obtained new high-quality data in the radio and infrared using the Jansky Very Large Array and Cerro Tololo 4m Victor Blanco telescopes.

The student will work on either or both of these data sets to make progress on testing the swollen high-mass young star hypothesis. New ALMA and/or GRAVITY interferometer data may also become available by the time the project begins and the student will be welcome to work on these data as well.

Astrophysical and Local Tests of the Einstein Equivalence Principle

Level: PhD or MSc

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), develop a taxonomy for the current and new model classes, and study how they are further constrained by experiments such as MicroSCOPE and ACES, in combination with astrophysical data from ESPRESSO, ALMA and other facilities. The work will also be directly relevant for the science case of several E-ELT instruments, as well as Euclid and the SKA.

Key relevant references are: Dimopoulos et al. PRL 98 (2007) 111102, Leite & Martins PRD 94 (2016) 023503, Martins Rep.Prog.Phys. 80 (2017) 126902, Martins et al. JCAP 1508 (2015) 047, Martins et al. PRD 93 (2016) 023506, and Will LRR 17 (2014) 4.

Chromospheric activity in evolved stars

Level: MSc
Supervisor: Elisa.Delgado@astro.up.pt
Co-supervisor: João Gomes da Silva

The Radial Velocity (RV) method to detect planets around stars has to deal with several processes of stellar origin that produce a similar variability as planetary bodies. Those signals can be caused by pulsations, granulation or stellar activity. The signals produced by stellar activity often present the same period as the rotation of the star (and their aliases) and can be detected by studying spectral lines affected by the chromospheric activity (such as Halpha or Ca H&K lines).

The aim of this work is to carry on a comprehensive analysis of stellar activity indicators on a sample of 150 red giant (evolved) stars where planets are being searched for. Since red giants have large radii and they tend to rotate very slowly, their rotational periods are of hundreds of days and these signals can be easily misinterpreted as long-period giant planets. Once the activity indexes are measured with the previously mentioned spectral lines we will be able to search for possible periodic variability and compare it to the variation of RV and with the rotational period of the stars. Moreover, this study will provide a wide view of stellar activity behaviour at different evolutionary stages and in stars of different masses and ages.

Determination of sulphur abundances in the HARPS-GTO planet search sample

Level: MSc
Supervisor: Elisa.Delgado@astro.up.pt

The derivation of chemical abundances in stars of different metallicities is of prime importance to understand the Galactic Chemical evolution. Moreover, by studying the abundances of different elements in stars with and without planets we can also obtain information about planet formation mechanisms.

The objective of this project is to derive sulphur (S) abundances in a sample of ~1000 stars (150 of them having planets) by using spectral synthesis with the spectral code MOOG. The student will have to develop a simple code that compares synthetic and observed spectra to determine the best fit (with chi2 method or other) in two small wavelength regions where there are sulphur atomic lines. Once the abundances are derived we will be able to study the evolution of this element with metallicity and age and to compare it to other elements with similar nucleosynthesis and with models. Furthermore, this element is also useful to help constraining planetary interiors (apart from other more important elements such as Mg, Si, C, O and Fe).

Ensemble asteroseismology of solar-type stars with the NASA TESS mission

Level: PhD
Supervisor: Tiago.Campante@astro.up.pt
Co-supervisors: Margarida Cunha, Mikkel Lund (Aarhus University, Denmark)

The Transiting Exoplanet Survey Satellite (TESS) is a NASA space mission, with launch scheduled for March 2018, that will perform an all-sky survey for planets transiting bright nearby stars. Furthermore, TESS's excellent photometric precision will enable asteroseismology, the detailed study of stars by the observation of their natural, resonant oscillations. Asteroseismology is proving to be particularly relevant for the study of solar-type stars (i.e., low-mass, main-sequence stars and cool subgiants), in great part due to the exquisite photometric data made available by NASA's Kepler space telescope and, more recently, by the repurposed K2 mission.

In extending the legacy of Kepler/K2, the main goal of this project will be to perform an ensemble asteroseismic study of bright solar-type stars that reside in the solar neighborhood, making use of data collected by TESS during its 2-year primary mission. To that end, we propose an end-to-end PhD project that will provide the student with skills in photometric time-series preparation from pixel data, asteroseismic data analysis and stellar modeling techniques. The implications of this project are far-reaching. The proposed research will provide a well characterized sample of benchmark solar-type stars to be used in studies of exoplanetary systems and of the chemical evolution of the solar neighborhood, the latter of which will impact on Galactic archaeology studies.

Galaxy interactions at Infrared wavelengths

Level: MSc
Supervisor: Tom.Scott@astro.up.pt
Notes: Catarina Lobo

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 gaseous interstellar medium which interacts with the ICM leaving the galaxy's old stellar population unaffected. However, ram pressure stripping can affect the location of young stars, by displacing the gas from which they form. 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, it remains unclear which of these wavelength band(s) optimally reflects a galaxy's old stellar population. The project will begin by reviewing the literature to gain an understanding the sources of the emission detected for nearby galaxies in each broadband filter, e.g. J, H K and Spitzer 3.6 and 4.5 micron bands. The study will then use astronomical software to compare the emission from a sample of spiral galaxies from 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). Part of the study will test the feasibly of using the independent component analysis (ICA) technique to isolate differences between images from different IR bands. Investigating these differences and the reasons for them, based on theories of the emission detectable in each band, will help determine which band best reflects the emission from the old stellar population. Resolving this question is an important step to understanding more fundamental issues of galaxy evolution.

On the extinction laws and dust re-emission of extragalactic objects

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

The presence of dust in galaxies is ubiquitous and has changed completely our understanding of galaxy formation and evolution. It is estimated that more than one-third of the total luminosity in local galaxies is dimmed due to the reprocessing of ultraviolet (UV) light by dust into the infrared (IR) emission. Additionally, dust limits our ability to interpret the electromagnetic emission of local and distant galaxies because it selectively dims the galaxy light from UV to IR bands, which leads to the reddening effect. A fundamental task in modern extragalactic research is to recover the star formation- and chemical enrichment history (SFH & CEH, respectively) of galaxies from spectra, the main objective of spectral synthesis codes. However, dust opacity makes the proper interpretation of the spectral energy distribution of galaxies in terms of the stellar populations' properties, such as age and metallicity distributions, difficult. FADO (Fitting Analysis using Differential evolution Optimization) is a conceptually novel, publicly available population spectral synthesis code developed at IA with the distinctive capability of permitting identification of the SFH and CEH that best reproduces the observed gas characteristics of a galaxy taking into account the effects of dust absorption and emission in the optically thin limit.

In this MSc project, the student will study, implement and test distinct model predictions for the extinction and emission of dust grains given their size distribution, their optical and thermal properties using, for instance, models available in the literature, such as Désert et al. (1990), Draine & Li (2001,2007), Compiègne et al. (2011), Jones et al. (2013) and Koehler et al. (2014). These predictions will be intercompared using the FADO dust module. Then, FADO will be applied to real star-forming galaxies from the SDSS and CALIFA in order to test possible biases on the recovered SFH & CEH of galaxies. Preferable computing languages are Fortran & Python.

Peering the details of two most massive binary systems in formation using ALMA and VLT

Level: PhD or MSc
Supervisor: Nanda Kumar (nanda@astro.up.pt)

The most massive stars form rapidly via gravitational collapse of the densest and monstrous molecular clouds. The accretion flow making up the massive star is so dense and contains such large mass, the flow or the disk itself fragments (due to Jeans instability) leading to the formation of a second near-equal massive star. This phenomenon leads to the formation of massive binary stars. We have obtained observations of several molecular and ionising gas emission line observations of two massive binary systems in the formation using the Atacama Large Millimetre Array and adaptive optics assisted integral field spectroscopy using the Very Large Telescope.

The student will work on analyzing and interpreting this thrilling data set. While no previous experience is required, the expected output and/or progress will benefit with familiarity or expertise in working with astronomy softwares.

Probing the architecture of multi- -planetary systems

Level: MSc
Supervisor: Susana.Barros@astro.up.pt
Co-supervisor: Olivier Demangeon

The Kepler satellite has revealed that a large percentage of the known transiting exoplanets are in multi-planetary systems (ca. 40%). Multi-planetary systems are great laboratories to test theories of formation and migration of planetary systems. Many interesting systems found by Kepler and others recently found by the K2 mission are still awaiting detailed modelling due to the extra-complexity that the gravitational interaction between the different planets of the system introduce. This project aims at the study of the architecture of multi-planetary systems using detailed state of the art n-body simulations coupled with a Bayesian modelling.

The project is built on a photodynamic transit and radial velocity (RV) fitting tool developed by our group to study interesting known Kepler multi-planetary systems and/or new multi-planetary systems discovered by the K2 and TESS new surveys. A photodynamical analysis, accounting for the dynamical interactions between the planets of the system at the earliest stage of the data analysis, achieves a better precision and accuracy on the determination of the system parameters than usual methods. It is also more sensitive to the low masse planets. The goal of this project is to focus on the lowest mass planets (super-Earths and mini-Neptunes), for which it is not possible to determine masses with current RV instruments alone and will probe this fascinating population of planets.

Our group has developed a pipeline to reduce K2 data and compute high precision light curves combined with a transit search algorithm to search for planetary transits. Hence we have a competitive advantage to discover knew interesting systems from K2 or even TESS data. We are also involved in a collaboration to obtain precise radial velocities with the HARPS spectrograph to confirm and characterise these candidates. The student will study the most promising know systems and is also expected to be involved in the search and characterisation of these new multi-planetary systems.

The relation between mass and radius for exoplanets

Level: MSc
Supervisor: Pedro Viana (viana@astro.up.pt)

Mass and radius are two fundamental properties of extrasolar planets. The way they are related holds information about the physical processes that were most important during planet formation. However, the characterisation of the relation between exoplanet mass and radius faces some difficulties. For example, the most important methods employed for the detection of exoplanets, radial velocity and transit surveys, can only yield information about either mass or radius, respectively. Further, the exoplanet detection probability depends on the property, either mass or radius, that can be constrained given the data used for the detection. If this is not taken into account in the derivation of the exoplanet mass-radius relation, the results will be biased with respect to the relation associated with the full exoplanet population. Care must also be taken with respect to biases in the way transit detected exoplanets are selected for radial-velocity follow-up and how the results are used. Namely, even the absence of re-detection with the radial velocity technique holds information that is relevant for the characterisation of the exoplanet massâ-radius relation.

Knowledge about this relation can also be used for probabilistic forecasting of one of the quantities based on prior knowledge we may have about the other. This capability will be of great interest for the next exoplanet-dedicated space missions, both scheduled to be launched during 2018. NASA mission TESS is expected to detect thousands of transiting exoplanets, around nearby bright stars. An accurate prediction of the masses of these exoplanets would allow an optimisation of the observing time dedicated to their radial velocity follow-up, for example with the ESO VLT spectrograph ESPRESSO. ESA mission CHEOPS will try to detect the transits of exoplanets discovered with the radial velocity technique. The forecast of an exoplanet radius based upon our knowledge about its mass would permit the prioritisation of the target list on the basis of the expected transit depth.

Therefore, the aims of this project are: (1) to constrain the exoplanet mass-radius relation; (2) to forecast one of those quantities based on knowledge about the other. Gaussian Processes are to be used conditioned on a sample of exoplanets first detected by the Kepler satellite, taking into account all measurement uncertainties and selection effects. This would constitute original work, expected to lead to a publication in a refereed journal.

Understanding the stellar jitter across the HR diagram

Level: MSc

Supervisor: Elisa.Delgado@astro.up.pt

Our ability to detect planets around stars with the radial-velocity (RV) method has a strong dependence on our understanding on the stellar noise of such stars, i.e. what is their intrinsic RV variability. This noise can be caused by stellar magnetic activity, pulsations or granulation and it behaves on a different way depending on the spectral type of the stars and on their evolutionary stage.

The goal of this project is to analyze and characterize the stellar jitter in a sample of giant stars within different open clusters and to find possible correlations with the stellar parameters and/or evolutionary stage. This study will help us to better understand the stellar noise of evolved stars and to better constrain the kind of planets we will be able to discover across the HR diagram.

Education/ outreach and undergraduate projects

Física fundamental com o ESPRESSO

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:
Experiência prévia de programação, análise e visualização de dados é essencial. Experiência anterior com projectos deste tipo é valorizada. Espera-se uma dedicação mínima de 6 horas de trabalho por semana, parcialmente presenciais. Serão disponibilizados um espaço de trabalho no CAUP e acesso a recursos computacionais apropriados. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e Actividades:
Os alunos serão integrados numa colaboração internacional que usará o espectrógrafo ESPRESSO (presentemente a ser instalado no VLT) 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 a definição e prioritização destes testes. 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) Simulação de observações com o ESPRESSO, e criação de catálogos de dados simulados para optimização de estratégias observacionais;

3) Planeamento e design experimental de futuros testes mais precisos, no contexto do ESPRESSO e dos instrumentos previstos para o ELT;

4) Organização e apresentação dos resultados obtidos.

Exemplos de bibliografia relevante para este projecto (alguma da qual resultou de estágios anteriores) incluem: https://arxiv.org/abs/1612.05284, https://arxiv.org/abs/1704.08728, https://arxiv.org/abs/1709.02923, https://arxiv.org/abs/1801.08089

Impacto cosmológico da observação da expansão do universo em tempo real

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:
Experiência prévia de programação, análise e visualização de dados é essencial. Experiência anterior com projectos deste tipo é valorizada. Espera-se uma dedicação mínima de 6 horas de trabalho por semana, parcialmente presenciais. Serão disponibilizados um espaço de trabalho no CAUP e acesso a recursos computacionais apropriados. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e Actividades:
Os alunos serão integrados numa colaboração 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 em breve, juntamente com dados do satélite Euclid (ESA) e instrumentos previstos para o ELT (ESO).
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.

Exemplos de bibliografia relevante para este projecto (alguma da qual resultou de estágios anteriores) incluem: https://arxiv.org/abs/1508.00765, https://arxiv.org/abs/1601.02950, https://arxiv.org/abs/1606.07261, https://arxiv.org/abs/1704.08728

Novas ferramentas para evolução de defeitos topológicos

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:
Experiência prévia de programação, análise e visualização de dados é essencial. Experiência anterior com projectos deste tipo é valorizada. Espera-se uma dedicação mínima de 6 horas de trabalho por semana, parcialmente presenciais. Serão disponibilizados um espaço de trabalho no CAUP e acesso a recursos computacionais apropriados. Poderá ser realizada uma entrevista aos candidatos.

Objectivos e Actividades:
Os alunos serão integrados numa colaboração internacional que estuda a evolução de vários tipos de defeitos topológicos, incluindo paredes de domínio, cordas cósmicas e supercordas. Este objectos formaram-se necessariamente no universo primitivo, e a sua caracterização dá-nos pistas cruciais sobre a física fundamental. O estudo da sua evolução é essencial no contexto dos dados do satélite Planck e de possíveis missões futuras da ESA (CORE e LISA). O objectivo do estágio é 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 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.

Organização e apresentação dos resultados obtidos. 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/1612.08863, https://arxiv.org/abs/1702.08453, https://arxiv.org/abs/1710.10420

Scientific literacy and astronomy teaching

Level: PhD or MSc
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. 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.

Studying the impact of cluster environments on the evolution of their galaxies

Orientador: Tom.Scott@astro.up.pt

Galaxy clusters are the largest gravitationally bound structures in the universe. Their member galaxies are known to be quite different from those found in the field in regard to properties such as morphology, star formation rate, stellar and gas content. This is thought to be caused by the higher density environment that the cluster provides: from both observations and simulations, it is expected that galaxy evolution is accelerated in clusters through different physical processes at work in these specific environments.

To unveil which is the dominant physical process at work, we study the evolution history of a galaxy, encoded in its emission spectrum, and relate it with the cluster environment in which the galaxy resides. This can be done with spectral synthesis: a technique which models the formation history of galaxy stellar populations based on the best fit to its currently observed spectrum.

The project will use the results of applying a new spectral synthesis code, FADO, developed at the IA to study the formation histories of a sample of cluster galaxies. The spectra are from the Sloan Digital Sky Survey (SDSS) and have been processed by FADO. The student will gain an understanding of how to interpret the spectra of galaxies and use data from FADO to explore how the star formation histories (SFH) of the galaxies relate to other galaxy properties (colours, gas content, morphology when available), to galaxy location inside the clusters, and to the properties of their parent clusters. For example: the student will use FADO output to look for trends in the fraction of stars formed within the last Giga-year as a function of distance from the cluster centre for both relaxed and merging clusters. By getting acquainted with the physical processes at work within clusters, the student will interpret his/her results and gain insight on what is the main driver of galaxy evolution in the clusters under study.

APPENDIX

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