Designação do Projeto|	Novos desafios na procura de outras Terras
Código do Projeto|	LISBOA-01-0145-FEDER-016886
Objetivo Principal|	Bringing exoplanet science to tomorrow
Região de Intervenção|	Lisboa
Entidade Beneficiária|	FCiências.ID – Associação para a Investigação e Desenvolvimento de Ciências e Fundação da Faculdade de Ciências da Universidade de Lisboa, FP.
Data de Aprovação|	08-04-2016
Data de Início|	01-07-2016
Data de Conclusão|	31-08-2018
Custo Total Elegível|	30.172,00 EUR
Apoio Financeiro da União Europeia|	FEDER – 12.068,80 EUR
Apoio Financeiro Público Nacional/ Regional|	OE – 18.103,20 EUR

Objetivos

WP#1: Paving the way for a precise detection and characterization of other Earths

This WP includes the study of 4 astrophysical problems that are fundamental for the success of the above mentioned missions, and that together will allow our team to have a unique expertise. It includes several points in the interface between exoplanet research and stellar astrophysics, topics where our team has a strong recognized international expertise.

- Task #1: Explores novel ways of modeling and correcting the signals caused by astrophysical sources of "noise" (e.g. stellar activity) in radial velocity and photometric measurements used to search and characterize other planets. These sources of "noise" are often the limiting factor precluding the full exploitation of the precision of existing instrumentation. Their understanding is recognized as fundamental for the detection and the precise characterization of low mass/small radii planets, the major goal of future instruments such as ESPRESSO and CHEOPS.
- Task #2: Addresses the problem of deriving precise parameters for cool M dwarfs, a fundamental issue for the derivation of the properties of planets orbiting these targets. The precise estimate of the planet radius (and thus its density) strongly depends on our capacity to derive precise radii for the host stars. For M dwarfs this has so far been a great challenge. The opportunity raised in this field by the advent of new NIR spectrographs (such as SPIRou) has the potential to change this scenario. For this purpose we will concentrate on the use of NIR spectroscopy (in complement to optical data) to develop new methods to precisely characterize M dwarfs with planets.
- Task #3: Will study the problem of detecting and validating the minute signals induced by low mass planets in the data. This problem is often in the origin of "false" planet discoveries. No agreement exists in the community regarding the best algorithms to approach this. A deep understanding on this will allow us to have a stronger return from our participation in the ESPRESSSO and SPIRou projects. Hence, we will concentrate in the development of new data analysis algorithms (using e.g. Bayesian inference) that allow us to detect and validate, amidst the existing noise, the tiny signals induced by low mass/small radii planets. These algorithms will include the modeling of stellar activity (see Task #1);
- Task #4: Explores the detection of exoplanet atmospheres using high-resolution spectroscopy. As preparation for the ESPRESSO data, we will concentrate in the development of novel techniques to detect the optical reflected light spectrum of exoplanets using a technique already developed by our team. The methods and know-how here developed will allow to further characterize the planets discovered in the context of the different missions/projects. To address these points, we will make use of existing or new data that will be acquired using state-of-the-art ESO facilities (e.g. we presently lead an ESO Large Program to search for low mass planets). Crucial also will be our participation in present-day planet search and characterization efforts, as well in the study of the star-planet connection (an important aspect to constrain planet formation and evolution models). This allows the team to be prepared for the arrival of the data from the new instruments/missions mentioned above.

WP#2: ESPRESSO and SPIRou

This WP is meant to support all activities relevant for the final construction phases of the ESPRESSO and SPIRou projects, in particular those related to the development and installation of the hardware and software components under our responsibility.

- Task #5: Meant to cover the final phases of the development of ESPRESSO and its integration ESO-VLT. The Portuguese "hardware" participation is already fully funded by FCT (projects RECI/FIS-AST/0176/2012 and RECI/FIS-AST/0163/2012) but no funds have been allocated to assure our scientific participation or to cover the necessary missions. ESPRESSO is fundamental for the full strategy of the team over the next 10-15 years as a planet search and characterization machine but also as a unique instrument to characterize low-mass planet candidates in the habitable zone discovered by the future ESA mission PLATO2.0.
- Task #6: Covers our contribution to the SPIRou project. Our team is responsible for part of the data reduction pipeline. A compromise exists to cover part of hardware components of the instrument.

Atividades

• Caracterização da atmosfera de Vénus pela técnica de velocimetria Doppler e pelo método de cloud tracking (seguimento de nuvens) no UV, visível e infravermelho. Estudo da dinâmica atmosférica do planeta Vénus. Colaboração no estudo da composição e dinâmica das atmosferas dos corpos do Sistema Solar.
• Desenvolvimento de protocolos de investigação de atmosferas no âmbito do Sistema Solar e sua adaptação para utilização no estudo, modelização e caracterização de atmosferas de exoplanetas.
• Colaboração com a missão espacial da ESA Venus Express (instrumento VIRTIS).
• Colaboração com a missão espacial japonesa (JAXA) Akatsuki.
• Dinâmica da atmosfera de Vénus, Marte, Saturno, Titã e Júpiter, usando técnicas de velocimetria Doppler e métodos de rastreamento de nuvens (ongoing work). Recentemente, eu estou a adaptar o meu método de velocimetria Doppler, com base em espectros de alta resolução, a atmosferas de outros planetas do sistema solar (Marte, Júpiter e Saturno) e a Titã.
• Também estou trabalhando no processo de adaptação destes métodos para diferentes gamas de comprimento de onda, como é o caso do infravermelho próximo, do infravermelho, do milímetro e sub-milímetro.
• Colaboração com a sonda espacial japonesa Akatsuki: realização de observações coordenadas entre a sonda espacial e observações terrestres, redução de dados.
• Espectroscopia de elevada resolução e Cloud Tracking, quer de observações a partir do solo (telescópios), quer a partir de sondas espaciais (Cassini, Venus Express, Akatsuki, Messenger, Mars Express.
• Composição atmosférica de componentes minoritários.
• Detecção e caracterização de ondas de gravidade atmosféricas usando dados dos instrumentos VIRTIS e VMC da missão Venus Express e UVI e LR1 da missão espacial Akatsuki (JAXA).
• Estudo da sismologia atmosférica planetária nos casos de Júpiter, Saturno e Vénus.
• Evolução temporal das atmosferas e correspondente alteração climática.
• Ocultações estelares por asteróides e objectos trans-neptunianos. Obtenção das respectivas curvas de luz.
• Caracterização e modelização de atmosferas de exoplanetas. Sinergia entre o estudo das atmosferas de corpos no Sistema Solar e atmosferas de exoplanetas

Resultados Esperados / Atingidos

Papers in journals (provide DOI or ADS Bib Code)

Peralta, J., Machado, P., et al., NIGHTSIDE WINDS AT THE LOWER CLOUDS OF VENUSWITH AKATSUKI/IR2: LONGITUDINAL, LOCAL TIME AND DECADAL VARIATIONS FROM COMPARISON WITH PREVIOUS MEASUREMENTS, ApJS, arXiv:1810.05418v1 [astro-ph.EP] 12 Oct 2018, accepted 11 October 2018.

Machado, P. and Widemann, T. and Peralta, J., Gonçalves, R., Donati, J.-F. and Luz, D., Venus cloud-tracked and doppler velocimetry winds from CFHT/ESPaDOnS and Venus Express/VIRTIS in April 2014, http://www.sciencedirect.com/science /article /pii/ S0019103516304328, Icarus, 285, 8-26, 2017.

Giovanna Tinetti,..., Machado, P., et al., A chemical survey of exoplanets with ARIEL, Experimental Astronomy, https://doi.org/10.1007/s10686-018-9598-x, September 2018.

Peralta, J., Lee, Y.J., Hueso, R., Clancy, R.T., Sandor, B.,Sánchez-Lavega, A., Imamura, T., Omino, M., Machado, P., Lellouch, E. Rengel, M., Murakami, S., Ando, H. and Peach, D., 2017; Venus's Winds and

Temperatures during the Messenger's flyby: a three dimensional instantaneous state, Geophysical Research Letters, 44, 3907–3915, doi:10.1002/2017GL072900, 2017.

Machado, P., Peralta, J., Widemann, T., Luz, D., Gonçalves, R., Silva, M., Silva. J VEx/VIRTIS and TNG/NICS cloud tracked winds at Venus' lower cloud level using night side observations,. (under submission).

Meza, E., Sicardy, B., ..., Machado, P., et al., Pluto's lower atmosphere and pressure evolution from groundbased stellar occultations, 1988-2016, Astronomy & Astrophysics, Submitted September 2018 (under revision).

• Papers in Proceedings (international and national)
Machado, P., et al., Venus' Meridional wind flow from: Akatsuki/UVI, Venus Express/VIRTIS, TNG/HARPS-N and CFHT/ ESPaDOnS, EPSC, Berlin 2018.

Machado, P., Comparative study of circulation regimes of terrestrial planets' atmospheres, HoRSE, Nice, September 2018.

Gonçalves, R., Machado, P., Akatsuki and TNG/HARPS-N coordinated wind measurements of cloud top Venus' atmosphere, EPSC, Berlin 2018.

Silva, M., Machado, P., et al., Ground-based Doppler Velocimetry: wind measurements in Saturn's atmosphere with UVES/VLT. EPSC, Berlin 2018.

Machado, P., Comparative study of circulation regimes of terrestrial planets' atmospheres, HoRSE, Nice, September 2018

Gonçalves, R., Machado, P., Venus' cloud top wind measurements with TNG/HARPS-N (Doppler velocimetry) and coordinated Akatsuki observations, HoRSE, Nice, September 2018.

Silva, J., Machado, P., Characterising Atmospheric Gravity Waves on the lower and upper cloud bank using Venus Express VMC and VIRTIS images, SEA, Salamanca, July 2018.

Silva, M., Machado, P., et al., Saturn atmospheric studies with Doppler velocimetry, SEA, Salamanca, July 2018.

Gonçalves, R., Machado, P., et al., Akatsuki e HARPS-N Venus' atmospheric studies, SEA, Salamanca, July 2018.

Communications in conferences
• Invited talks
Machado, P., Comparative study of circulation regimes on planetary atmospheres, Soft Matter in Astronomy and Astrophysics, Lisbon, December 2018.

• Contributed talks
Machado, P., Comparative study of circulation regimes of terrestrial planets' atmospheres, HoRSE, Nice, September 2018

Gonçalves, R., Machado, P., Venus' cloud top wind measurements with TNG/HARPS-N (Doppler velocimetry) and coordinated Akatsuki observations, HoRSE, Nice, September 2018.

Machado, P., et al., Venus' Meridional wind flow from: Akatsuki/UVI, Venus Express/VIRTIS, TNG/HARPS-N and CFHT/ ESPaDOnS, EPSC, Berlin 2018.

Machado, P., Comparative study of circulation regimes on planetary atmospheres, Soft Matter in Astronomy and Astrophysics, Lisbon, December 2018.

Gonçalves, R., Machado, P., Akatsuki and TNG/HARPS-N coordinated wind measurements of cloud top Venus' atmosphere, EPSC, Berlin 2018.

Silva, M., Machado, P., et al., Ground-based Doppler Velocimetry: wind measurements in Saturn's atmosphere with UVES/VLT. EPSC, Berlin 2018.

Silva, J., Machado, P., Characterising Atmospheric Gravity Waves on the lower and upper cloud bank using Venus Express VMC and VIRTIS images, SEA, Salamanca, July 2018.

Silva, M., Machado, P., et al., Saturn atmospheric studies with Doppler velocimetry, SEA, Salamanca, July 2018.

Gonçalves, R., Machado, P., et al., Akatsuki e HARPS-N Venus' atmospheric studies, SEA, Salamanca, July 2018.

Peralta, J., Machado, P., et al., Venus's winds and temperatures during the MESSENGER's flyby: towards a three-dimensional instantaneous state of the atmosphere, JpGU, Japan, 2018.