Towards Other Earths III: The Planet-Star connection

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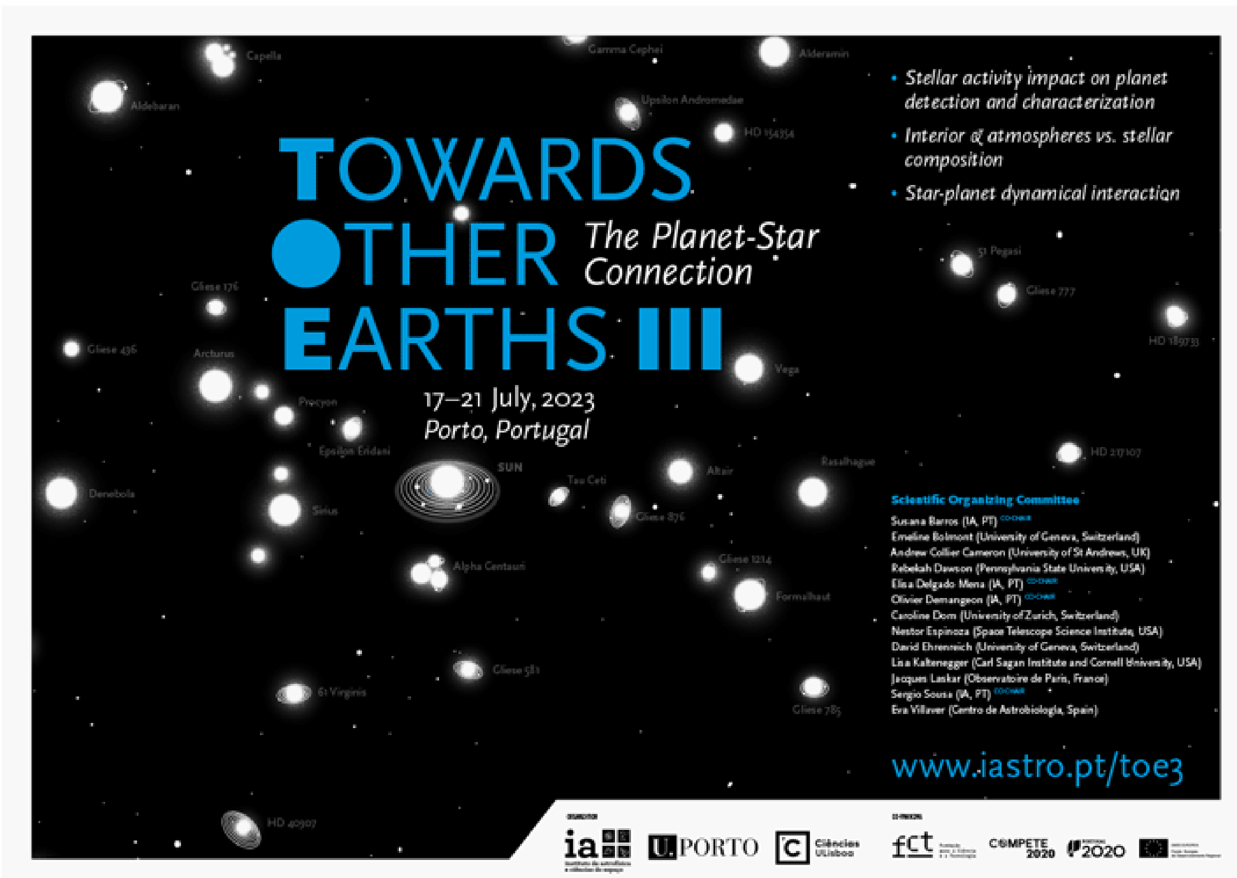

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Poster nº: 1

A Radio Search for White Dwarf Planets

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A growing number of detections of the broken-up remnants of minor planets around white dwarfs (WDs), as well as the first discoveries of surviving planets reveal how evolving stars transform planetary systems. These observations provide chemical and dynamical insights which are unavailable in main-sequence exoplanetary systems. Further detections of major planets are crucial to discerning how and when the observed minor planets are perturbed towards the WD. Also, given a possibility of long-lasting habitable zones around WDs, such planets could represent hubs for the long-term survival of life in the Universe.

We discuss our program to detect WD planets by observing magnetic WDs with an active unipolar dynamo mechanism, which is well known to operate in the Jupiter satellite system. The same mechanism has been proposed to function in the magnetized WD/conducting planet systems and produce periodic bursts of the electron cyclotron maser emission at radio frequencies.

We will present the initial observations of a small sample of nearby WDs with the Arecibo and Green Bank radio telescopes, and describe the strategy for a much larger project currently under development.

Poster nº: 2

Secondary ionisation by photoelectrons in exoplanetary systems

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Co-authors: Antoine Strugarek & Antonio Garcia Muñoz

Close-in exoplanets undergo extreme irradiation levels, leading to hydrodynamic atmospheric escape and the formation of a planetary wind. Planetary mass loss is governed by several physical mechanisms, including photoionisation, that may impact the evolution of its atmosphere. The stellar radiation energy deposited as heat depends strongly on the energy of the primary electrons following photoionisation and on the local fractional ionisation. All these factors affect the model-estimated atmospheric mass loss rates. Therefore, simulating escaping atmospheres is essential to provide insight into observational signatures (Lyα) and to understand the complexity of star-planet interactions. To examine the quantitative effect of photoelectrons we perform 1D spherical and 2D cartesian hydrodynamical simulations with the PLUTO code, which describes the photoionisation process in an atomic hydrogen atmosphere. We also assess the impact of the shape of different XUV spectra taken from the MUSCLES survey of type K and M type stars on the mass loss rate. For the first time, we take into account the effect of secondary ionisation by photoelectrons self-consistently in different exosystems. In our explored sample, varying planetary masses and stellar spectral type, we report a significant diminution up to 54% of the planetary mass loss rate.

Poster nº: 3

Low-mass companions to seven enigmatic PTPS stars.

Andrzej Niedzielski
Nicolaus Copernicus University

Co-authors: Jaros, R., Paczuski, A., Wolszczan, A.

Nearly 1000 evolved stars at various evolutionary stages were monitored for radial velocity variations within the Pennsylvania-Toruń Planet Search (PTPS). Detailed spectral analysis revealed 28 objects with intrinsic parameters indicating anomalies. Here we present analysis of available HET/HRS radial velocities for these stars which resulted in detection of seven low-mass companions, two with estimated masses in the planetary range.

Poster nº: 4

BD+20 2457 revisited

Andrzej Niedzielski
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Co-authors: Jaros, R., Paczuski, A., Wolszczan, A.

The K giant BD+20 2457 was found to be a very rare host of a two-planet system in Niedzielski et al. (2009). An updated detailed spectroscopic analysis (Zieliński et al. 2012, Adamczyk et al. 2016) showed that the mass of the stars is much lower than assumed in the discovery paper, and the star is an extreme example of an elder Sun, an evolved solar-mass object near the tip of the Red Giant Branch. Here we present an updated analysis of both radial velocities and stellar activity based on fourteen years of observations.

Poster nº: 5

Numerical Simulations (HD and MHD) of planetary winds in the vicinity of stellarinds emanating from their host stars

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A significant fraction of extrasolar giant planets orbits their host stars at less than 0.1 AU, leading to significant atmospheric blow-off which strongly influences key aspects of planetary evolution. Also known as hydrodynamic (HD) evaporation, atmospheric blow-off is the planet's initial mass evaporation due to strong extreme-ultraviolet radiation from the host star. However, many open questions remain, requiring improved physical modelling to explain observations [1].
The aim of this poster is to present the investigation behind the physical processes that impact the wind structure and outflow rates of a Hot Jupiter (HJ), such as wind anisotropy [2] and planetary magnetic fields [3]. Primarily, it is intended to attain similar results to [2], and in a subsequent step, it is explored the stellar and planetary wind interactions when inserting magnetic dipolar fields such that global results can be compared to the work of [5].
To achieve this goal, it was used the astrophysical code PLUTO to perform HD and MHD simulations, building a 3D grid to incorporate a star, a HJ, and realistic outflows to study the desired asymmetries by varying the parameters' phase space.
Results show that temperature anisotropy creates an inflow of material from the planet's day side to the night driven by the high ram pressure of the day side. Additionally, since the HJ is orbiting at high speeds, the presence of rotational effects such as Coriolis and centrifugal forces affect deeply the outflow. The MHD simulations are quite rich in several features, being qualitatively discussed in a time-dependent framework and supported by theoretical predictions using characteristic length scales.
Overall, this investigation contributes to a better understanding of the major physical processes that govern the interacting winds' morphology and the quantitative and qualitative behavior of outflows.

Poster nº: 6

Cooling functions for water-rich atmospheres

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Co-authors: Andrés Asensio Ramos

Sub-Neptune-size exoplanets are ubiquitous and, yet, our understanding of most aspects of their formation, evolution and internal structure remains poor. A prime hypothesis to explain the nature of these ubiquitous objects is that they formed beyond their host star's ice lines where they accumulated large amounts of water. Central to this idea is the assumption that the planets retained their atmospheres through the phases of highest stellar activity early in their lives. Unlike hydrogen, the rovibrational states of the water molecule are easy to excite, in particular in collisions with other water molecules or with thermal electrons. Once excited, the water molecules radiate promptly over a broad spectrum, thus acting as sinks of energy. These processes are expected to have a significant impact on the long-term stability of water-rich atmospheres. We are currently looking into the collisional-radiative modeling of water in exoplanet atmospheres with the goal of constraining the mass loss rates of the exoplanets and, therefore, their long-term stability. As recent work has shown, this is particularly important for exoplanets transiting low-mass stars such as TRAPPIST-1, because weak far-ultraviolet stellar emission favors the survival of water up to low pressures in the atmosphere. The presentation will report on the current status of the modeling, and the implications that it might have for the imminent investigation of some JWST targets.

Poster nº: 7

Predicting the time-dependent high-energy irradiation of exoplanetary atmospheres

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Observations and modeling of stellar XUV emission in different evolutionary phases is fundamental for understanding photochemistry and evaporation processes in exoplanetary atmospheres. In the context of the project THE StellaR PAth (Time-dependent High-Energy Radiation and Planetary Atmosphere interaction) we present results of the study of selected gaseous exoplanets irradiated by young solar-like stars, based on observations in the UV and X-ray bands.
We derived spectral properties of the high-energy emission which allowed us to test different scaling laws for predicting EUV fluxes from measurements in X-rays. We discuss the implications for the long-term effects of the global XUV irradiation on the planetary atmospheres.

Poster nº: 8

Optimized radial velocity extraction and spot modeling in young/active fast rotating stars

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Co-authors: A. Petralia, G. Micela and S. Benatti and the GAPS Team

The intrinsic variability that characterizes young active stars poses one of the main challenges in detecting and characterizing exoplanets using Doppler spectroscopy. Stellar activity can induce radial velocity (RV) signals that mimic the presence of planetary companions, making it crucial to account for the activity of the star during the RVs extraction.

We introduce SpotCCF, a method that optimizes the RVs extraction for fast-rotating stars. It is based on the cross-correlation function (CCF) technique and accounts for the presence of multiple spots on the stellar surface by adapting the equation of the rotational broadening.

To validate the model, we applied our technique to a young/fast rotating star, which exhibits distorted CCF profiles due to its high activity level. We found that the star is well-modelled by applying a “Two-spots model” to the CCFs. When the SpotCCF model was applied to HARPS-N observations, it provided accurate RV measurements, showing a significantly lower dispersion (decreasing ranging from 40% to 60% in each seasons) compared to the TERRA pipeline dataset.

The robustness of the method was confirmed by the consistency of the spot configurations obtained from different observations taken during the same night, but a few hours apart.

The SpotCCF model also provides the physical properties of the spots, modulated by rotation, and filling factors consistent with data present in the literature.

Poster nº: 9

A CHEWIE first bite: the transmission spectrum of WASP-69b

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Co-authors: Monika Lendl

The CHEWIE survey (Clouds, Hazes and Elements vieWed on giant Exoplanets) aims to study the impact of the stellar environment on planet atmospheres and their aerosols at the day-night terminator through transmission spectra of planets in the Jupiter to Neptune mass range. It does this with ground-based, medium resolution observations between 330nm and 1100nm with the FORS2 instrument on the VLT. Our coverage of the optical wavelengths can constrain the short-wavelength features of aerosols that are inaccessible with the planned JWST observations. In this talk we present the first transmission spectrum of the survey, that of WASP-69b, a warm Saturn-mass planet with a puffed up atmosphere.

Poster nº: 10

Measuring the Masses of the TOI-700 Planets with ESPRESSO

Emily Gilbert
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Co-authors: Jennifer Burt, Andrew Vanderburg, Joey Rodriguez, and others from the TOI-700 Collaboration

We present the observations of the low-mass planet host, TOI-700 using the Echelle Spectrograph for Rocky Exoplanet and Stable Spectroscopic Observations (ESPRESSO) instrument on ESO's 8.2 meter Very Large Telescope (VLT). TOI-700 is an M2.5 dwarf (0.415 M_{sun}, .421 R_{sun}, T = 3460 K, d = 31.1 pc), with 4 known, transiting planets discovered using data from NASA's Transiting Exoplanet Survey Satellite (TESS) mission. TOI-700 b, c, e, and d have periods of 9.98, 16.05, 27.81, and 37.42 days and radii of 0.91, 2.6, 0.95, and 1.07 R_{earth}, respectively. Using ESPRESSO, we have obtained over 150 precise radial velocity measurements of the host star and will present our initial mass measurement results here.

Poster nº: 11

Inferring planetary orbits with MCMC: Common pitfalls and how to avoid them

Florian Liebing
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Markov-Chain Monte-Carlo (MCMC) Simulations have become the primary way to do Bayesian parameter inference in Astrophysics, besides variations of Nested-Sampling. This is not just due to the avaiability of ready-made and easy to use software implementations, such as emcee, but also the fairly intuitive logic behind the algorithm, easy to interpret results, and built-in uncertainty determination and propagation. Like all statistics tools available to scientists however, one has to be carefull about the use-case. Between hard boundaries, acidentally-informative parameter transformations and overly strong bayesian priors it is easy to obtain technically correct, visually accurate but factually biased parameter inferences. I will show a selection of examples to highlight common pitfalls, how they might affect results, and some paths to recognize and avoid them within the context of orbital parameter determination.

Poster nº: 12

The XUV environment of the 45 Myr old super-Neptune DS Tuc Ab

George King
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Co-authors: Lia Corrales

X-ray and extreme-ultraviolet irradiation of exoplanets is thought to be able to drive significant atmospheric escape for planets orbiting close to their host star. The level of irradiation is highest in the first 100 Myr of a star's life, and there is evidence that points to young planets in open clusters and stellar associations being larger than their older counterparts. We present an investigation of the high-energy environment of the 45 Myr old exoplanetary system DS Tuc, using observations taken across four different epochs with Chandra. For the first time at X-ray wavelengths, we successfully fully separate the PSFs of the two stars in the system. The stars show significant variation within and between epochs, including flares, and we compare the amplitude of that variation to the observed scatter in empirical relations of X-ray emission vs stellar age/rotation. Finally, we make predictions as to the future evolution of the currently super-Neptune-sized planet DS Tuc Ab.

Poster nº: 13

TOI-2498 b: A hot bloated super-Neptune within the Neptune desert

Ginger Frame
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Co-authors: David Armstrong, Heather Cegla, Jorge Fernández Fernández, Ares Osborn

I present the discovery and confirmation of a transiting hot, bloated Super-Neptune using photometry from TESS and LCOGT and radial velocity measurements from HARPS. The host star TOI-2498 is a V = 11.2, G-type (Teff = 5905 ± 12 K) solar-like star with a mass of 1.09 ± 0.02 $M_\odot$ and a radius of 1.28 ± 0.03 $R_\odot$. The planet, TOI-2498 b, orbits the star with a period of 3.7 days, has a radius of 6.3 ± 0.3 $R_\oplus$, and a mass of 34 ± 4 $M_\oplus$. This results in a low, Saturn-like density of 0.76 ± 0.21 g cm-3. TOI-2498 b resides on the edge of the Neptune desert; a region of mass-period parameter space in which there appears to be a dearth of planets. Therefore TOI-2498 b is an interesting case to study to further understand the origins and boundaries of the Neptune desert. Through modelling the evaporation history, we determine that over its ~3.6 Gyr lifespan, TOI-2498 b has likely reduced from a Saturn sized planet to its current radius through photoevaporation. Moreover, TOI-2498 b is a potential candidate for future atmospheric studies searching for species like water or sodium in the optical using high-resolution, and for carbon based molecules in the infra-red using JWST.

Poster nº: 14

The KOBE experiment: the K-dwarf opportunity for habitable worlds

Jorge Lillo-Box
Center for Astrobiology (CAB, CSIC-INTA)

The study of habitable exoplanets will be clearly enhanced in the coming years by the development of high-spatial resolution and high-contrast instrumentation that will allow the direct detection of planets (and thence the study of their atmospheres) in the habitable zone of solar-type stars (and even M-dwarfs). On one hand, the sweet spot for habitability in astrophysical terms requires relatively quiet stellar hosts, with M dwarfs clearly threatening their habitable planets. On the other hand, the need for targets hosting habitable planets amenable to this new technological capabilities requires that those planets are easily detectable, with habitable zone periods in G dwarfs being too long for RV characterization. Hence, K-dwarfs and specifically the late K-dwarfs are the Goldilocks environments for this purpose. In this talk I will summarise the goals and status of the KOBE experiment survey (including preliminary results) taking place with the CARMENES instrument, devoted to this relevant role.

Poster nº: 15

The impact of stellar line shapes on exoplanet atmospheric sodium detections

Julia Seidel
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I will provide an overview of recent sodium detections for smaller planets along the Neptune desert and the impact of stellar effects on said detections. Especially the exposure time has an important impact on the flux level at the centre of the stellar sodium lines which can lead to non-detections or worse: false detections. This will be an overview of work conducted on WASP-127 b (Seidel et al. 2020b) and WASP-166 b (Seidel et al. 2020c and 2022), both bordering the Neptune desert with an outlook of implications for future work with larger facilities and smaller planets.

Poster nº: 16

The HADES Program with HARPS-N@TNG HADES: THE HArps-n red Dwarf Exoplanet Survey

Laura Affer
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Co-authors: HADES Team

Many efforts to detect Earth-like planets around low-mass stars are currently devoted to almost every extra-solar planet search. M dwarfs stand as ideal targets for Doppler radial velocity searches as their low masses and luminosities make low-mass planets orbiting within their habitable zones more easily detectable than those around higher-mass stars. Nonetheless, the statistics of the frequency of this kind of planet hosted by low-mass stars remains poorly constrained.

Our M-dwarf radial velocity monitoring with HARPS-N within the HARPS-N Red Dwarf Exoplanet Survey Radial Velocity (HADES) project started in 2012 and is contributing to the widening of the current statistics through the in-depth analysis of accurate radial velocity observations in a narrow range of spectral subtypes from M0 to M3, to investigate the planetary population around a well-defined class of host stars. The HADES project is the result of a collaborative effort between the Italian Global Architecture of Planetary Systems (GAPS) Consortium, the Institut de Ciències de l'Espai de Catalunya (ICE), and the Instituto de Astrofísica de Canarias (IAC). Two photometric programs regularly and almost simultaneously follow up the sample of M stars to characterize the stellar activity, to highlight periods that are due to chromospheric inhomogeneities modulated by stellar rotation and differential rotation, and thus to distinguish from the periodic signals those due to activity and to the presence of planetary companions. We present the complete analysis of the HADES survey and the results obtained concerning the statistical, activity, and characterization part as well as the planet revealing part, around M dwarfs.

Poster nº: 17

Towards the characterization of Earth analogues: news from the HARPS-N Collaboration

Luca Malavolta
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Co-authors: The HARPS-N Collaboration

The installation in 2012 of the high-resolution, ultra-stable spectrograph HARPS-N at the Telescopio Nazionale Galileo has represented a pivotal point for the mass determination of Super-Earths and Mini-Neptunes from the Northern hemisphere. In over ten years of Guaranteed Time of Observations the HARPS-N Collaboration has published precise masses determinations of almost 50 transiting super-Earth and sub-Neptune planets, leading the community efforts for obtaining a well-characterized sample of small planets in synergy with Kepler, TESS and CHEOPS space missions. Additionally, the HARPS-N Collaboration has published masses for a number of non-transiting planets and/or larger transiting planets and contributed to multi-collaboration mass measurement efforts. The installation of the HARPS-N Solar Telescope in 2015, followed by similar initiatives on state-of-the-art instruments, paved the way in fostering open, international, and cross-disciplinary collaborations as the only path in reaching and surpassing the 10 cm/s barrier for the characterization of Earth analogues.

In this proposed talk, I will review our most recent efforts to fill and interpret the mass-radius diagram while tackling the prominent effects of stellar activity, and highlight the role of HARPS-N as science enabler for JWST and the upcoming PLATO and ARIEL missions.

Poster nº: 18

PyORBIT: a tool to characterize planets (and virtually anything else) hiding in your data.

Luca Malavolta
Università degli Studi di Padova

Co-authors: The HARPS-N Collaboration

PyORBIT is a robust, versatile, and user-friendly code for the complete characterization of planetary systems. Originally developed back in 2015 for the analysis of radial velocities (RVs) in a Bayesian framework, PyORBIT has been constantly improved to expand its functionalities since then. With this tool it is now possible to fit RVs and transit light curves simultaneously, with Gaussian process regression trained on the activity indexes or the light curve itself or using Multidimensional Gaussian processes to take into account the effects of stellar activity. PyORBIT can handle different kinds of datasets with their specific characteristics, including independent limb darkening coefficients for groups of observations obtained in different bands. RV computation can be performed using either non-interacting Kepler orbits or n-body integration, with the parameterization of your choice. It is possible to assign a prior or a fixed value for any of the parameters of a model. It allows the computation of Bayesian evidence for model selection, and much more. All these features can be activated with just a few lines of text in a configuration file, without the need of knowing the syntax of the Python language. PyORBIT relies on familiar and widespread packages such as emcee, dynesty, ultranest, george, celerite, BATMAN, PyTransit, TRADES, in order to deliver robust and reliable results. Thanks to the modularity of the code and the use of abstract classes, it is relatively straightforward to add new physical models, such as those required to detect and characterize rings, exocomets, oblateness of planets, and other unconventional effects.

Poster nº: 19

How to find TESS's coldest planets

Mallory Harris
University of New Mexico

Co-authors: Diana Dragomir

The Transiting Exoplanet Survey Satellite (TESS) is optimized to search small, low-mass stars or "M dwarfs" in the solar neighborhood for transiting extrasolar planets. By focusing on these cool stars and observing the whole sky, TESS presents an opportunity to study the demographics of planets in these systems, even out to previously unexplored regions of parameter space. Using TESS data, I am conducting a survey of an unseen population of cold planets orbiting low-mass stars to calculate their occurrence rates and to provide targets for future characterization. To date, only ~10 such M dwarf orbiting planets have been discovered at distances greater than 0.2 AU from their host stars. These planets and their demographics, however, could provide new insight into theories of planet formation and migration around cool stars. To identify these planets in the TESS data, I am developing a pipeline capable of detecting both single- and multiply-transiting planet events using a modified version of the Transit-Least Squared algorithm and the signal-to-noise ratio of transit events. I will report on the current state of this search, as well as the discovery of a multi-planet system around low-mass stars that contains an 84-day period planet (the coldest M dwarf planet found by TESS to date) that represents the potential embodied by this work.

Poster nº: 20

Single Line Analysis of Kelt-9b atmosphere

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Co-authors: GAPS team

We present the HI Balmer and other metal lines detection of the ultra-hot Jupiter (UHJ) KELT-9b. We analyse six primary transits of the planet obtained with the HARPS-N high-resolution spectrograph attached to the Telescopio Nazionale Galileo in the context of The Global Architecture of Planetary Systems (GAPS2) project. We extract the transmission spectrum of each individual line by comparing the master-out of transit spectrum with the in-transit spectra and computing the weighted average of the tomography in the planet reference frame.
We correct the Center to Limb Variation (CLV) and the Rossiter-McLaughlin Effect (RME) by modelling the region of the star disk obscured by the planet during the transit and subtracting it from the master-out spectrum. We detected the Hα (0.901 ± 0.018%; 1.527 Rp), Hβ (0.581 ± 0.017%; 1.363 Rp), Hγ (0.481 ± 0.026%; 1.308 Rp), Hδ (0.560 ± 0.040%; 1.352 Rp), Hε (0.398 ± 0.056%; 1.260 Rp); Hζ is marginally detected in our data. Since Kelt-9b is the hottest exoplanet known and Kelt-9 is an A0 type star, we also focused on metal species that may be absent in the star atmosphere and present in planet one. A preliminary analysis suggests the detection of NaI, CaI, CaII, MgI, FeI, FeII and Ti II but a deeper analysis is required. This is the first joint analysis of all 6 nights available with HARPS-N. We studied the Balmer series detecting the Hε line for the first time ever in the atmosphere of an exoplanet. Our results are in agreement with the previous studies of the target atmosphere corroborating the method we used to extract the planetary signal of individual lines.

Poster nº: 21

Line-by-line sensitivity to activity in M dwarf stars

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Stellar activity poses one of the main obstacles for the detection and characterisation of exoplanets around cool stars, as it deforms the absorption line profiles of stellar spectra creating signals that can hide or mimic the presence of companions. A wide variety of techniques are being developed with the aim of disentangling signals of stellar and planetary origins. These range from the decorrelation or modelling of the activity signals in the radial velocity (RV) time series, to the RV extraction using carefully selected wavelength regions of the stellar spectrum which are less affected by activity. In this work, we analyse the effects of activity on individual absorption features present on the optical spectra of several active M dwarf stars observed with the CARMENES high-resolution spectrograph. By studying the correlations between the individual line RVs and activity indicators, we are able to classify the observed lines according to their sensitivity to activity. This allows us to select differently affected lines and use them to compute RVs for which we mitigate or enhance the activity signal to varying degrees. We also observe that the same lines on similar stars show different sensitivities to activity, suggesting the generalisation of a line list a challenging endeavour.

Poster nº: 22

Detection and characterization of long-period transiting giant planets by TESS and SOPHIE

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In this poster, we present the discovery and characterization of six new transiting exoplanets, TOI-2295b, TOI-2537b, TOI-4081b, TOI-5076b, TOI-5110b, and TOI-1836c. These are all giant planets, with varying densities, which were initially identified as promising TESS Objects of Interest (TOIs) and then characterized with SOPHIE. They have orbital periods ranging from nine to three months, allowing them to experiment with different magnitudes of insolation and histories of formation and evolution. The TOI-2537 b with the 90 days orbital period is in a range where planetary transits are very rare. TOI-1836 c (p= 20.4 d) is a warm Jupiter (WJ) in multiple systems with a transiting sub-Neptune (P= 1.77 days). The presence of these two planet types in a system creates a unique laboratory for testing formation and evolution models. Importantly, unlike the many similar systems, TOI-1836b and c are not locked in a resonance. It makes this system more interesting to study whether these planets form independently or undergo dynamic interactions. Our work is an ongoing project that, by being presented in TOE3, enables the development of new collaborations.

Poster nº: 23

Optimizing SOPHIE data reduction software

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A highly precise data reduction system is essential in radial velocity (RV) measurements to detect low-mass planets and address the possible sources of error. In this poster, I will highlight the results of my Ph.D. study on troubleshooting and enhancing the SOPHIE Data Reduction Software (DRS) to overcome instrumental limitations. The study focused on adding new features to the DRS including atmospheric dispersion effect correction, fixing the number of mask lines at different epochs, optimizing long-term variation from the zero-point, optimizing conditions for detecting solar contamination spectra, and correcting background contamination from calibration lamps. The addition of these improvements has significantly enhanced SOPHIE's planet detection limit. Remarkably, it substantially improved the RMS of the FWHM SOPHIE activity indicator by 18.57 m/s, resulting in FWHM being used to trace stellar activity more reliably. I will demonstrate in several examples, these improvements enhanced data accuracy and interpretation, leading to a promising outlook on prospective discoveries from archived data. Some of those improvements could be relevant and adapted for other high-precision spectrographs such as Neo-NARVAL, SPIRou, HARPS, and ESPRESSO. This work plays a significant role in the precise detection and in-depth characterization of current and upcoming planets detection by SOPHIE, and consequently in the preparation and exploitation of exoplanet missions like PLATO.

Poster nº: 24

Updated analysis of multi-planetary system HD20794 with ESPRESSO and HARPS

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Bright nearby stars are relevant targets for RV follow-up. The large angular separation between planets and their host stars will make it feasible to study these systems with future instrumentation for high contrast direct imaging such as the ANDES spectrograph for ELT, the HabEx or LUVOIR Nasa Missions, and the ESA LIFE mission. Among nearby stars, solar-type stars are of particular interest as they allow us to study the architecture and evolution of planetary systems born in similar environments to our own.

HD 20794 is a G6 star known for hosting a multi-planetary system. According to the literature, the system is composed of 4 planets, with orbital periods spanning a range between 18 and 147 days and minimum masses between 2.4 and 4.8 Earth masses. The results were achieved by analyzing more than 10 years of HARPS observations.

This star is one of the most stable targets of HARPS in the neighborhood of the Sun. We present here an updated analysis of this star.

In our analysis, we used 4 years of observations made with the ESPRESSO spectrograph combined with the HARPS data reprocessed with the new YARARA pipeline. This analysis confirms the great stability of the star over long timescales with an RMS of 1.16 m/s over more than 17 years. We perform a state-of-the-art analysis of the RV data combined with the activity indicators to obtain the most refined model to date for the planetary and stellar components of the data.

Poster nº: 25

RoPES program with HARPS and HARPS-N

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The search for exoplanets orbiting solar-type stars is one of particular importance. Thanks to the large angular separation between the planets and the stars, the planets orbiting these stars are prime candidates for characterization with future high-contrast instruments, such as ANDES for the ELT or space missions like NASA HabEx or LUVOIR, or the ESA LIFE mission.

Past and current photometric missions have contributed greatly to the characterization of the inner regions of planetary systems. However, for moderate-to-long orbital periods, the situation is very different. Transit missions have difficulties accessing this region of the parameter space. The only way to find planets at these orbital periods and establish their occurrence rates is with long-term radial velocity campaigns.

The RoPES program, led by the Instituto de Astrofisica de Canarias, aims to investigate the presence of super-Earths and mini-Neptunes at orbital periods compatible with the habitable zone of these systems. To do that, an intensive observational campaign with the HARPS and HARPS-N spectrographs is conducted, to create a dense sample of observations for more than 20 systems over a long timescale, to characterize both the short and long-term Keplerian and activity signals. The sample of the RoPES program consists of low-activity stars with spectral types between G0 and K3, and V-magnitudes between 3 and 9. This program has already obtained its first results, with the discovery and publication of a multi-planetary system (HD176896). We are currently working on several new candidate planetary systems, which we expect to confirm over the coming months.

Poster nº: 26

Effect of energetic particles on the atmosphere of terrestrial exoplanets

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M-dwarf stars have been preferred targets of exoplanet search due to the favourable parameters of the system for remote characterisation. However, planets in the habitable zones of these stars are expected to experience intense radiation.

We present the INCREASE project (INfluence of strong stellar particle Events and galactic Cosmic Rays on Exoplanetary AtmoSpherEs), aiming at modelling the effect of energetic particles on the atmosphere of terrestrial exoplanets. The INCREASE model suite is an almost self-consistent simulation chain coupling the state-of-the-art magnetospheric and atmospheric propagation and interaction models PLANETOCOSMICS (Desorgher et al. 2006) and AtRIS (Banjac57 et al. 2019) with the atmospheric chemistry and climate models 1D-TERRA (e.g., Wunderlich et al. 2020) and ExoTIC. Finally, spectral characterisation is done using the GARLIC line by line radiative transfer model.

By combining these models, we are able to constrain the habitability of such planets, the stability of their atmosphere as well as simulating observational features.

Poster nº: 27

The PolarBase archive of stellar spectra

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PolarBase is an online archive offering stellar data collected with the ESPaDOnS and NARVAL high-resolution spectropolarimeters, in their reduced form. All spectra feature a continuous coverage of the 370-1,000 nm spectral domain, at a spectral resolution of 65,000. As of 2022, observations of 4,700+ stellar objects throughout the Hertzsprung-Russell diagram are available for a total of more than 2x105 spectra. Intensity spectra are offered for all targets, and the majority of the observations also include simultaneous spectra in circular or linear polarization. Most observations are associated with a cross-correlation profile, significantly increasing the detectability of weak polarized signatures. Stokes V Zeeman signatures are detected for about 500 stars of all masses and evolutionary stages, and linear polarization is detected in a few dozen targets. This unique set of Zeeman detections offers the first opportunity to run homogeneous magnetometry studies throughout the H-R diagram. The web interface of PolarBase is available at http://polarbase.irap.omp.eu.

Poster nº: 28

PLATOSpec a new spectrograph for the support of PLATO space mission

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We present a new instrument PLATOSpec which will be installed at E152 telescope at La Silla Observatory, Chile in 2023/2024. PLATOSpec will be an echelle spectrograph with resolving power of 70000 capable of monitoring wavelength range from 380 to 680 nm with an expected accuracy in radial velocities around 3 m/s. PLATOSpec will have a blue sensitive chip, therefore, we will be able to provide a valuable information about the stellar activity which is an important factor when searching for Earth 2.0. Main aims of PLATOSpec will be the ground based follow-up of currently TESS and later PLATO missions planetary candidates. We will be able to contribute mainly to characterisation of stellar activity, to detection and characterisation of hot Jupiters, to discrimination of false positives and to determination of stellar parameters.

Poster nº: 29

Probing the M dwarf radius valley with CARMENES

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M dwarfs, the most ubiquitous stars in our galaxy are known to be active in their early stages of evolution. An outcome of their stellar activity can cause erosion of outer H atmosphere by XUV irradiation in the initial 100 Myrs of planet formation. This is considered as one of the main reasons for the observed radius valley in planets around M dwarfs, a relative paucity of planets between 1.5 R_earth and 1.8 R_earth. We have observed several M dwarf transiting systems with the space-based satellite TESS and performed follow-up radial velocity (RV) observations with the optical and NIR spectrograph, CARMENES, fiber-coupled with the 3.5-meter telescope at the Observatorio de Calar Alto in Almería (Spain). Multi-planetary systems, a subset of transiting M dwarfs, situated on each side of the radius valley have been useful in discerning the possible causes for the bimodal distribution of planets. Formation of planets in a gas poor environment wherein substantial Hydrogen (H) could not be accreted and photoevaporation are competing theories discussing the origin of the radius valley. We would focus on a handful of multi-planetary systems studied with CARMENES and TESS to discuss this issue at hand. I would make a case presentation for the M3.0 V star TOI-1468, first detected with the TESS mission with the confirmation of two super-Earths in the system. We find the shorter-period planet, TOI-1468b (P_b= 1.88d) to be consistent with a mostly rocky composition. The outer planet, TOI-1468c (P_c = 15.53 d), corresponds to a rocky core composition with a H/He gas envelope. Discoveries of these kind can further help determine a more precise location of the radius valley for small planets around M dwarfs and, therefore, shed more light on planet formation and evolution scenarios for these Super-Earths.

Poster nº: 30

Exploring the Impact of Coronal Mass Ejections on the Atmosphere of Hot Jupiters.

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A significant portion of exoplanets that have been discovered are called Hot Jupiters (HJs). These are massive gas giant planets that orbit very close to their host stars. Due to their close proximity, HJs are ideal candidates for studying how planets interact with their host stars (known as stellar-planet interaction or SPI). One important aspect of SPI is the study of the effects of coronal mass ejections (CMEs) on the planet's atmosphere.

All stars have winds that may vary over time. In the case of our own Sun, the most significant perturbations in the solar wind are CMEs. CMEs are massive ejections of plasma, with a total mass of around 10^15 g, that travel at a velocity of 500-1000 km/s. Recently, Argiroffi et al. (Nature Astronomy, vol.3 742-748, 2019) observed a CME in an active star that was not the Sun. Their study suggests that the energy associated with the CME could be much higher than the solar equivalent, depending on the stellar activity level.

In our study, we developed a 3D magnetohydrodynamic model to investigate the effects of CMEs on the atmosphere of HJs. Our model takes into account the planetary magnetic field and the upper atmosphere of the planet. We determined under which conditions CMEs can have an active role in perturbing the dynamics and structure of the HJ atmosphere, and where they can significantly erode the planetary atmosphere.

Overall, our study sheds light on the potential impact of CMEs on HJs and highlights the importance of understanding the dynamics of SPI.

Poster nº: 31

Determining the true planetary masses of the close-by non-transiting system GJ1061

Sandra V. Jeffers
Max-Planck-Institute for Solar System Research

Accurate masses of habitable zone planets orbiting low mass stars have so far only been determined using a combination of observations using the Radial Velocity technique to derive minimum planetary masses, msini, and transit observations to determine the planetary inclination. In this poster we present a new method to determine the true planetary masses of non-transiting compact multiplanetary systems. The method that we have developed uses the mutual gravitational interaction between the planets of a multiplanetary system to break the degeneracy between mass and inclination, and thus to determine the actual mass of each individual planet.

Poster nº: 32

The radio star AU Microscopii: Hunting for signatures of star-planet interaction in the presence of stellar activity

Sanne Bloot
ASTRON, the Netherlands Institute for Radio Astronomy

A key question in stellar astronomy is whether there are habitable planets around stars other than our Sun. An important factor in determining this is stellar activity, as stellar eruptions have direct impact on the atmosphere of an exoplanet. Radio emission, especially with a high degree of circular polarization, can provide a direct measurement of the magnetic field and the plasma properties of the star. Although many stars have been observed at radio frequencies, very few have been studied extensively enough to see the full phenomenology of radio emission. In this talk, I will present our year-long observing campaign of AU Microscopii, a young M-dwarf system with three detected planets. This system has been studied in detail at many wavelengths, but not at radio frequencies. With over 200 hours of observations, this campaign has allowed us to describe and categorize different types of stellar radio emission in a detail never before attainable for a single star. This includes characterizing rare types of emission such as those similar to solar radio bursts and Jovian magnetospheric emission. I will conclude with an interpretation of the physical processes causing these types of emission.

Poster nº: 33

The Near-InfraRed Planet Searcher: A new ESO spectrograph in La Silla

Valentina Vaulato
University of Geneva

The Near-InfraRed Planet Searcher (NIRPS) is a new ultra-stable infrared (YJH) spectrograph installed at the ESO 3.6 meters telescope in La Silla. NIRPS is designed to search for rocky planets orbiting M-dwarf stars and it operates in synergy with HARPS spectrograph. It is built with the goal of reaching a precision of 1 m/s, the typical radial velocity signal expected by an Earth analogue around a cool M-dwarf. The main goals of the mission are to perform an high-precision RV survey of M-dwarfs, to measure mass and density of known transiting planetary candidates around M stars and to characterise planetary atmospheres via transmission spectroscopy.

Poster nº: 34

Impact of stellar activity contamination on the high-resolution cross-correlation spectroscopy retrievals of exoplanet atmospheres

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Co-authors: Heather Cegla, Matteo Brogi

Novel advancements in atmospheric retrieval for ground-based high-resolution cross-correlation spectroscopy have enabled the measurement of atmospheric C/O and metallicity of gas giant exoplanets at remarkable precisions comparable to that of solar system gas giants. However, the effect of stellar contamination on such measurements remains yet to be understood. The effect can stem from temporally varying photospheres and chromospheres, e.g. due to inhomogeneities like spots, plage, and faculae that imprint their spectral signatures on the observed stellar spectra. We simulate typical scenarios of a gas-giant exoplanet observed at high-resolution in emission and transmission around solar type stars. Our aim is to evaluate the impact of various sources of stellar contamination on the inferred C/O and metallicity of the planetary atmosphere through mock model grid comparison and Bayesian retrievals. Quantifying the effect of stellar activity in this way is important as the measured chemical abundances of gas-giant exoplanet atmospheres hold clues to the formation and evolution pathways that sculpt the exoplanet population.

Poster nº: 35

Addressing the mass discrepancy of the transiting multi-planetary system GJ 9827

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GJ 9827 is a nearby K5V star with three known planets that were discovered by Niraula et al. 2017 and Rodriguez et al. 2018 from K2 transits. Up to now the system has been observed with several instruments, and data is available from K2, TESS, HIRES, FIES, PSF, HARPS, and HARPS-N. In the literature, the parameters of the planets are not well defined, and their masses spread between 3.4-8.2, 0.7-2.6, and 2.3-5.2 M_e for planets b, c, and d, respectively. However, an accurate determination of the planetary masses and radii is important for a detailed analysis of the planets' composition and evolution. Moreover, the system is an excellent target for atmospheric characterization by the James-Webb-Telescope and the future ANDES spectrograh, for the ELT. Precise masses are also neccesary to interpret transit spectroscopy observations, as it is one of the parameters determining the atmospheric scale height through the surface gravity, and the only one measurable in a non model-dependent manner.

With the variety of data available, we accurately characterize the planetary system by including high-precision radial velocities obtained with ESPRESSO and performing a combined analysis of photometric and radial velocity data using Gaussian Processes to also account for stellar activity modeling. We present the results of our study and reveal the nature of the three known planets. Are they mini-Neptunes, super-Earths, or even Earths? Could there be a fourth signal in the data?

Poster nº: 36

A DREAM program: Joining the atmospheric and dynamical evolution of close-in exoplanets

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Co-authors: DREAM team

Nearly half of known exoplanets orbit within 10 days around their star. These close-in planets range from small rocky objects to gas giants larger than Jupiter, putting in perspective our Solar system. Addressing the diversity of these worlds is tied to the study of the Neptunian desert and savanna, respectively a lack of hot Neptunes on short orbits and a milder deficit of warm Neptunes at longer periods, which bear the imprint of evolutionary processes that shape the exoplanet population.

Atmospheric escape plays a major role in sculpting the desert, eroding Neptune-size planets into mini-Neptunes or bare cores, but it is not clear how far into the savanna this process is active and when in a planet life it occurs. Most studies accounting for long-term atmospheric escape assume early erosion, kindled during disk-driven migration. Yet gaseous planets may avoid the strongest irradiation from the young star by migrating long after formation. The interplay between atmospheric evolution and this late dynamical migration, also proposed as one of the processes shaping the desert, remains to be explored.

The study of this coupling is the main objective of the DREAM (Desert-Rim Exoplanets Atmosphere and Migration) program, which is part of the SPICE DUNE project. I will present the first DREAM results, highlighting how new measurements of orbital architectures and mass loss in a sample of planets around the desert and savanna challenge our understanding of close-in planet evolution.

Poster nº: 37

HARPS search for long-period companions around Solar-type stars

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The HARPS volume-limited radial velocity survey, initiated in 2003, provides an unparalleled dataset with a 19-year baseline. This allows detections of long-period exoplanets, brown dwarfs, and low-mass binaries. Only 6% of the planets discovered so far have periods longer than 3 years, we are probing this largely unknown population. Characterization is challenging due to the radial velocity entanglement with the stellar activity cycle. We conducted a thorough examination of the Main-Sequence stars to rule out magnetic cycles as the cause of observed variation. Our research yielded the discovery of five Jupiter-mass exoplanets with minimal masses ranging from 0.4 to 2.0 MJup and periods ranging from 5.2 to 17.4 years, with well-constrained orbital elements.

We searched for possible TESS transits, but none were identified. Combining the radial velocity observations with absolute astrometry data from the Hipparcos-Gaia catalog of accelerations (HGCA, Brandt 2021), allows the derivation of an upper limit on the true mass and inclination of the exoplanets, enabling us to confirm their nature.

The detection of long-period planets, particularly "cold-Jupiters" (M > 0.3 MJup, a > 1 AU), is strongly correlated with the presence of inner super-Earths. Zhu & Wu (2018) quote a conditional probability of super-Earths of 90% +/- 20%. All our discoveries are potentially hosting inner Earth-like planets. Overall, these findings highlight the ongoing importance of the HARPS survey in expanding our understanding of the exoplanet population and their formation scenarios.

Poster nº: 38

NIRPS and HARPS further characterizing planetary systems and their host stars

Yolanda Frensch
ESO

The Near-InfraRed Planet Searcher (NIRPS) recently joined HARPS on the 3.6-meter telescope in La Silla. Combining visible and near-infrared high-resolution spectroscopy provides new diagnostics as well as new key parameters for a deeper characterization of both exoplanets and their host stars. Extending the spectral range of HARPS (0.38–0.69 μm) to the near-infrared with NIRPS (0.97–1.85 μm) allows a better disentangling of stellar activity as well as a better spectroscopic characterization of host stars including detailed abundances. Thanks to its adaptive optics system NIRPS can also better identify close stellar companions.

The NIRPS-GTO - started in April 2023 - searches for exoplanets around stars covering a wide range of parameter space in order to better understand the relationship between planets and stars. Our sample is covering stars from late K to ultra-cool L dwarfs. It also includes young stars, stars with debris disks, and evolved stars in order to probe evolutionary stages. We present the on-sky performance of NIRPS and the main objectives of our exoplanets RV blind search and transit FU programs.

Poster nº: 39

Implications of Bright Millimeter Flares from Young M Dwarfs on Planets

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Recently, the South Pole Telescope and the Atacama Cosmology Telescope reported the detection of several bright stellar transients in millimeter wavelengths. Five of these events are from rapidly rotating young M dwarfs. The luminosity of these events reaches 10^29 erg/s, which is 5 orders of magnitude greater than the largest solar flares in millimeters and 4 orders of magnitude greater than the millimeter flares observed from Proxima Cen and AU Mic. These flares are also unusual due to their flat to rising spectra. In this presentation, I will discuss plausible emission mechanisms for these events as well as parameters for the underlying energetic electron and proton flux. These events offer a glimpse into the extreme energetic particle environment surrounding young M dwarfs and the evolution of planetary atmospheres around them.

Poster nº: 40

A compact system of super-Earth to Neptune mass planet candidates orbiting an active main sequence star

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The Dispersed Matter Planet Project (DMPP) has shown that hot, low mass planets can be efficiently found by performing RV searches on stars with anomalously low chromospheric emission, below the basal limit for main sequence stars. We hypothesise that hot planets lose mass, forming a circumstellar gas and dust shroud that absorbs the star's chromospheric emission. In this work we target a young, active main sequence star in a nearby cluster which has chromospheric emission clearly below the cluster trend, but above the main sequence basal level. We are testing the hypothesis that the DMPP approach allows the host stars of short period, mass losing planets to be picked out among cluster member stars. This star is much younger and more active than the current DMPP sample. Success in this work demonstrates we can efficiently find hot, low mass planets orbiting young stars. We use a combination of GLS and recursive periodogram searches to identify significant signals in the RV data, performing the analysis with and without correlations with activity indicators. We find multiple planet candidates with periods ranging from 1.7 to 14.7 d and with minimum masses from 5.2 to 22 M_{\oplus}. Stellar activity causes a number of significant periodic signals. Trailed periodograms can help to disentangle these from true planetary signals. We utilise existing Bayesian GLS trailed periodogram code and our own new recursive F-ratio periodograms. We used multi-dimensional Gaussian process regression to model the stellar activity contribution to the RVs, adapting the Pyaneti code to use nested sampling to determine the best fit parameters. We discover evidence for a number of short period planets, some of which may have or be losing mass, leading to the observed depressed stellar chromospheric emission. The period and mass of these planets puts them in the vicinity of the Neptune desert and the radius valley, providing a key opportunity to learn how these demographic features arise.

Poster nº: 41

The M-dwarf Atmosphere Problem

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About 70-80% of stars in our solar and galactic neighborhood are M dwarfs. They span a range of low masses and temperatures relative to solar-type stars, facilitating molecule formation throughout their atmospheres. Standard stellar atmosphere models primarily designed for FGK stars face challenges when characterizing broadband molecular features in spectra of cool stars. We show the arduous task of modeling M-dwarf atmospheres and the challenges that come along with it. First, we introduce SPHINX — a new 1-D self-consistent radiative-convective thermochemical equilibrium chemistry model grid of atmospheres and spectra for M dwarfs in low-resolution (R~250). SPHINX incorporates the latest pre-computed absorption cross-sections with pressure-broadening for key molecules dominant in late-K, early/main-sequence-M stars. Next, we validate the new grid models by acquiring fundamental properties (Teff, log(g), [M/H], radius, and C/O) for 10 benchmark M+G binary stars with known host metallicities and 10 M dwarfs with interferometrically measured angular diameters. Incorporating a Gaussian-proces inference tool Starfish, we then account for correlated and systematic noise in low-resolution (spectral stitching of SpeX, SNIFS, and STIS) observations and derive robust estimates of fundamental M dwarf atmospheric parameters. Additionally, we assess the influence of photospheric heterogeneity on acquired [M/H] and find that it could explain some deviations from observations. We also probe whether the model-assumed convective mixing-length parameter influences inferred radii, effective temperature, and [M/H] and again find that may explain discrepancies between interferometry observations and model-derived stellar parameters for cooler M dwarfs. Mainly, I show the unique strength in leveraging broadband molecular absorption features occurring in low-resolution M dwarf spectra and demonstrate the ability to improve constraints on fundamental properties of exoplanet hosts and late brown dwarf companions. I also show ongoing work extending the capability of SPHINX to characterize atmospheres of mid-to-late type M-dwarfs. Using SpeX IRTF low-resolution observations both archival data (from SpeX Prism Library Database) and from empirical studies with previous observations, I get constraints on fundamental atmospheric properties of 71 low-mass, late-type M-dwarfs and understand spectroscopic degeneracies arising due to stellar activity, cloud/dust condensation and convection. With the newly validated atmosphere models, we can compare the chemical properties of these stars against main-sequence stars and acquire a more holistic understanding of

M-dwarfs as a class of objects—a persistent problem for both theory, observations, and in the quest to properly characterize the star-planet interaction environment.

Poster nº: 42

Stellar and exoplanetary content of the solar neighbourhood

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The discovery and characterisation of exoplanets have made significant strides, yet much remains to be learned about the relationship between the physical properties of planets and their host stars.

The proximity of stars in the solar neighbourhood not only offers valuable insights into the Galactic stellar population, but also provides opportunities to better infer the statistical properties of exoplanets, as in a volume-limited sample the inherent biases of the detection methods are reduced, thereby enhancing our understanding of the conditions for potential life beyond solar system.

Furthermore, many astrometric planet detections among the nearby stars are expected in the near future, making the exoplanet census around the nearby stars more complete as opposed to more distant host stars.

In this work, we review the census of stars and brown dwarfs within 25 pc of the Sun, based on the recently published Fifth Catalogue of Nearby Stars (CNS5) by Golovin et al. (2023), and discuss its content and completeness.

We also discuss the updates to the catalogue, which has been expanded to include a sample of 347 exoplanets in the solar neighbourhood, in addition to the newly identified nearby stars and brown dwarfs.

Finally, we summarise the content changes in the upcoming version of the catalogue (CNS6), which will incorporate stellar parameters and comprehensive multiplicity information for objects within 25 pc of the Sun.

Poster nº: 43

Detailed chemical composition of wide FGK+M binary systems

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Studying the chemical composition of stars in detail is crucial for a range of topics in modern stellar astrophysics. Specifically, it can provide vital insight into the chemical evolution of the Galaxy, as well as the formation, composition, and structure of exoplanets. Therefore, it is essential to gather detailed information about the chemical composition of stars. In our previous work, we established a sample of 193 wide physically-bound systems, formed by a late-F, G, or early-K primary star and a M-dwarf companion. Using high-resolution spectra and the equivalent width method, we derived precise stellar atmospheric parameters (Teff, logg, xi, and chemical abundances for 13 atomic species) for the primary stars. We also performed a kinematic analysis, classifying the stars in different Galactic populations and stellar kinematic groups. Our ongoing project extends this abundance analysis by deriving abundances for new key elements such as C and O, and updating previously determined Sc, V, Mn, and Co abundances by accounting for hyperfine structure effects (HFS) and correcting for non-local thermodynamical equilibrium (NLTE), covering a total of 15 chemical species investigated. These elements are particularly important for discovering habitable worlds, mapping the star formation history of the Milky Way, or constraining the physics of supernovae type Ia. Furthermore, we investigated the distributions of [X/Fe] ratios and [C/O] as a function of metallicity, indicating the stars from different kinematic populations, namely thin disk, thick disk, or halo stars. We found that the observed trends were consistent with predictions from Galactic chemical evolution models and previous findings reported in the literature. Additionally, we searched for confirmed exoplanets around our primary stars in the literature and found 25 exoplanets in 17 systems, while none of the M-dwarf companions in our sample presented confirmed exoplanets. These data will enable us to study the C/O ratio, which, when combined with the Mg/Si and Fe/Si ratios, provides crucial information about the structure, composition, and mineralogy of exoplanets. In future work, we will focus on deriving the stellar parameters and abundances of the M-dwarf companions using CARMENES high-resolution spectra through spectral synthesis. These values will then be compared against those of the primary stars, establishing the sample of binary systems as a benchmark for the accurate determination of chemical abundances in M dwarfs. In conclusion, our study provides

valuable new insights into the chemical composition of stars, paving the way for further research on stellar abundances and exoplanetary science.

Poster nº: 44

Identifying activity- and magnetically-sensitive spectral lines in M dwarfs using CARMENES visible and near infrared spectra

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Co-authors: López-Gallifa, Álvaro ; Labarga, Fernando; and CARMENES consortium

In this contribution we summarize our project devoted to identify activity- and magnetically-sensitive spectral lines in the CARMENES visible and near-infrared spectral range of M dwarfs. The aim is to contribute to solve the problem of stellar activity in radial velocity (RV) measurements to search for exoplanets around these stars and in the determination of precise stellar parameters. To identify lines with a significant chromospheric contribution, apart from well known activity indicators (Na I D 1 D 2 He I D 3 Hα, and Ca II IRT lines, He I 10830 Å, Paγ and Paβ lines), we have used the spectral subtraction technique using our Python code iSTARMOD (Labarga & Montes, 2020) choosing as reference the spectrum of the star with lower activity level. We confirm the new activity-sensitive lines by analysing the correlation with the other well known activity indicators in the same spectra and their temporal evolution. In addition, we have analysed line by line the template spectrum (co added of all the individual spectra available) applying also the spectral subtraction using in this case as reference star an inactive M dwarf star of similar spectral type to search for magnetically-sensitive spectral lines, that is lines with detectable Zeeman broadening. We are now studying the impact of the elimination of the lines identified in this way on the RV determination using cross correlation functions with weighted binary masks as in Lafarga et al. (2020) and comparing with activity-sensitive lines identified by line-by-line RV analysis in Lafarga et al. (2023).

Poster nº: 45

Probing the Limits of Planet Formation through the Demographics of Circumbinary Planets

Dominic Oddo
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Circumbinary planets (CBPs; planets orbiting outside of both stars in a tight stellar binary) represent one of the most exciting frontiers in exoplanet research. While they are some of the most difficult planets to find, CBP discoveries yield deeper troves of orbital and physical properties relative to discoveries of planets around single stars. This in turn provides rich insights into the history of each system, making the discovery of each planet important. Despite this, with only a small sample of 14 transiting CBPs so far, we cannot yet tell a complete story about some of the most interesting planets in the galaxy. There are many mysteries regarding CBP formation and evolution which are yet to be addressed, including reliably explaining how CBPs form. By finding more CBPs, we will learn more about the limits of planet formation and the extremes of planetary system architectures. We are searching for transiting CBPs in the light curves of many eclipsing binaries (EBs) observed by the NASA Transiting Exoplanet Survey Satellite (TESS) mission. We describe here our search methods, including the masking of EB signatures and the identification of transit events. We further discuss our use of injection and recovery of dynamically-simulated transits, which we employ as a test of our sensitivity. Finally, we discuss prospects for candidate follow-up and vetting.

Poster nº: 46

Metallicity effect on the age-chromospheric activity diagram

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Co-authors: Jorge Meléndez; Giulia Martos

The study of planetary systems and their evolution is highly impacted by the determination of stellar ages, since they also represent the ages of the hosted planets. However, these determinations can be very challenging, especially as we go to colder main-sequence stars. An alternative way for estimating ages is to take advantage of the magnetic changes along the stellar evolution. Many efforts have been put into improving the age-chromospheric activity (AC) relations. For instance, the use of solar twin data to study the magnetic evolution of stars similar to the Sun, show a clear correlation between chromospheric activity and age. In this work, we are investigating the effects of stellar metallicity on the R'_HK index of solar analogs, derived from Ca II H and K chromospheric emissions. We showed that without a metallicity factor, these AC relations could underestimate the ages of metal-rich stars and overestimate in a critical way the ages of metal-poor stars.

Poster nº: 47

TOI-544 b: a potential water-world inside the radius valley in a two-planet system

Hannah Osborne
ESO

TOI544b is a newly-characterised small planet (mass < 4 Earth masses) recently detected with TESS and followed-up by the KESPRINT consortium. High-precision RV observations have allowed the mass of the planet to be constrained within 15% uncertainty and detect a previously-unknown longer-period companion with a mass precision of 10%, meaning these are some of the most precisely known exoplanet masses found using the RV method. The relatively low density of the inner planet puts it within a small subset of exoplanets which could be composed of mainly rocky silicates or water ices with or without layers of atmospheric hydrogen. However, the short orbital period means the effective temperature of this planet is above what would be expected for a rocky core to be able to sustain a hydrogen layer. We present the possibility of this planet joining the small group of 'ocean worlds' containing a significant fraction of water. As well as this, the planet sits firmly within the radius valley, a region where very few exoplanets are expected to be found. This, coupled with the high Transmission Spectroscopy Metric (TSM) and Emission Spectroscopy Metric (ESM) values make TOI-544b an excellent target for future atmospheric characterisation with the JWST and future Ariel mission. Finally, the importance of the TOI-544 system in relation to the wider population of small exoplanets and our understanding of planetary compositions will be presented.

Poster nº: 48

Identifying Exo-planetary Compositions using Polluted White Dwarfs

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Co-authors: Boris Gaensicke

White dwarfs are the electron degenerate remnants of stars such as our Sun. The outer bodies of planetary systems are expected to survive the evolution into white dwarfs and due to dynamical interactions objects are scattered towards the star. The high surface gravity of white dwarf stars leads to any elements heavier than helium to sink into their cores over characteristic timescales, leading to purely hydrogen or helium atmospheres. Therefore, any photospheric metals observed must be from recent or ongoing accretion, where metals are being supplied into the atmosphere faster than they can sink. Using observations of these metal polluted white dwarfs in the ultraviolet and optical along with state-of-the-art atmospheric models, the composition of the accreted material can be determined, which demonstrates the diverse nature of exo-planetary systems.

We present a polluted white dwarf database which contains information on the photospheric metal abundances of over 1400 individual white dwarfs from the literature. Those with more detailed analysis also contain the metal accretion rates and sinking timescales. Using this database, the frequency of systems containing objects with bulk Earth abundances can be calculated. The impact of effective temperature and the presence of magnetic fields have been considered. Core- or mantle-rich accreted fragments can be determined, which suggests the presence of chemical differentiation. Any observational biases and discrepancies have been identified, allowing systematic errors to be reduced in future work. This database is the largest collection of information on polluted white dwarfs, allowing insights into exo-planetary compositions.

Poster nº: 49

Detailed abundance of the TESS' First Circumprimary Planet in a very wide binary system

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Co-authors: Jhon Yana Galarza, Thiago Ferreira, Henrique Reggiani and Diego Lorenzo Oliveira

We recently used MAROON-X spectra to confirm the existence of an exoplanet in a wide binary system (projected separation ~ 11 400 AU). Our results indicate that only one component (TOI 1173 A) hosts an exoplanet, probably a Super-Neptune, with Msini = 26 ME (Earth Masses), R = 9 RE (Earth Radii), P = 7 days and e = 0.11. The spectroscopic stellar parameters show that the planet-hosting component (TOI 1173 A) is hotter (~300 K) and higher in iron (~0.025 dex) than its companion (TO I1173 B). When the differential abundance between both components (TOI 1173 A - B) is plotted against the condensation temperature (TC), a clear abundance pattern is revealed in which TOI 1173 A is enhanced in refractory elements relative to the volatiles. To our knowledge, this is the first circumprimary exoplanet with a TC trend detected in a very wide binary system. In this work we will discuss the various scenarios from planet formation to planet engulfment that can explain the chemical anomalies observed in TOI 1173 A/B and other planet-hosting wide binaries as those systems provide a unique opportunity to investigate the effect of stellar multiplicity on planet formation and the evolution of planetary orbits.

Poster nº: 50

Constraining Flaring Properties for the beta Pictoris Moving Group

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Stellar flares occur when the magnetic field reorganizes, releasing panchromatic radiation which has a higher brightness temperature (~9-20 kK) than the star itself. The heightened magnetic activity in young low mass stars compared to earlier types and older stars leads to flaring events becoming a substantial contributor to the radiation environment around the star. For low mass stars especially, the excess ultraviolet and X-ray emission has notable implications for observable exoplanetary phenomena including photochemistry and atmospheric evolution.
Identifying the evolution of stellar flare properties is integral to fully understanding the broader planetary context needed to interpret observations of exoplanet masses and radii and transmission spectra. The beta Pictoris moving group (24 +/- 3 Myr) provides an ideal starting point for an investigation of low mass stellar flares as a well-populated and nearby stellar association. Isolating this sample within the context of larger flare studies allows for study into how flare properties evolve with age. We use TESS observations to extract flare properties of 49 young K and M dwarfs in this moving group, such as total energy and cumulative flare rate, and associate them with stellar properties. We successfully reproduce the ‘saturated’ upper limit with respect to rotation rate, similar flare-frequency power law relations, and inflated flare activity seen in large studies, confirming the calibration of our TESS flare reduction pipeline for other moving groups and associations at various ages. The shallower power laws of these stars (a = -1.58) are indicative of this population’s tendency to produce more large flares than older samples. Additionally, we present an overview of flaring behavior as a function of spectral type for the beta Pictoris Moving Group.

Poster nº: 51

Simultaneous Multiwavelength Observations of the Highly Active M Dwarf Wolf 359

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M dwarf stars are cool low-mass stars that are the most common stellar type in our galaxy and are known to frequently host small planets. Most M dwarfs exhibit high levels of activity in the form of flares and coronal mass ejections due to magnetic reconnection processes. This energetic activity may subject potential planets, orbiting around them, to significantly more radiation than we receive from the Sun. It remains unclear just how much this radiation affects a planet's atmosphere and potential habitability. I will present preliminary results on our multiwavelength analysis of the highly active M6V dwarf, CN Leo, also known as Wolf 359, located at 2.41 pc. We used simultaneous ultraviolet, X-ray, and optical observations from the Neil Gehrels Swift Observatory, XMM-Newton, and the Transiting Exoplanet Survey Satellite (TESS) taken during December 2021. We analyzed the energy partition of the flares and compared the flare frequency distribution (FFDs) of events, observed by the different observatories, to estimate the overall energy output, allowing us to investigate the relationship of stellar flares at different wavelengths.

Poster nº: 52

How common are Earth-like Habitats? The role of the host star

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The existence of an Earth-like Habitat, that is, a rocky exoplanet within the Habitable Zone of Complex Life that hosts an N2-O2-dominated atmosphere with minor amounts of CO2, is depending on a certain set of known (and, potentially, unknown) astrophysical and geophysical requirements that have to be met to allow for its evolution and environmental stability. A few of these requirements are already quantifiable to a certain extent by our current scientific knowledge while others are still under debate. One crucial factor that has to be taken into account when estimating the prevalence of Earth-like Habitats within the galaxy is a planet's host star. Its radiation and plasma environment may affect the stability of an Earth-like atmosphere to such an extent that it can even render its existence over geological timescales unlikely around highly active stars. A star's metallicity and location within the galactic disk may pose further restrictions on the prevalence of Earth-like Habitats within the Milky Way. Taking some of these factors into account, we will illustrate that only a certain fraction of stars within the galaxy will in principle be able to host planets with Earth-like atmospheres. Early K dwarfs with a stellar mass around 0.8 solar-masses may constitute a particularly interesting environment for the existence of Earth-like Habitats. M stars, on the other hand, exhibit several different problems; planets suitable for complex life as we know it may therefore be a rare occasion around the smallest, but most abundant, stars in the galaxy.

Poster nº: 53

The (un-)solved issues of the spectroscopic analysis of young/active stars

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The detailed characterization of planet-host stars is of primary importance when studying planetary systems. In particular, this is crucial to understand fully the observed correlations between exoplanets' properties and the characteristics of the host stars (such as the giant planet-metallicity correlation). One of the most powerful techniques at disposition is high-resolution spectroscopy (R>40000), which enables us to derive precise stellar parameters and most importantly the complete chemical makeup. However, recent investigations have pointed out major limitations of the most commonly used analysis techniques when applied to very young/active stars (ages less than the Hyades, ~600 Myr). The main effects are the overestimation of the microturbulence velocity parameter (with consequently an underestimation of the atomic abundances), and anomalous behaviour of some elements (such as the slow neutron-capture ones or carbon). In this talk, I will revise the topic of the spectroscopic abundance analysis of young/active stars and present new innovative analysis methods to (for the moment) overcome these issues.

Poster nº: 54

Where should we look for Earth 2? Target selection for the Second Earth Spectrograph

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Co-authors: Melissa Hobson, Thomas Henning, Lars Buchhave, 2ES team

The Second Earth Initiative Spectrograph (2ES) is an upcoming extreme-precision radial velocity instrument for the ESO/MPG 2.2m telescope at La Silla, which will be dedicated to the hunt for Earth-twins: Earth-mass planets orbiting Sun-like host stars. For the success of this project, we will need a pre-selected, pre-vetted target list of ideal stars to observe, comprised of quiet, bright, slow-rotating Sun-like stars. In this contribution, we will present the 2ES project, currently being developed in cooperation between Copenhagen, Heidelberg, and Göttingen, and describe the selection and vetting process employed to build our target list.

Poster nº: 55

Multi-Objective Optimisation of Incomplete Stellar Abundance Data for Jupiter Host ML Classification

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Several bodies of work have demonstrated a correlation between a stellar host's chemical composition and the presence of planetary companions, particularly in the case of gas-giant planet occurrence. Assuming that there is a generalisable transformation function which can generate a probability score of a star being a gas-giant host, simply by looking at the stellar chemistry, stellar chemical abundance datasets could be used to train an ML classifier capable of discriminating between the host and comparison samples. Since abundance data tends to be incomplete, imputation techniques are also required before training. To reach both goals simultaneously, that is, a generalisable classification model and reliable imputation, we employ a multi-objective optimisation model based on the NSGA-II algorithm. This allows for an effective search of the parameter space for Pareto solutions of the ideal combination of hyperparameters for both objectives. Within the algorithm, we use a fuzzy clustering model for the feature imputation and an XGBoost algorithm for classification.

Poster nº: 56

Statistical inquiry of transiting planets with the PlanetS catalog : Mass-radius relations, M-R diagram of small planets around M-dwarfs and radius valley dependencies.

Léna Parc
University of Geneva

Thanks to the continuous development of characterization techniques, the increasing number of exo-planetary parameters allows to carry out statistical studies on large populations. The aim of these studies is to investigate the link to the physical and chemical processes that govern the formation and evolution of planets, such as migration, atmospheric loss, inflation mechanism, etc., in order to improve our formation models. However, only less than 1000 planets have a measured mass and radius listed in different databases which are often incomplete and not homogeneous enough to conduct reliable statistical studies.

Initially built and presented in Otegi et al. 2019, I present here the PlanetS catalog which contains now 677 transiting exoplanets with more than 40 different parameters (e.g. planetary and stellar parameters, orbital constrains…) from the NASA Exoplanet Archive, Gaia DR3 and TEPCat. This catalog is based on reliable, robust, and accurate mass and radius measurements of transiting planets. An effort was done on the references to ensure the reliability and robustness of the analysis of the photometric and spectroscopic data. The precise knowledge of the planetary mass, radius and irradiation is essential to estimate the planetary bulk density and to deduce the possible compositions and internal structures.

Since its publication, the catalog has been extended to all planetary masses and updated to avoid any missing data. Moreover, all the last recent studies (2022 and early 2023) have been included as well as the updated values of older discoveries. A great effort has been made to expand the number of available parameters, especially stellar properties.

The work done to keep this catalog up to date is key to perform accurate statistical studies, exploring the multitude of parameters to try to understand the formation and evolution of exo-planetary systems. More specifically, the link between the stellar properties and the frequency, bulk and atmospheric composition of planets.

Based on this, I will present revisited mass-radius relations according to the spectral type of the host star. My study focuses in more detail on the M-R diagram of small planets around M-dwarfs. I will critically analyze the recent study of Luque & Pallé (2022) by performing a multimodal study of the radius and density of these small planets. The consequences on their internal and atmospheric compositions will be investigate too.

Then, I compare these observational data with planetary formation models. I also revisit the dependencies of the radius valley with stellar parameters.

Poster nº: 57

The TESS Rotation Collaboration: A Stellar Rotation Data Challenge for the TESS Era

Rae Holcomb

The rotation period of a star is a fundamental parameter governing stellar activity, and accurately measuring it is an essential first step in understanding the stellar environment of an exoplanetary system. The Transiting Exoplanet Survey Satellite (TESS) provides high cadence photometric time series for hundreds of thousands of stars, creating the opportunity to measure stellar rotation periods across nearly the entire sky. This wealth of data has sparked an explosion of new methods and open source tools for analyzing stellar rotation, including Fourier-based methods, autocorrelation, machine learning, Gaussian processes, and more. However, the question remains of which of these methods is most effective for identifying rotation periods when faced with the specific limitations and challenges of TESS data. The TESS Rotation Collaboration (TRC) is a multi-institutional effort to compare the effectiveness of these methods and assess the state of our ability as a field to use TESS to measure stellar rotation. The TRC is running an double-blinded data challenge open to all members of the astronomical community to recover stellar rotation periods from a data set of 10,000 simulated TESS light curves. We will investigate which methods perform best when trying to recover short vs. long periods, which data reduction pipelines best preserve long term stellar signals, and where the inherent detection limitations imposed by the TESS survey strategy might be. Ultimately, we aim to improve the overall reliability of rotation periods measured with TESS, illuminate what challenges still remain when studying stellar rotation with current technology, and create a solid foundation for further study of exoplanets in the context of their host star environments.

Poster nº: 58

SWEET-Cat: The Cat is still SWEETer

Sergio Sousa
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The catalog of Stars With ExoplanETs (SWEET-Cat) was originally introduced in 2013. Since then many more exoplanets are being confirmed, continuously increasing the number of planet-host stars. A crucial step toward a comprehensive understanding of these worlds is the precise and homogeneous characterization of their host stars. Better spectroscopic stellar parameters along with new results from Gaia DR3 provide updated and precise parameters for the discovered planets. A new version of the catalog, whose homogeneity in the derivation of the parameters is key to unraveling star–planet connections, is available to the community.

Here we present the current status of the catalogue and show the new information that was recently added, in particular the new SWEET-Cat table can now be more easily combined with the planet properties listed both at the Extrasolar Planets Encyclopedia and at the NASA exoplanet archive to perform statistical analyses of exoplanets. We also made use of the recent GAIA eDR3 parallaxes and respective photometry to derive consistent and accurate surface gravity values for the host stars.

With the increased number of stars with homogeneous parameters we review and update the metallicity distributions of stars hosting planets with different mass regimes comparing the low-mass planets ($<30M_{\oplus}$) with the high-mass planets. The new data strengthen previous results showing the possible trend in the metallicity-period-mass diagram for low-mass planets.

Poster nº: 59

Connecting observations and interior modeling of warm exoplanets

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Warm Jupiters provide a unique opportunity to better understand the formation and evolution of planetary systems. Their atmospheric properties remain largely unaltered by the impact of the host star, and their orbital arrangement reflects a different, and less extreme, migrational history compared to close-in objects. Warm Jupiters are known to cover a wide range of eccentricities and their formation pathways remain unclear. Increasing the sample of long-period exoplanets with known radii is thus crucial. In this talk, I report the results of a survey set out to find transiting giants with orbital periods between 20 and 200 days. We selected 50 stars which show a single transit in one TESS sector (27d baseline) and followed them with ground and space-based photometric and radial velocity facilities (e.g. NGTS, CHEOPS, HARPS). After two years of observations, we report the detection and characterization of 15 new transiting warm Jupiters, increasing by 50% the number of known warm Jupiters with precise masses and radii. We infer the metal enrichment of the newly discovered warm giants and explore their influence on the mass-metallicity correlation of giant planets. The growing sample of warm Jupiters allows us to interpret these systems in terms of planet formation models. Finally, I present the first results of a newly accepted ESPRESSO program to unveil the dynamical history of warm Jupiters based on measurements of the system' spin-orbit alignment.

Poster nº: 60

Galactic Chemical Evolution of Exoplanet Hosting Stars: Are High-mass Planetary Systems Young?

Swastik Chowbay
Indian Institute of Astrophysics

The imprints of stellar nucleosynthesis and chemical evolution of the galaxy can be seen in different stellar populations, with older generation stars showing higher α-element abundances and the later generations becoming enriched with iron-peak elements. The evolutionary connections and chemical characteristics of circumstellar disks, stars, and their planetary companions can be inferred by studying the interdependence of planetary and host star properties. Numerous studies in the past have confirmed that high-mass giant planets are commonly found around metal-rich stars, while the stellar hosts of low-mass planets have a wide range of metallicity. In this work, we analyzed the detailed chemical abundances for a sample of >900 exoplanet hosting stars drawn from different radial velocity and transit surveys. We correlate the stellar abundance trends for α- and iron-peak elements with the planets' mass. We find the planet mass–abundance correlation to be primarily negative for α-elements and marginally positive or zero for the iron-peak elements, indicating that stars hosting giant planets are relatively younger. This is further validated by the age of the host stars obtained from isochrone fitting. The later enrichment of protoplanetary material with iron and iron-peak elements is also consistent with the formation of the giant planets via the core accretion process. A higher metal fraction in the protoplanetary disk is conducive to rapid core growth, thus providing a plausible route for the formation of giant planets. This study, therefore, indicates that the observed trends in stellar abundances and planet mass are most likely a natural consequence of Galactic chemical evolution.

Poster nº: 61

Radio emission as a stellar activity indicator

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ASTRON, the Netherlands Institute for Radio Astronomy

Radio observations are excellent probes of the environmental conditions in the coronae/magnetospheres of stars and brown dwarfs. In particular, radio emission traces the impact of stellar plasma on exoplanet atmospheres, the processes of coronal heating, and key parameters for assessing exo-habitability. The strong magnetic field of these stellar systems leads to radio emission via different mechanisms such as gyrosynchrotron radiation, electron cyclotron maser instability, and plasma oscillation. As the ongoing LOFAR Two-metre Sky Survey (LoTSS) and VLA Sky Survey (VLASS) are some of the deepest and most sensitive radio sky surveys ever conducted, I shall present our latest efforts on identifying different radio emissions from stellar systems in these surveys. By using the radio-detected population's properties, I shall differentiate the two possible acceleration mechanisms (the so-called engines): (a) chromospheric/coronal acceleration similar to that observed on the Sun, and (b) magnetospheric acceleration occurring far from the stellar surface similar to that observed on Jupiter. Since one expects stars to have Sun-like engines, and brown dwarfs to have Jupiter-like engines, our aim is to search for a transition from one to another in the realm of M dwarfs: the tail of the main-sequence stars. Furthermore, to understand how stellar activity impacts radio detectability, I shall also investigate whether the radio detection rate in our samples correlate with canonical activity indicators in the optical and X-ray bands.

Poster nº: 62

Close stellar flyby and the evolution of Trans-Neptunian Objects: A Gigayear Perspective

Amith Govind
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This study examines the evolution of orbital features of trans-Neptunian objects (TNOs) in our Solar System over a Gigayear, subsequent to a close encounter with a star (with mass = 0.8 $M_\odot$, perihelion distance = 110 au, and inclination = 70°). Our findings suggest this stellar flyby event can account for the observed features of TNOs and Sedna-like objects without affecting the planets' orbits. Over 1 gigayear of evolution, notable orbital transformations occur. A subset of the ‘cold’ TNO population — characterized by low inclination, perihelion distance, and semi-major axis — migrate towards more eccentric orbits with higher semi-major axes, while others with initially high values of these parameters shift towards 'colder' orbits. The extreme TNOs (ETNOs), while experiencing boundary losses, gain new members — primarily particles with eccentricities less than 0.6 and perihelion distances under 40 au — which get scattered into high eccentricity orbits, with some transitions happening over a few million years. Sedna-like objects exhibit minimal population change, with shifts occurring mainly along the boundaries of the population definition in terms of orbital parameters. These findings offer insights into the potential influence of a past stellar encounter on our solar system's architecture.

Poster nº: 63

The effect of dynamically formed binaries on young planetary systems

Christina Schoettler
Imperial College London, UK

Stars do not form in isolation but together with other stars, often in a clustered environment. During the dynamical evolution of these environments, the stars in the region will interact with each other. These encounters will affect not only the stars but also any planetary systems that are in the process of forming around them. Many typical fly-by simulations focus on a single fly-by event's effect on a planetary system. However, during the early dynamical evolution of the birth cluster, dynamical binaries can form quickly from two single stars. We find these dynamical binaries in many of our simulations, but their effect on planetary systems that have formed around their initially single stars is largely unexplored.

In this talk, I will present results from young star cluster N-body simulations showing how dynamical binaries can be formed and destroyed again. I will then show isolated planet system simulations and present results focussing on the differences in the orbital parameters of planetary systems from either of the interaction scenarios. I will show how dynamical binaries can accelerate the disruption of planetary systems and compare the differences in the resulting planetary architectures after 100 Myr.

Poster nº: 64

Birth and destruction in protoplanetary disks: dust production by planetesimal collisions

Danae Polychroni
INAF - Osservatorio Astr4onomico di Trieste

Dust plays a central role in the chemical evolution of protoplanetary disks and is the source material from which planetary bodies form. Coagulation into planetesimals and planets is expected to steadily decrease the dust abundance in disks over time. However, recent surveys point to the median dust content of disks increasing from 1 to 2 Myr in nearby star-forming regions. Furthermore, resolved observations of HD 163296 reveal unexpected regions of high dust concentration across its extension. Building on our insight on the collisional evolution of small bodies from the Solar System, we show that such unexpected behaviours of the dust stem from the planet formation process. The early formation of massive planets dynamically stirs the nearby planetesimals and causes high-velocity impacts between them, resulting in the production of second-generation dust. This collisional production naturally explains the rise in the dust population observed in disks with ages between 1 and 2 Myr, suggesting this is the characteristic timescale of giant planet formation. The appearance of second-generation dust also explains the spatial distribution of dust observed in older disks like HD 163296. By sustaining the dust population over time, this collisional rejuvenation process acts to extend the duration of the planet formation process and the chemical evolution of disks.

Poster nº: 65

Star-planet interaction during formation

Giovanni Picogna
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Co-authors: Michael Weber, Barbara Ercolano

Star-planet interaction is probably most effective in the early stages of planet formation. The energetic stellar irradiation shapes the planet-forming disk by cutting the supplies available to the planetary growth, eventually dispersing the disk, shutting off atmospheric accretion, and stopping planet migration.
We modelled with 2D/3D hydrodynamical simulations the evolution of planet-forming disks orbiting stars from 0.1 to 1 Solar masses and irradiated by observationally derived stellar spectra with a range of spectral hardness and X-ray luminosities.
From these models, we can place strong constraints on planet formation lifetimes based on stellar properties. We provide 1D surface density mass-loss rates that can be readily adopted in planet population synthesis models to track the gas/dust reservoir available to growing (migrating) planetary cores.
Furthermore, we studied how a forming giant planet can affect the disk wind launched by the stellar X-ray irradiation, potentially connecting the inner and outer disk.

Poster nº: 66

Testing tidal dissipation with transit timing variations of hot jupiters: preliminary results

Jan Golonka
Nicolaus Copernicus University

Tidal dissipation of waves induced by hot jupiters in their host stars could cause the orbits of these planets to shrink. Following the predictions of Barker (2020) I performed TTV analysis of systems which are good candidates to observe this phenomena. Preliminary results of this work is presented in this poster.

Poster nº: 67

The Search for Water Worlds with Palomar Observatory

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Caltech

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Models predict that planets with water-rich compositions may be common around low-mass stars, but definitive evidence for the existence of water worlds has remained elusive. Precise mass and radius measurements for small planets allow us to identify candidate water worlds which have bulk densities too low to be consistent with a rocky composition, and masses too low to retain any H-rich envelope against hydrodynamic escape and photoevaporation. Dynamical interactions between adjacent planets in near-resonant multi-planet systems produce transit timing variations (TTVs) that can be observed with high-precision photometry, and measurements of these TTVs can be inverted to produce constraints on planetary densities. For the past two years, we have collected dozens of transit observations for small, Earth-sized exoplanets in nearby multi-planet M dwarf systems, using the 200" Hale Telescope at Palomar Observatory and other ground-based observatories. I will discuss some of the most promising early results from this survey of candidate water worlds.

Poster nº: 68

A new ground-based investigation of orbital decay in the hot Jupiter WASP-12b

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Orbital decay in close-in transiting exoplanets can be detected via decade-long monitoring of transit timing variations. This allows us to detect or constrain a monotonic decrease of orbital period $dP/dt < 0$ due to mechanical energy being dissipated by tidal friction. WASP-12b is the first planet for which a tidal decay scenario was found to be convincing, and this discovery paved the way to a better understanding of the host star-planet interactions. Here we present a new analysis of WASP-12b based on 28 unpublished high-precision transit light curves gathered over a twelve-year baseline and combined with all the available archival data. We also derive an improved set of stellar parameters from new high-resolution spectroscopic data. We refine the value of the dP/dt rate, found to be statistically consistent with previous studies, and discuss its implications for different dynamical scenarios. We also report the presence of an excess scatter in the timing data and discuss its possible origin.

Poster nº: 69

Hunting for exoplanets via star-planet interactions

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Low-mass stars host the bulk of all exoplanets in our galaxy. While the population of exoplanets discovered to date is dominated by those that are close-in, massive, and transit, such a population is not representative of the complete sample. M dwarfs, which are the most common type of star in the galaxy, are expected to favour hosting small rocky planets. Finding such planets however is very difficult through traditional methods, as their signatures are very weak, and can be drowned out by stellar activity. M dwarfs also harbour strong surface magnetic fields, which dominate the energetics of the surrounding plasma environment out to large distances. In this region, the motion of a planet through the star's large-scale magnetic field can produce Alfvén waves, which carry energy back to the star. Such a scenario is expected to power bright radio emission from the star via the electron cyclotron maser (ECM) instability. Due to the beamed nature of ECM emission, such signatures could be more favourable for detection from exoplanetary systems with architectures distinct from the currently known population. In this talk, I will discuss our recent work utilising numerical models to identify the most favourable systems for detecting these signatures based on the characteristics of the star and planetary orbit.