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1 Editorial

Welcome to Edition 154 of the ExoPlanet News!

In this April issue you will find abstracts of scientific papers, conference announcements, Exoplanet Archive updates, job postings, and an overview of exoplanet-related articles on astro-ph.

We remind you of some guidelines for using our templates. If you follow these guidelines, you will make our job easier:

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For the next month we look forward to your paper abstracts, job ads or meeting announcements. Also special announcements are welcome. As always, we would also be happy to receive feedback concerning the newsletter. The Latex template for submitting contributions, as well as all previous editions of ExoPlanet News, can be found on the ExoPlanet News webpage (http://nccr-planets.ch/exoplanetnews/).

The next issue will appear on 10 May 2022.

Holly Capelo
Daniel Angerhausen
Lokesh Mishra
Timm-Emanuel Riesen
Julia Venturini

2 Abstracts of refereed papers

Periodic orbits in the 1:2:3 resonant chain and their impact on the orbital dynamics of the Kepler-51 planetary system

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Astronomy & Astrophysics, in press, "arXiv:2203.03349"

Space missions have discovered a large number of exoplanets evolving in (or close to) mean-motion resonances (MMRs) and resonant chains. Often, the published data exhibit very high uncertainties due to the observational limitations that introduce chaos into the evolution of the system on especially shorter or longer timescales. We propose a study of the dynamics of such systems by exploring particular regions in phase space. We exemplify our method by studying the long-term orbital stability of the three-planet system Kepler-51 and either favor or constrain its data. It is a dual process which breaks down in two steps: the computation of the families of periodic orbits in the 1:2:3 resonant chain and the visualization of the phase space through maps of dynamical stability. We present novel results for the general four-body problem. Stable periodic orbits were found only in the low-eccentricity regime. We demonstrate three possible scenarios safeguarding Kepler-51, each followed by constraints. Firstly, there are the 2/1 and 3/2 two-body MMRs, in which $e_b < 0.02$, such that these two-body MMRs last for extended time spans. Secondly, there is the 1:2:3 three-body Laplace-like resonance, in which $e_c < 0.016$ and $e_d < 0.006$ are necessary for such a chain to be viable. Thirdly, there is the combination comprising the 1/1 secondary resonance inside the 2/1 MMR for the inner pair of planets and an apsidal difference oscillation for the outer pair of planets in which the observational eccentricities, e_b and e_c, are favored as long as $e_d \approx 0$. With the aim to obtain an optimum deduction of the orbital elements, this study showcases the need for dynamical analyses based on periodic orbits performed in parallel to the fitting processes.

Download/Website: `https://doi.org/10.1051/0004-6361/202142953`

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Grid of pseudo-2D chemistry models for tidally locked exoplanets - II. The role of photochemistry

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Monthly Notices of the Royal Astronomical Society, in press (arXiv:2203.11233)

Photochemistry is expected to change the chemical composition of the upper atmospheres of irradiated exoplanets through the dissociation of species, such as methane and ammonia, and the association of others, such as hydrogen cyanide. Although primarily the high altitude day side should be affected by photochemistry, it is still unclear how dynamical processes transport photochemical species throughout the atmosphere, and how these chemical disequilibrium effects scale with different parameters. In this work we investigate the influence of photochemistry in a two-dimensional context, by synthesizing a grid of photochemical models across a large range of temperatures. We find that photochemistry can strongly change the atmospheric composition, even up to depths of several bar in cool exoplanets. We further identify a sweet spot for the photochemical production of hydrogen cyanide and acetylene, two important haze precursors, between effective temperatures of 800 and 1400 K. The night sides of most cool planets ($T_{eff} < 1800$ K) are shown to host photochemistry products, transported from the day side by horizontal advection. Synthetic transmission spectra are only marginally affected by photochemistry, but we suggest that observational studies probing higher altitudes, such as high-resolution spectroscopy, take photochemistry into account.

Download/Website: `https://arxiv.org/abs/2203.11233`

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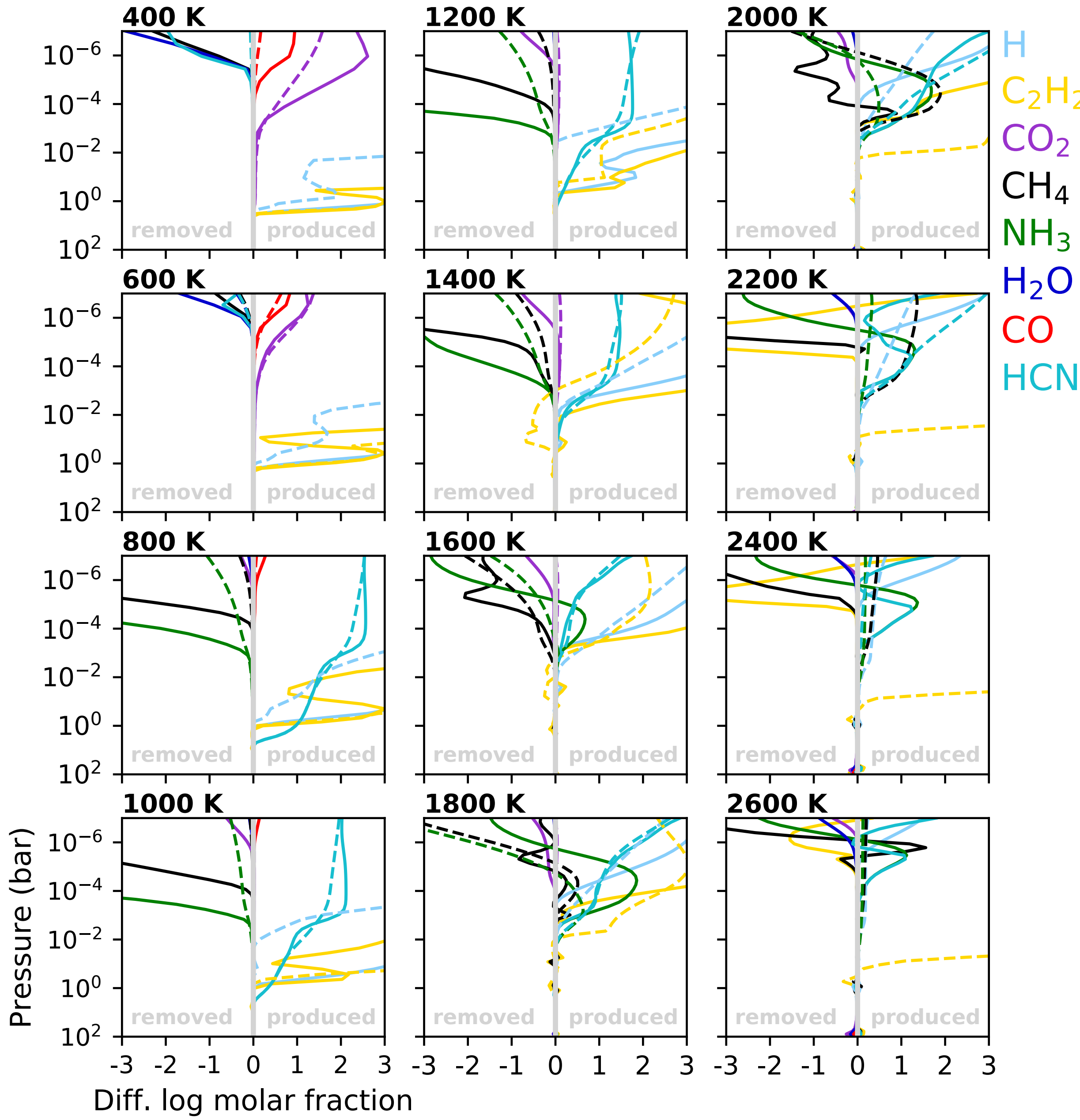

Figure 1: The differences in molecular abundance between models with photochemistry and without photochemistry are shown for planets with different effective temperature. Solid lines denote the substellar point and dashed lines shown the antistellar point. Strong photochemical activity can be seen between 800 and 1400 K, demonstrated by a production of HCN and C_2H_2, and dissociation of CH_4 and NH_3. Photochemically produced HCN remains abundant on the night side (dashed lines), while vertical mixing partially replenishes destroyed CH_4/NH_3.

A Self-Consistent Model for Dust-Gas Coupling in Protoplanetary Disks

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Astronomy & Astrophysics, in press

Various physical processes that ensue within protoplanetary disks – including vertical settling of icy/rocky grains, radial drift of solids, planetesimal formation, as well as planetary accretion itself – are facilitated by hydrodynamic interactions between H/He gas and high-Z dust. The Stokes number, which quantifies the strength of dust-gas coupling, thus plays a central role in protoplanetary disk evolution, and its poor determination constitutes an important source of uncertainty within the theory of planet formation. In this work, we present a simple model for dust-gas coupling, and demonstrate that for a specified combination of the nebular accretion rate, $\dot{M}$, and turbulence parameter, α, the radial profile of the Stokes number can be calculated uniquely. Our model indicates that the Stokes number grows sub-linearly with orbital radius, but increases dramatically across the water-ice line. For fiducial protoplanetary disk parameters of $\dot{M} = 10^{-8}\,M_{\odot}/\mathrm{year}$ and $\alpha = 10^{-3}$, our theory yields characteristic values of the Stokes number on the order of $\mathrm{St} \sim 10^{-4}$ (corresponding to ∼mm-sized silicate dust) in the inner nebula and $\mathrm{St} \sim 10^{-1}$ (corresponding to ∼few-cm-sized icy grains), in the outer regions of the disk. Accordingly, solids are expected to settle into a thin sub-disk at large stellocentric distances, while remaining vertically well-mixed inside the ice line.

Download/Website: `https://caltech.box.com/s/mh6dc8mdm1ibtsix3udkbnf6mt8cgd7t`

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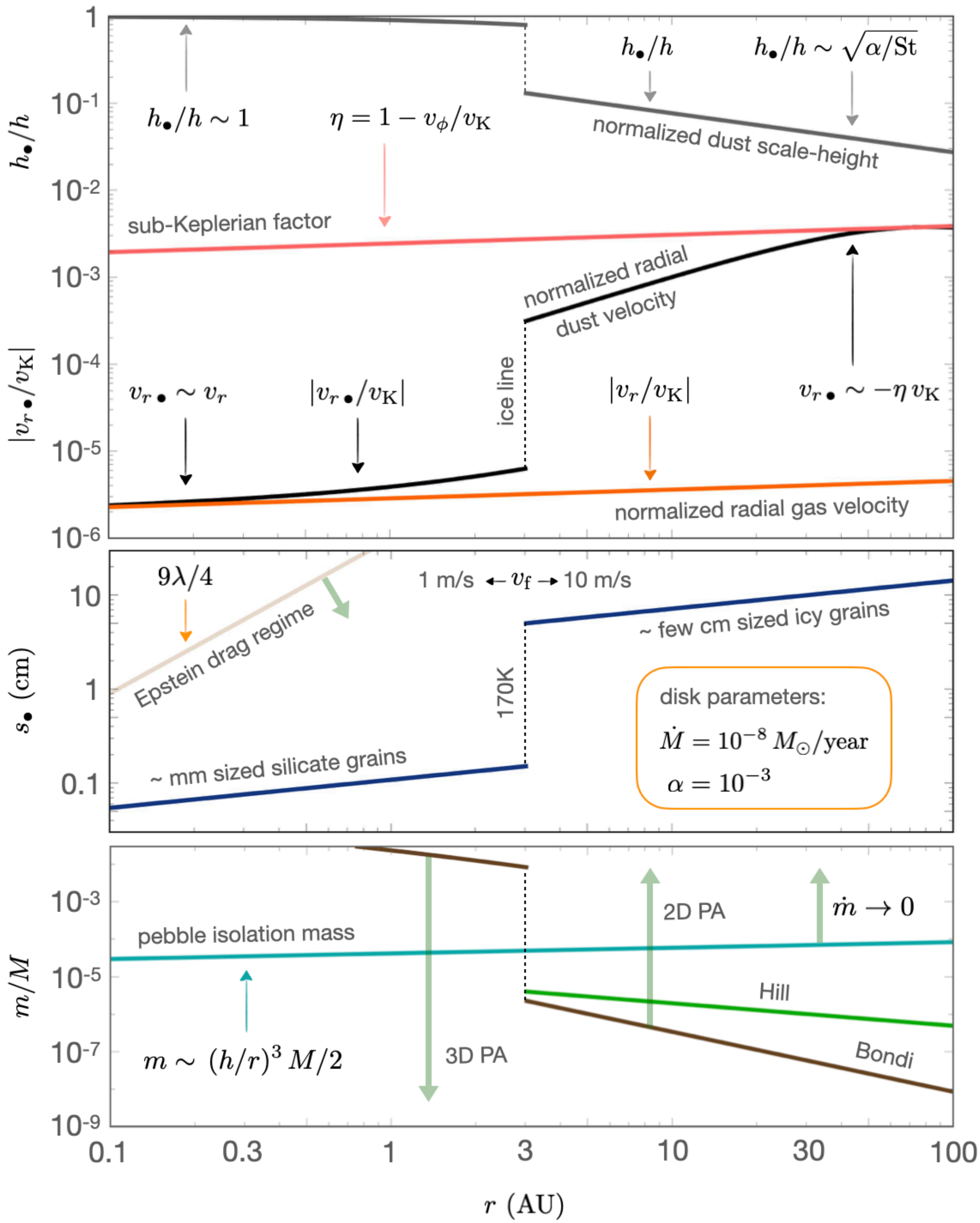

$h_\bullet/h$
$|v_{r\bullet}/v_K|$
$h_\bullet/h \sim 1$
$\eta = 1 - v_\phi/v_K$
$h_\bullet/h$
$h_\bullet/h \sim \sqrt{\alpha/\mathrm{St}}$
normalized dust scale-height
sub-Keplerian factor
normalized radial dust velocity
ice line
$v_{r\bullet} \sim v_r$
$|v_{r\bullet}/v_K|$
$|v_r/v_K|$
$v_{r\bullet} \sim -\eta\, v_K$
normalized radial gas velocity
$s_\bullet$ (cm)
$9\lambda/4$
1 m/s ← v_f → 10 m/s
Epstein drag regime
~ few cm sized icy grains
170K
disk parameters:
$\dot{M} = 10^{-8}\, M_\odot/\mathrm{year}$
$\alpha = 10^{-3}$
~ mm sized silicate grains
m/M
pebble isolation mass
2D PA
$\dot{m} \to 0$
Hill
Bondi
3D PA
$m \sim (h/r)^3\, M/2$
r (AU)

Figure 2

The polar orbit of the warm Neptune GJ 436b seen with VLT/ESPRESSO

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Astronomy & Astrophysics, in press / arXiv:2203.06109

GJ 436b might be the prototype of warm Neptunes that have undergone late migration induced by an outer companion. Precise determination of the orbital architecture of such systems is critical to constraining their dynamical history and evaluating the role of delayed migration in the exoplanet population. To this purpose we analyzed the Rossiter-McLaughlin (RM) signal of GJ 436 b in two transits —recently observed with ESPRESSO— using three different techniques. The high level of precision achieved in radial velocity (RV) measurements allows us to detect the deviation from the Keplerian orbit, despite the slow rotation of the M dwarf host ($v \sin i_* = 272.0^{+40.0}_{-34.0}\,\mathrm{m\,s^{-1}}$), and to measure the sky-projected obliquity ($\lambda = 102.5^{+17.2}_{-18.5}{}^{\circ}$). The Reloaded RM technique, which allows the stellar RV field along the transit chord to be analyzed, yields $\lambda = 107.5^{+23.6}_{-19.3}{}^{\circ}$ and $v \sin i_* = 292.9^{+41.9}_{-49.9}\,\mathrm{m\,s^{-1}}$. The RM Revolutions technique, which allows us to fit the spectral profiles from all planet-occulted regions together, yields $\lambda = 114.1^{+22.8}_{-17.8}{}^{\circ}$ and $v \sin i_* = 300.5^{+45.9}_{-57.0}\,\mathrm{m\,s^{-1}}$. The consistent results between these three techniques, and with published results from HARPS/HARPS-N data, confirm the polar orbit of GJ 436b and support the hypothesis that its origin lies in Kozai migration. Results from a joint RM Revolutions analysis of the ESPRESSO, HARPS, and HARPS-N datasets ($\lambda = 113.5^{+23.3}_{-17.3}{}^{\circ}$; $v \sin i_* = 293.5^{+43.7}_{-52.2}\,\mathrm{m\,s^{-1}}$) combined with a revised stellar inclination ($i_\star = 35.7^{+5.9}_{-7.6}{}^{\circ}$ or $144.2^{+7.6}_{-5.9}{}^{\circ}$) lead us to constrain the 3D obliquity Ψ to $103.2^{+12.8}_{-11.5}{}^{\circ}$.

Download/Website: `arxiv:2203.06109`

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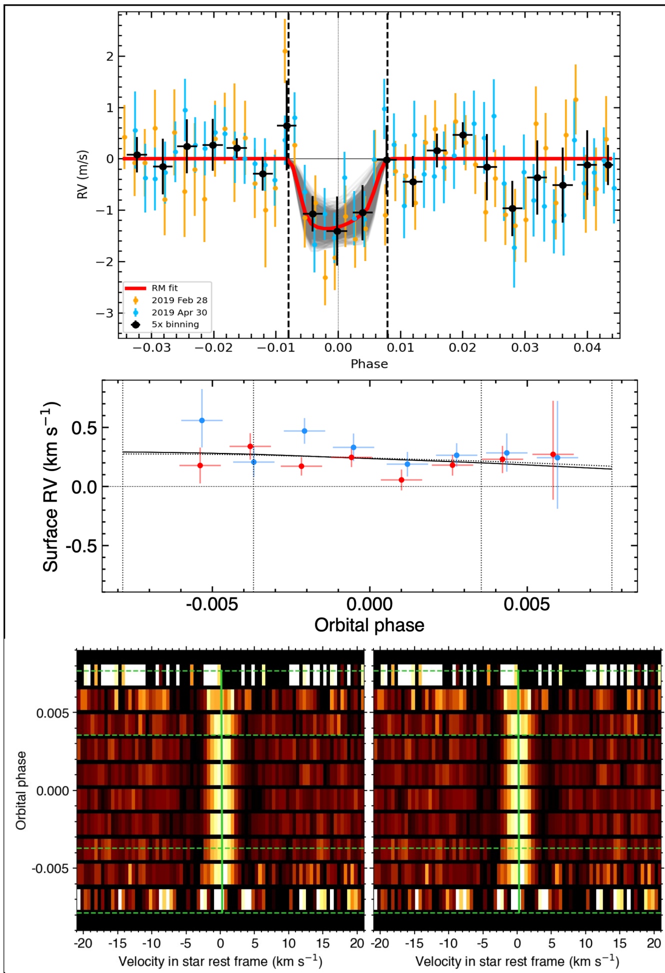

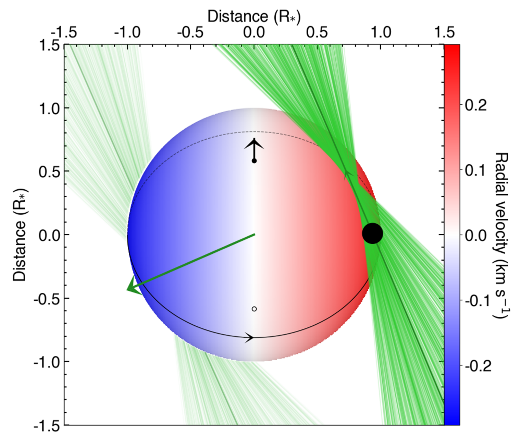

Orbital architecture of the GJ 436 system

GJ 436 is the first M dwarf across which a spectroscopic Rossiter-McLaughlin signal was detected, using HARPS/HARPS-N observations of its transiting warm Neptune companion (Bourrier et al. 2018, Nature). Here we confirm this detection with two ESPRESSO transits, comparing analyses of the classical RV anomaly (*left top panel*), of the stellar surface RVs extracted with the Reloaded RM method (*left middle panel*), and of the spectral line profiles from the planet-occulted regions fitted together with the RM Revolutions technique (*left bottom panel*). The three techniques yield consistent results for the polar orbit of GJ436b, and we refine its 3D spin-orbit angle to 103.2+12.8-11.5° (*right panel*)

Figure 3

High-contrast, high-angular resolution view of the GJ 367 exoplanet system

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Monthly Notices of the Royal Astronomical Society, in press (arXiv:2204.02998)

We search for additional companions in the GJ 367 exoplanet system, and aim at better constraining its age and evolutionary status. We analyse high contrast direct imaging observations obtained with HST/NICMOS, VLT/NACO, and VLT/SPHERE. We investigate and critically discuss conflicting age indicators based on theoretical isochrones and models for Galactic dynamics. A comparison of GAIA EDR3 parallax and photometric measurements with theoretical isochrones suggest a young age $\leq$60 Myr for GJ 367. The star's Galactic kinematics exclude membership to any nearby young moving group or stellar stream. Its highly eccentric Galactic orbit, however, is atypical for a young star. Age estimates considering Galactic dynamical evolution are most consistent with an age of 1 to 8 Gyr. We find no evidence for a significant mid-infrared excess in the WISE bands, suggesting the absence of warm dust in the GJ 367 system. The direct imaging data provide significantly improved detection limits compared to previous studies. At 530 mas (5 au) separation, the SPHERE data achieve a 5 sigma contrast of 2.6×10^{-6}. The data exclude the presence of a stellar companion at projected separations $\geq$0.4 au. At projected separations $\geq$5 au we can exclude substellar companions with a mass $\geq$ 1.5 $M_{\rm Jup}$ for an age of 50 Myr, and $\geq$ 20 $M_{\rm Jup}$ for an age of 5 Gyr. By applying the stellar parameters corresponding to the 50 Myr isochrone, we derive a bulk density of $\rho_{\rm planet} = 6.2$ g/cm^3 for GJ 367 b, which is 25% smaller than a previous estimate.

Download/Website: https://doi.org/10.1093/mnras/stac961

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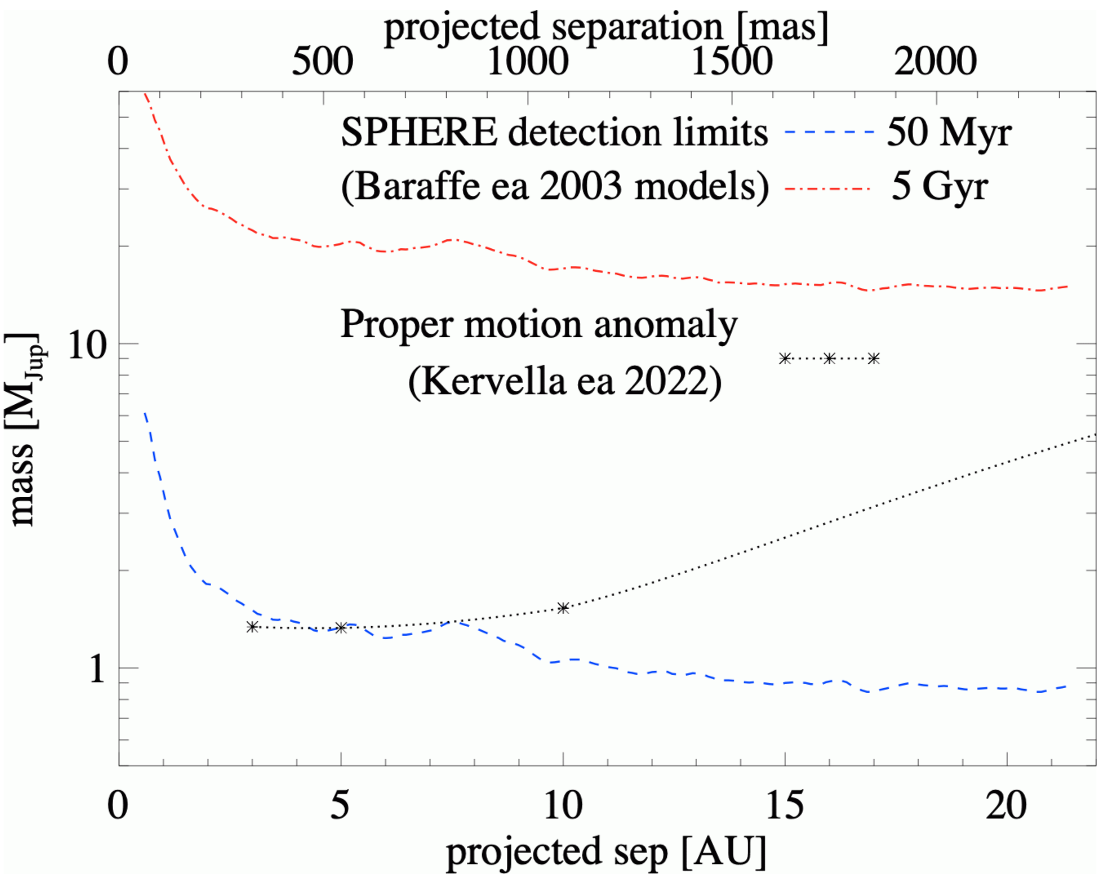

Figure 4: Radial mass detection limits for SPHERE, transformed from $5\,\sigma$ contrast limits using the models by Baraffe et al. 2003 for ages of 50 Myr (blue dashed line) and 5 Gyr (red dashed-dotted line). The asterisk symbols and the dotted line mark the companion mass to orbital radius relation explaining the proper motion anomaly of GJ 367 according to Kervella et al. 2022.

Longitudinally asymmetric stratospheric oscillation on a tidally locked exoplanet

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The Astrophysical Journal, in press (arXiv:2111.11281)

Using a three-dimensional general circulation model, we show that the atmospheric dynamics on a tidally locked Earth-like exoplanet, simulated with the planetary and orbital parameters of Proxima Centauri b, support a longitudinally asymmetric stratospheric wind oscillation (LASO), analogous to Earth's quasi-biennial oscillation (QBO). In our simulations, the LASO has a vertical extent of 35–55 km, a period of 5–6.5 months, and a peak-to-peak wind speed amplitude of -70 to +130 ms^{-1} with a maximum at an altitude of 41 km. Unlike the QBO, the LASO displays longitudinal asymmetries related to the asymmetric thermal forcing of the planet and to interactions with the resulting stationary Rossby waves. The equatorial gravity wave sources driving the LASO are localised in the deep convection region at the substellar point and in a jet exit region near the western terminator, unlike the QBO, for which these sources are distributed uniformly around the planet. Longitudinally, the western terminator experiences the highest wind speeds and undergoes reversals earlier than other longitudes. The antistellar point only experiences a weak oscillation with a very brief, low-speed westward phase. The QBO on Earth is associated with fluctuations in the abundances of water vapour and trace gases such as ozone which are also likely to occur on exoplanets if these gases are present. Strong fluctuations in temperature and the abundances of atmospheric species at the terminators will need to be considered when interpreting atmospheric observations of tidally locked exoplanets.

Download/Website: `https://arxiv.org/abs/2111.11281`

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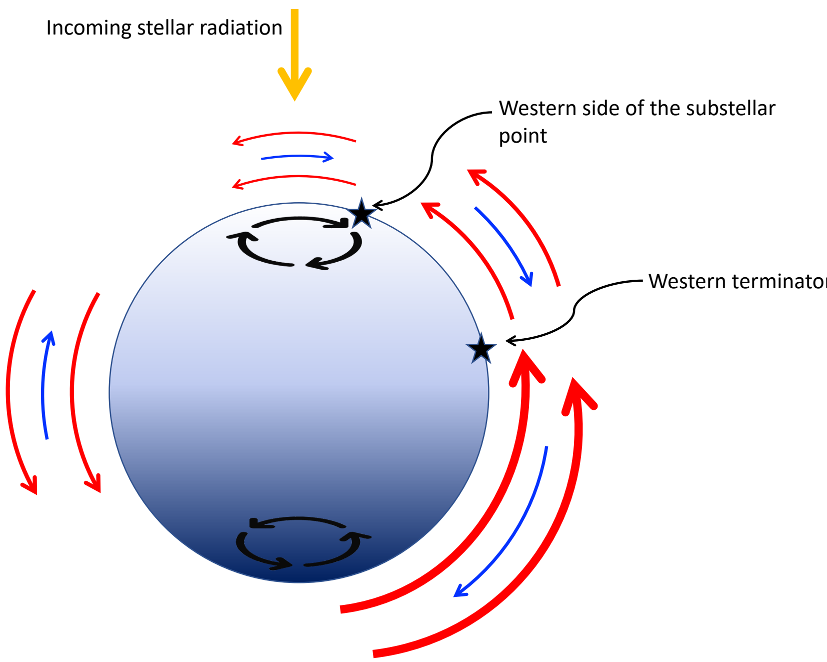

Figure 5: Schematic diagram of the location and interaction of Rossby waves, equatorial jets, and gravity wave sources. The perspective is looking downward from the north pole. The lighter side of the sphere is the dayside and the darker is the nightside. Red (blue) arrows indicate eastward (westward) air flow, with larger arrows representing faster wind speeds. Black spirals represent Rossby waves. The star symbol indicates gravity wave sources.

Half-sibling regression meets exoplanet imaging: PSF modeling and subtraction using a flexible, domain knowledge-driven, causal framework

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Astronomy & Astrophysics, in press (arXiv:2204.03439)

Context: High-contrast imaging of exoplanets hinges on powerful post-processing methods to denoise the data and separate the signal of a companion from its host star, which is typically orders of magnitude brighter.
Aims: Existing post-processing algorithms do not use all prior domain knowledge that is available about the problem. We propose a new method that builds on our understanding of the systematic noise and the causal structure of the data-generating process.
Methods: Our algorithm is based on a modified version of *half-sibling regression* (HSR), a flexible denoising framework that combines ideas from the fields of machine learning and causality. We adapt the method to address the specific requirements of high-contrast exoplanet imaging data obtained in pupil tracking mode. The key idea is to estimate the systematic noise in a pixel by regressing the time series of this pixel onto a set of causally independent, signal-free predictor pixels. We use regularized linear models in this work; however, other (non-linear) models are also possible. In a second step, we demonstrate how the HSR framework allows us to incorporate observing conditions such as wind speed or air temperature as additional predictors.
Results: When we apply our method to four data sets from the VLT/NACO instrument, our algorithm provides a better false-positive fraction than PCA-based PSF subtraction, a popular baseline method in the field. Additionally, we find that the HSR-based method provides direct and accurate estimates for the contrast of the exoplanets without the need to insert artificial companions for calibration in the data sets. Finally, we present first evidence that using the observing conditions as additional predictors can improve the results.
Conclusions: Our HSR-based method provides an alternative, flexible and promising approach to the challenge of modeling and subtracting the stellar PSF and systematic noise in exoplanet imaging data.

Download/Website: `https://github.com/timothygebhard/hsr4hci`

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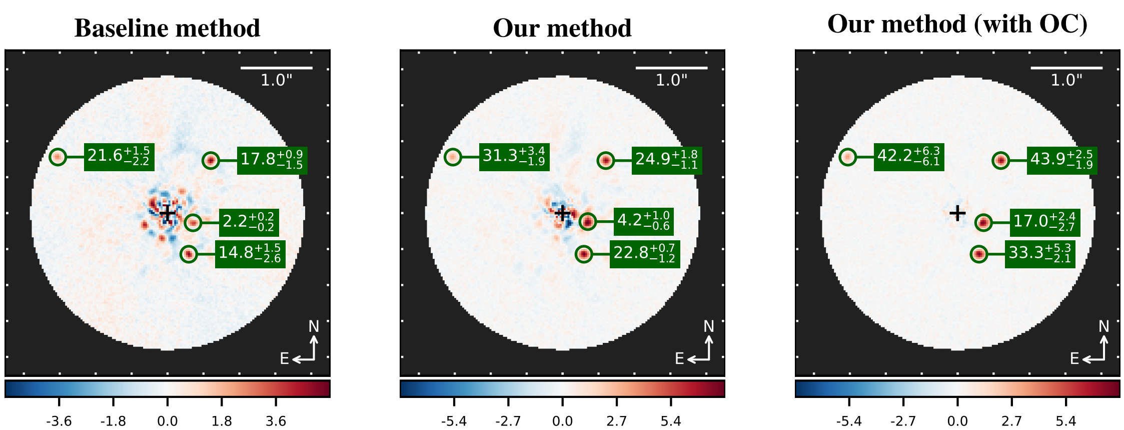

Figure 6: Exemplary post-processing results on an L'-band data set of the well-known HR 8799 system obtained with VLT/NACO. The figure shows a comparison between the baseline method (i.e., PCA-based PSF subtraction) and our method, both with and without the observing conditions (OC) as additional metadata. Each panel contains the respective signal estimate in units of flux. The numbers on the labels denote the negative decimal logarithm of the false positive fraction (i.e., $-\log_{10}\mathrm{FPF}$). Higher values indicate higher confidence in a detection. Among other things, we find that our algorithm usually provides better $-\log_{10}\mathrm{FPF}$ scores than the baseline method and show that incorporating the observing conditions into an HCI/ADI post-processing pipeline can improve the results.

Gap carving by a migrating planet embedded in a massive debris disc

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Monthly Notices of the Royal Astronomical Society, in press (arXiv:2203.03611)

When considering gaps in debris discs, a typical approach is to invoke clearing by an unseen planet within the gap, and derive the planet mass using Wisdom overlap or Hill radius arguments. However, this approach can be invalid if the disc is massive, because this clearing would also cause planet migration. This could result in a calculated planet mass that is incompatible with the inferred disc mass, because the predicted planet would in reality be too small to carve the gap without significant migration. We investigate the gap that a single embedded planet would carve in a massive debris disc. We show that a degeneracy is introduced, whereby an observed gap could be carved by *two* different planets: either a high-mass, barely-migrating planet, or a smaller planet that clears debris as it migrates. We find that, depending on disc mass, there is a minimum possible gap width that an embedded planet could carve (because smaller planets, rather than carving a smaller gap, would actually migrate through the disc and clear a wider region). We provide simple formulae for the planet-to-debris disc mass ratio at which planet migration becomes important, the gap width that an embedded planet would carve in a massive debris disc, and the interaction timescale. We also apply our results to various systems, and in particular show that the disc of HD 107146 can be reasonably well-reproduced with a migrating, embedded planet. Finally, we discuss the importance of planet-debris disc interactions as a tool for constraining debris disc masses.

Download/Website: `https://ui.adsabs.harvard.edu/abs/2022MNRAS.tmp..658F/abstract`
Contact: `marc.friebe@uni-jena.de`

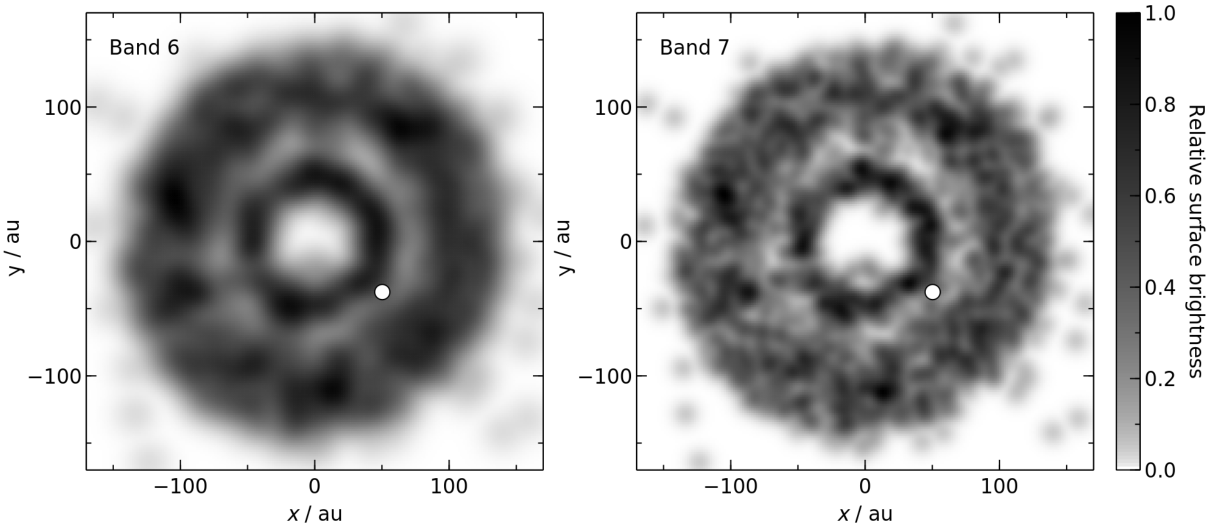

Figure 7: Simulated ALMA images from an n-body simulation of $\mathrm{HD}\ 107146$ if the debris disc gap is carved by a single migrating planet. The simulation had a $0.03\ \mathrm{M_{Jup}}$ ($10\ \mathrm{M_{\oplus}}$) planet initially located at $81\ \mathrm{au}$, embedded in a disc with initial mass $50\ \mathrm{M_{\oplus}}$, span $40 - 146\ \mathrm{au}$, and surface density $\propto r^{-1/4}$. The figure shows the simulation at $150\ \mathrm{Myr}$, the system lifetime, over which time the planet migrated inwards by $15\ \mathrm{au}$ before its migration stalled. To make the simulated ALMA images, the system has been rotated to the orientation of $\mathrm{HD}\ 107146$ on the sky, each n-body particle scaled for emission, and convolved with a 2D Gaussian representing the ALMA beam (band 6 left, band 7 right). White circles denote the planet. The simulation reproduces observations reasonably well; compare the figure to Figures 1 and 2 in Marino et al. 2018.

Architectures of Compact Super-Earth Systems Shaped by Instabilities

M. Goldberg[1], *K. Batygin*[2]

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[2] Division of Geological and Planetary Sciences, California Institute of Technology, 1200 E. California Blvd, Pasadena, CA 91125, USA

The Astronomical Journal, in press (arXiv:2203.00801)

Compact non-resonant systems of sub-Jovian planets are the most common outcome of the planet formation process. Despite exhibiting broad overall diversity, these planets also display dramatic signatures of intra-system uniformity in their masses, radii, and orbital spacings. Although the details of their formation and early evolution are poorly known, sub-Jovian planets are expected to emerge from their natal nebulae as multi-resonant chains, owing to planet-disk interactions. Within the context of this scenario, the architectures of observed exoplanet systems can be broadly replicated if resonances are disrupted through post-nebular dynamical instabilities. Here, we generate an ad-hoc sample of resonant chains and use a suite of N-body simulations to show that instabilities can not only reproduce the observed period ratio distribution, but that the resulting collisions also modify the mass uniformity in a way that is consistent with the data. Furthermore, we demonstrate that primordial mass uniformity, motivated by the sample of resonant chains coupled with dynamical sculpting, naturally generates uniformity in orbital period spacing similar to what is observed. Finally, we find that almost all collisions lead to perfect mergers, but some form of post-instability damping is likely needed to fully account for the present-day dynamically cold architectures of sub-Jovian exoplanets.

Download/Website: `https://arxiv.org/abs/2203.00801`

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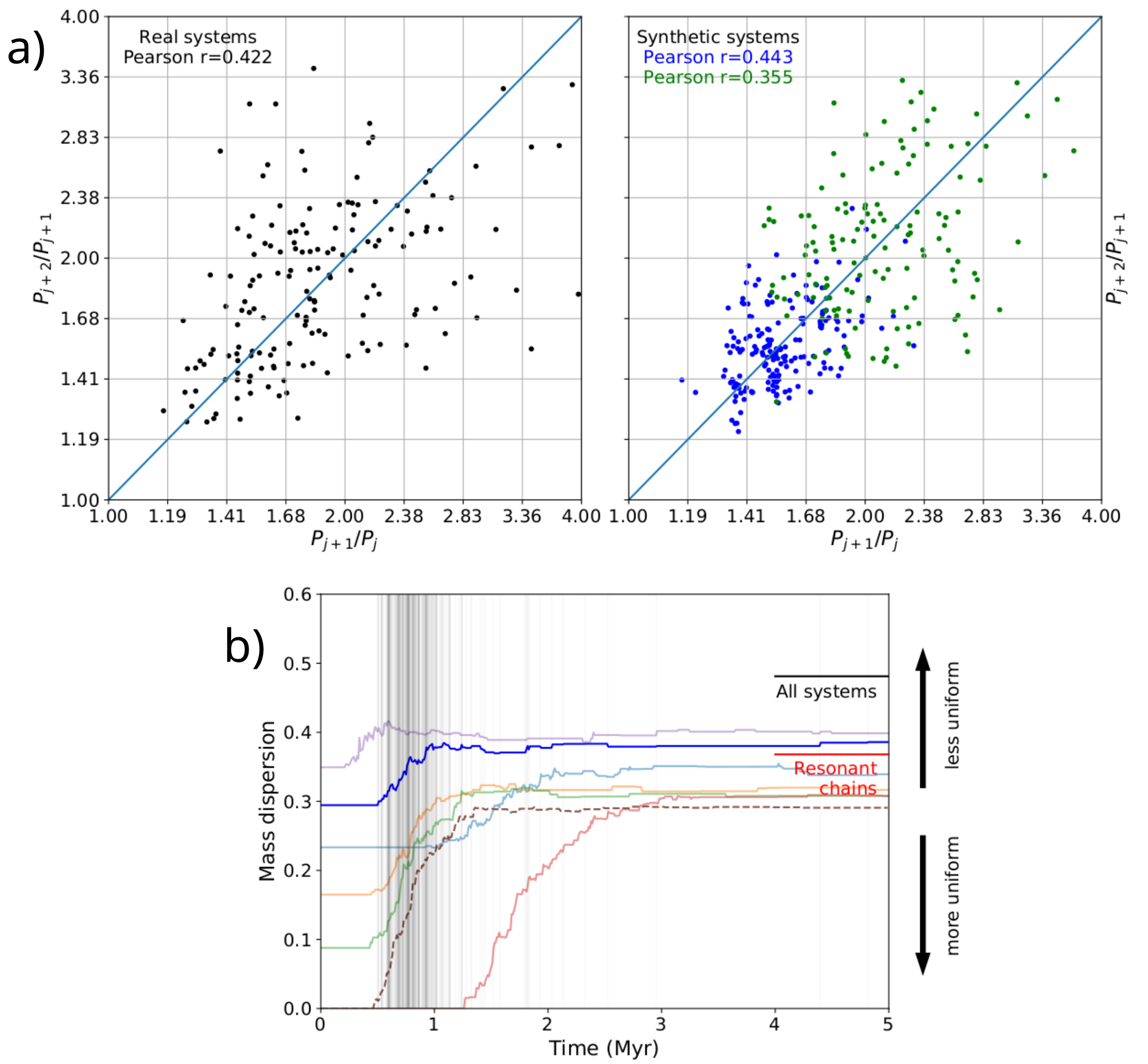

Figure 8: **a)** For trios of planets, the orbital period ratio of the inner planet pair vs. outer planet pair for the well-characterized systems in the California Kepler Survey **(left)** and synthetic post-instability systems **(right)**. In the right panel, blue and green dots correspond to low-mass and high-mass planets, respectively.
b) Changes in the intra-system mass dispersion during the post-disk instability phase for super-Earth systems that initially have 11 planets in resonance. The dashed line marks a set of simulations with lower planet masses. The red and black horizontal lines represent the mass dispersion for the observed resonant chains and all systems, respectively. For the set of simulations plotted darker in blue, translucent vertical lines indicate the time of a collision and merger, which triggers a change in the mass dispersion.

Large Interferometer For Exoplanets (*LIFE*): I. Improved exoplanet detection yield estimates for a large mid-infrared space-interferometer mission

S.P. Quanz[1], M. Ottiger[1], E. Fontanet[1], J. Kammerer[2,3], F. Menti[1], F. Dannert[1], A. Gheorghe[1], O. Absil[4], V.S. Airapetian[5], E. Alei[1], R. Allart[6], D. Angerhausen[1], (+58 co-authors; the LIFE collaboration[8])

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[2] ESO, Garching
[3] Australia National University
[4] University of Liège
[5] NASA Goddard
[6] Université de Montréal
[7] www.life-space-mission.com

Astronomy & Astrophysics, in press (arXiv:2101.07500)

One of the long-term goals of exoplanet science is the atmospheric characterization of dozens of small exoplanets in order to understand their diversity and search for habitable worlds and potential biosignatures. Achieving this goal requires a space mission of sufficient scale that can spatially separate the signals from exoplanets and their host stars and thus directly scrutinize the exoplanets and their atmospheres.

We seek to quantify the exoplanet detection performance of a space-based mid-infrared (MIR) nulling interferometer that measures the thermal emission of exoplanets. We study the impact of various parameters and compare the performance with that of large single-aperture mission concepts that detect exoplanets in reflected light.

We have developed an instrument simulator that considers all major astrophysical noise sources and coupled it with Monte Carlo simulations of a synthetic exoplanet population around main-sequence stars within 20 pc of the Sun. This allows us to quantify the number (and types) of exoplanets that our mission concept could detect. Considering single visits only, we discuss two different scenarios for distributing 2.5 years of an initial search phase among the stellar targets. Different apertures sizes and wavelength ranges are investigated.

An interferometer consisting of four 2 m apertures working in the 4–18.5 μm wavelength range with a total instrument throughput of 5% could detect up to $\approx$550 exoplanets with radii between 0.5 and 6 $R_\oplus$ with an integrated S/N$\geq$7. At least $\approx$160 of the detected exoplanets have radii $\leq$1.5 $R_\oplus$. Depending on the observing scenario, $\approx$25–45 rocky exoplanets (objects with radii between 0.5 and 1.5 $_\oplus$) orbiting within the empirical habitable zone (eHZ) of their host stars are among the detections. With four 3.5 m apertures, the total number of detections can increase to up to $\approx$770, including $\approx$60–80 rocky eHZ planets. With four times 1 m apertures, the maximum detection yield is $\approx$315 exoplanets, including $\leq$20 rocky eHZ planets. The vast majority of small, temperate exoplanets are detected around M dwarfs. The impact of changing the wavelength range to 3–20 μm or 6–17 μm on the detection yield is negligible.

A large space-based MIR nulling interferometer will be able to directly detect hundreds of small, nearby exoplanets, tens of which would be habitable world candidates. This shows that such a mission can compete with large single-aperture reflected light missions. Further increasing the number of habitable world candidates, in particular around solar-type stars, appears possible via the implementation of a multi-visit strategy during the search phase. The high median S/N of most of the detected planets will allow for first estimates of their radii and effective temperatures and will help prioritize the targets for a second mission phase to obtain high-S/N thermal emission spectra, leveraging the superior diagnostic power of the MIR regime compared to shorter wavelengths.

Download/Website: `https://arxiv.org/abs/2101.07500`

Contact: `sascha.quanz@phys.ethz.ch`

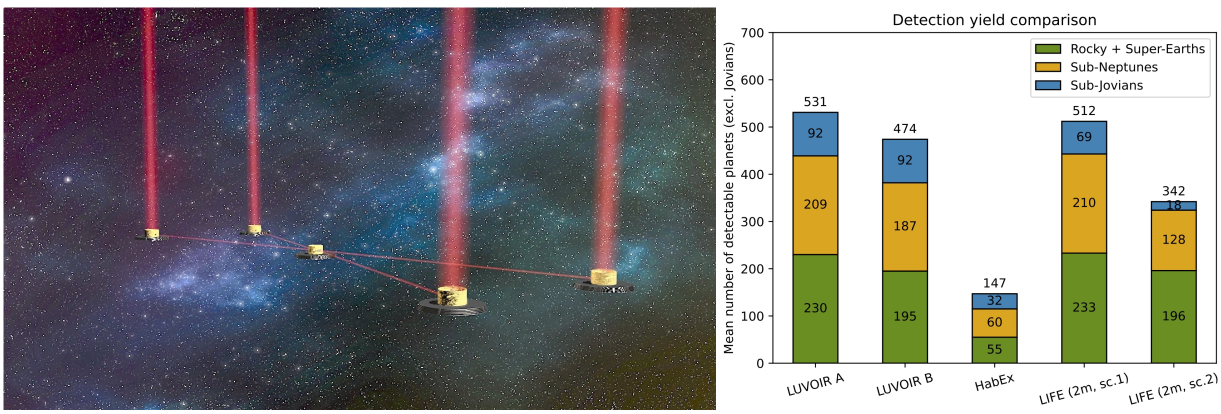

Figure 9: Left: Artist's impression of the LIFE nulling-interferometry mission, consisting of four collector spacecraft in a rectangular array configuration sending light to a beam combiner spacecraft in the center. Right: Detection yield comparison between LUVOIR A/B, HabEx, and LIFE. For LIFE we show the numbers for the D = 2 m reference case (and 2 mission scenarios) and for HabEx the numbers from the baseline 4-meter concept. Jovian planets are not shown, because they were not included in the LIFE simulations

Large Interferometer For Exoplanets (LIFE): III. Spectral resolution, wavelength range, and sensitivity requirements based on atmospheric retrieval analyses of an exo-Earth

B.S. Konrad[1,2], *E. Alei* [1,2], *S.P. Quanz* [1,2], *D. Angerhausen* [1,2,3], *Ó. Carrión-González*[4], *J.J. Fortney*[5], *J.L. Grenfell*[6], *D. Kitzmann*[7], *P. Mollière*[8], *S. Rugheimer*[9], *F. Wunderlich*[6], *LIFE Collaboration* [10]

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[10] www.life-space-mission.com

Astronomy & Astrophysics, in press (arXiv:2112.02054)

Context: Temperate terrestrial exoplanets are likely to be common objects, but their discovery and characterization is very challenging because of the small intrinsic signal compared to that of their host star. Various concepts for optimized space missions to overcome these challenges are currently being studied. The *Large Interferometer For Exoplanets (LIFE)* initiative focuses on the development of a spacebased mid-infrared (MIR) nulling interferometer probing the thermal emission of a large sample of exoplanets.
Aims: This study derives the minimum requirements for the signal-to-noise ratio (S/N), the spectral resolution (R), and the wavelength coverage for the *LIFE* mission concept. Using an Earth-twin exoplanet as a reference case, we quantify how well planetary and atmospheric properties can be derived from its MIR thermal emission spectrum as a function of the wavelength range, S/N, and R.
Methods: We combined a cloud-free 1D atmospheric radiative transfer model, a noise model for observations with the *LIFE* interferometer, and the nested sampling algorithm for Bayesian parameter inference to retrieve planetary and atmospheric properties. We simulated observations of an Earth-twin exoplanet orbiting a G2V star at 10 pc from the Sun with different levels of exozodiacal dust emissions. We investigated a grid of wavelength ranges ($3-20\,\mu$m, $4-18.5\,\mu$m, and $6-17\,\mu$m), S/Ns (5, 10, 15, and 20 determined at a wavelength of $11.2\,\mu$m), and Rs (20, 35, 50, and 100).
Results: We find that H_2O, CO_2, and O_3 are detectable if S/N $\geq$ 10 (uncertainty $\leq \pm1.0$ dex). We find upper limits for N_2O (abundance $\leq 10^{-3}$). In conrtrast, CO, N_2, and O_2 are unconstrained. The lower limits for a CH_4 detection are R $= 50$ and S/N $= 10$. Our retrieval framework correctly determines the exoplanet's radius (uncertainty $\leq \pm10\%$), surface temperature (uncertainty $\leq \pm20\,$K), and surface pressure (uncertainty $\leq \pm0.5$ dex) in all cloud-free retrieval analyses. Based on our current assumptions, the observation time required to reach the specified S/N for an Earth-twin at 10 pc when conservatively assuming a total instrument throughput of 5% amounts to $\approx$ 6-7 weeks with four 2 m apertures.
Conclusions: We provide first order estimates for the minimum technical requirements for *LIFE* via the retrieval study of an Earth-twin exoplanet. We conclude that a minimum wavelength coverage of $4-18.5\,\mu$m, an R of 50, and an S/N of at least 10 is required. With the current assumptions, the atmospheric characterization of several Earth-like exoplanets at a distance of 10 pc and within a reasonable amount of observing time will require apertures $\geq$ 2 meters.

Download/Website: `https://arxiv.org/abs/2112.02054`

Contact: `konradb@ethz.ch, sascha.quanz@phys.ethz.ch`

Feasibility of detecting and characterizing embedded low-mass giant planets in gaps in the VIS/NIR wavelength range

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Astronomy & Astrophysics, accepted (arXiv:2203.01891)

High-contrast imaging in the visible and near-infrared (VIS/NIR) has revealed the presence of a plethora of substructures in circumstellar disks (CSDs). One of the most commonly observed substructures are concentric gaps that are often attributed to the presence of embedded forming planets. However, direct detections of these planets are extremely rare, and thus ambiguity regarding the origin of most gap features remains. The aim of this study is to investigate the capabilities of high-contrast VIS/NIR imaging of directly detecting and characterizing low-mass giant planets in gaps in a broad systematic parameter study. To this end, a grid of models of protoplanetary disks was generated. The models include a central T Tauri star surrounded by a face-on CSD harboring an accreting planet, which itself is surrounded by a circumplanetary disk (CPD) and carves a gap. These gaps are modeled using empirically determined profiles, and the whole system is simulated fully self-consistently using the Monte Carlo radiative transfer code Mol3D in order to generate temperature distributions and synthetic observations assuming a generic dust composition consisting of astronomical silicate and graphite. Based on these simulations, we measured the impact the planet and its CPD have on contrast curves and quantified the impact of the observing wavelength and of five key parameters (planetary mass, mass accretion rate, distance to the star, mass of the CPD, and mass of the CSD) on the determined signal strength. Subsequently, we applied a detection criterion on our results and assess the capabilities of the instrument SPHERE/VLT of detecting the embedded planets. We find that a part of the investigated parameter space includes detectable planets, and we elaborate on the implication a non-detection has on the underlying parameters of a potential planet and its CPD. Furthermore, we analyze the potential loss of valuable information that would enable the detection of embedded planets by the use of a coronagraphic mask. However, we find this outcome to be extremely unlikely in the case of SPHERE. Finally, within the VIS/NIR wavelength range we identify for each of the investigated basic properties of the planets and the disks the most promising observing wavelengths that enable us to distinguish between different underlying parameter values. In doing so, we find that the detectability and the characterization often benefit from different observing wavelengths, highlighting the complementarity and importance of multiwavelength observations.

Download/Website: `https://arxiv.org/abs/2203.01891`

Contact: `akrieger@astrophysik.uni-kiel.de`

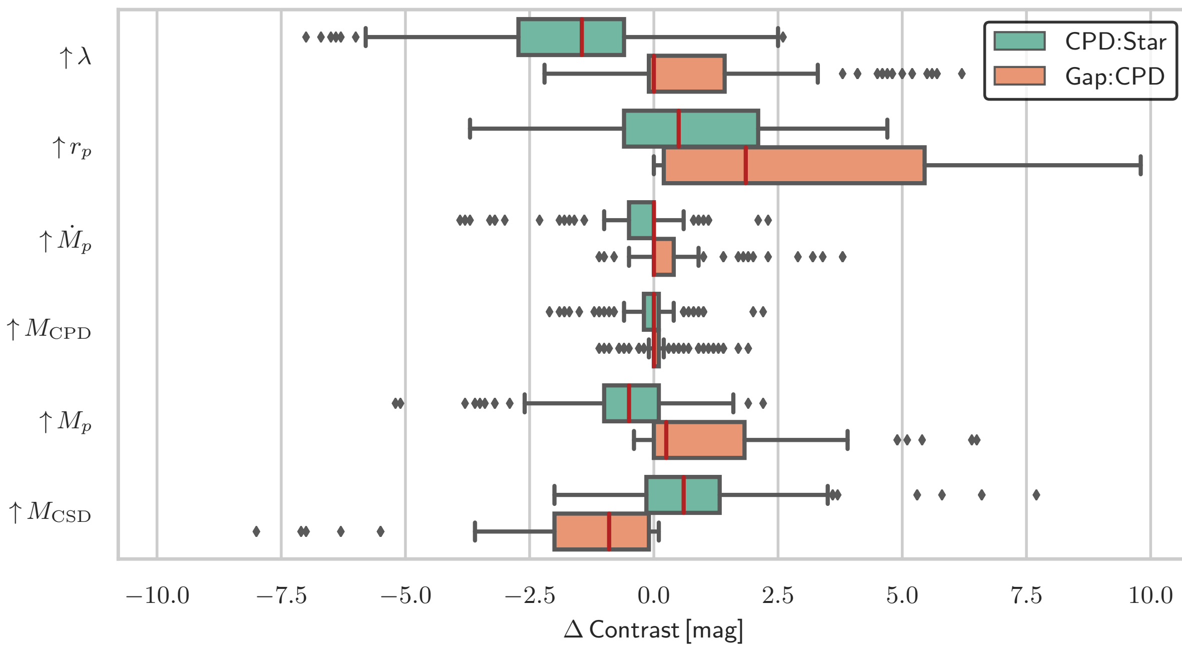


Figure 10: Distribution of contrast value changes of CPD : Star (contrast between CPD and star) and Gap : CPD (contrast between gap and CPD) with respect to the change in a single model parameter using boxplots. Generally, an increase in any parameter value may lead to an improved or a worsened contrast. In this context, an improved contrast refers to a contrast change that is beneficial for a detection, for instance a reduced contrast CPD : Star or an increased contrast Gap : CPD. Each boxplot's median is highlighted by a red line, the middle $50\,\%$ of data are represented by a box, and the maximum whisker length equals $\Delta w = 1.5\,$IQR, where IQR is the interquartile range (i.e., the width of the box). The labels to the left characterize the data used in generating the corresponding boxplots to the right of the label. A label refers to a parameter that has been increased to its next simulated value. The parameters are the observing wavelength (λ), the planetary mass (M_p), the mass accretion rate onto the planet ($\dot{M}_p$), the distance between the star and the planet (r_p), the mass of the CPD ($M_{\rm CPD}$), and the mass of the CSD ($M_{\rm CSD}$). Outliers are shown as black diamonds.

3 Exoplanet Archive Updates

April 2022 Updates at the NASA Exoplanet Archive

The NASA Exoplanet Archive team
Caltech/IPAC-NASA Exoplanet Science Institute, MC 100-22 Pasadena CA 91125

Pasadena CA USA, April 12, 2022

Note: Unless otherwise noted, all planetary and stellar data mentioned in the news are in the Planetary Systems Table (`http://bit.ly/2Pt0tM1`), which provides a single location for all self-consistent planetary solutions, and its companion table the Planetary Systems Composite Parameters (`https://bit.ly/2Fer9NU`), which offers a more complete table of parameters combined from multiple references and calculations. Data can also be found in the Microlensing Planets Table (`https://bit.ly/3urUyZU`) or Direct Imaging Planets Table (`http://bit.ly/3ayD185`).

March 31, 2022

Four New Planets, Including A Newborn Giant

This week we have four new planets, including 11 million-year-old TOI-1227 b, which has a radius almost equal to Jupiter, making it the largest planet ever seen around a low-mass star. Read the discovery paper (`https://bit.ly/3uiqLoG`) and this Nature article (`https://go.nature.com/3NUCq4O`) for details.

This week's other new planets are HD 191939 e & f and OGLE-2014-BLG-0319L b. We've also added 13 new K2 candidates and parameter sets for six planets.

March 21, 2022

5,000+ Alien Worlds and Counting

Today's update marks a major milestone for exoplanet science: the archive has more than 5,000 planets!

In the 30 years that have passed since two planets were found orbiting pulsar PSR1257+12, the field of exoplanet science has exploded. New missions, instruments, and detection techniques have proliferated, and with them the discoveries of all sorts of alien worlds. This week's milestone marks 30 years of discovery that shows no signs of ebbing, as current missions like NASA's TESS and ESA's Gaia and upcoming missions like NASA's Roman and ESA's PLATO will require the NASA Exoplanet Archive to expand and scale for the onslaught of more planets and bigger data sets. We accept the challenge—and we can't wait!

In celebration of today's milestone, our friends and colleagues at NASA's Exoplanet Exploration program (`https://exoplanets.nasa.gov/`) have created some fun and educational media about our search for new worlds:

- This NASA media release (`https://go.nasa.gov/3r9LtVO`) reflects on what we've learned about exoplanets over three decades.
- This video (`https://bit.ly/370C4sV`) shows how we've managed to find exoplanets everywhere we've looked.

- **What do 5,005 exoplanets sound like?** Turn up the volume for this sonification (https://bit.ly/38BwWMk), where instrumental melodies and tones play according to a chart of every exoplanet discovered. Be sure to check out the version for mobile devices for a 360-degree experience.

This Week's New Planets

This week's release of 65 new planets features the K2-384 system—a TRAPPIST-1-like system of five small planets orbiting a mid-M dwarf—as well as K2-399 b, an ultra-short period sub-Saturn located where hot Saturns are not typically found. Read the discovery paper for details (https://bit.ly/3v0OWXR).

The other new planets this week are WASP-189 b, HD 73583 b & c, TOI-1670 b & c, EPIC 206317286 c (a.k.a. K2-303 c), and all K2 systems starting with K2-365 through K2-409.

March 11, 2022

Five Planets, Including Two Microlensing Super-Earths

This week's new planets include two super-Earth microlensing planets—-a further indication that microlensing detections are ramping up and pushing to smaller-mass planets. The new planets are KMT-2017-BLG-2509L b, OGLE-2017-BLG-1099L b, OGLE-2019-BLG-0299L b, KMT-2021-BLG-0912L b, and KMT-2018-BLG-1988L b. These bring the archive's total confirmed planet count to 4,940. Only 60 discoveries to go to hit the 5,000-planet milestone!

Download/Website: https://exoplanetarchive.ipac.caltech.edu

Contact: mharbut@caltech.edu

4 Jobs and Positions

PhD Position in Atmosphere Modelling

Physics Institute, University of Bern, Switzerland

Deadline: 29 April 2022,

The Space Research and Planetology Division at the University of Bern (WP, http://space.unibe.ch) is seeking a PhD student to join its Space Science Group. The Space Science Group studies the composition of tenuous gases in the vicinity of solar system objects and determines surface compositions using laser ablation techniques. Over the past 20 years, our group has developed a model for the collision-less regime of planetary atmosphere. This model has been successfully applied to a variety of planets, moons, asteroids, and comets (e.g., Mercury, Moon, Venus, Titan, Europa, Callisto, Ganymede, Churyumov-Gerasimenko) and includes all relevant physical processes governing these atmospheres. Our modeling work is often performed as scientific support of upcoming ESA and NASA space missions, most recently for ESA's BepiColombo mission to Mercury and ESA's JUICE mission to Jupiter and its icy moons, to the latter of which we contributed the mass spectrometer.
The goal of the proposed PhD project is to extend this model to also cover the collisional regime in atmospheres with a Direct Simulation Monte Carlo module to which our existing model will be coupled. This model will be used to study atmospheres of planetary objects in our own solar system as well as in other solar systems (i.e., exoplanets). Collisional atmospheres are found on a wide variety of objects in our solar system, including Mars, Earth, Venus, Titan, and Callisto. Numerous Earth- and space-based spectroscopic and in situ measurement campaigns of planetary atmospheres within our solar system have provided us with a wealth of data that we can use to test and verify our model. For exoplanets, the first and often only way to determine the planet's chemical composition is to observe its atmosphere. In addition, atmospheric properties such as density and temperature provide further information about the exoplanet and the environment in which it is situated. One of the main objectives here is to determine if an exoplanet might be habitable.
The PhD position is part of the National Centre of Competence in Research (NCCRs) PlanetS (https://nccr-planets.ch/de/) at the University of Bern. PlanetS is dedicated to study all aspects of planet formation and evolution. The work will be carried out in close collaboration within the NCCR at the national level and within the upcoming ESA and NASA Jupiter missions at the international level.
The deadline for applications is 29 April 2022, the position is available from 1 June 2022. An MSc in physics or astrophysics or similar experience is required. Proficient English language skills, both written and spoken, are also required; German language skills are a plus. Experience in programming is necessary. The salary is in accordance with the personnel regulations of the Canton of Bern. A complete application consists of a single pdf file including a cover letter in which you describe your motivation and qualifications for the position, a CV, list of your publications, and a list with names of three references.
Applicants should a complete application to:
Dr. Audrey Vorburger, +41 31 684 44 16, audrey.vorburger@unibe.ch
Prof. Dr. Peter Wurz, +41 31 684 44 26, peter.wurz@unibe.ch

Download/Website: `http://nccr-planets.ch/`

Contact: `exoplanetnews@nccr-planets.ch`

Residential fellowships “Exoplanets and Biological Activity on Other Worlds”

Ulrike Heiter, coordinator for SCAS-Exoplanets
Department of Physics and Astronomy, Uppsala University, Sweden

Swedish Collegium for Advanced Study, from Sep 2022 and from Sep 2023

We would like to draw your attention to the opportunity to apply for a residential fellowship at the Swedish Collegium for Advanced Study (SCAS) in Uppsala, focusing on the theme “Exoplanets and Biological Activity on Other Worlds” within the Natural Sciences Programme.
For the academic years 2022-23 and 2023-24 the Collegium offers residential fellowships for senior and early-career scholars from all countries (note two separate application deadlines).
Fellows-in-residence should normally spend one semester or an academic year at SCAS, although other periods of some months can exceptionally be arranged (within either autumn or spring semester).
At the time of application, the candidate must have held a PhD (or equivalent degree) for at least three years.
The holder of a fellowship receives a monthly salary. Accommodation for Fellows who do not live in the Stockholm-Uppsala region is arranged by the Collegium and all Fellows have their own fully equipped office at the Collegium.
The deadline for application for the academic year **2022/23** is on **30 April 2022**.
The deadline for application for the academic year **2023/24** is on **1 July 2022**.
Further information and application instructions can be found on the Website linked below.

Download/Website: http://www.swedishcollegium.se/subfolders/Fellowships/Natural_Sciences.html

Contact: ulrike.heiter@physics.uu.se

Exoplanets PhD position in Geneva for statistical analysis of transiting exoplanets

François Bouchy

Department of Astronomy of Geneva University, position open for 2022 July 1st

The exoplanet team of the University of Geneva has an opening for a PhD position to work on the statistical analysis of transiting exoplanet properties. The project is linked to the study of the properties of transiting exoplanets including the impact of observational biases, the correlation between exoplanets and host-stars properties, the comparison with synthetic populations and internal structure models, the characterization of the transition in mass, radius and density between purely rocky planets and volatile-rich planets. A specific focus will be done on warm exoplanets with low stellar irradiation. The PhD student will be involved in different photometric and radial-velocity follow-up programs for the mass and density measurement of TESS and K2 transiting candidates. He/She will be strongly involved in the development of specific tools for the PlanetS exoplanets catalog maintained in the Data and Analysis Center for Exoplanets (DACE) platform.

The Department of Astronomy of the University of Geneva offers a modern and vibrant work environment, with a wide range of activities including theory, numerical simulations, observations and instrumental developments in the domains of exoplanets, stellar physics, galactic dynamics, observational cosmology and high-energy astrophysics. The exoplanet team is especially well renown, with strong involvement in planet detection, the determination of the planet physical properties, the characterization of planet atmospheres, and the development of an associated world-class instrumentation. We are also co-leading the Swiss-wide National Centre of Competence in Research (NCCR) PlanetS, dedicated to the study of the origin, evolution, and characterization of planets inside and outside our Solar System. The applicant will also have the opportunity to develop collaborations with members of PlanetS.

The applicants are required to have a Master in Astrophysics. Proficiency in Python programming, signal processing and strong interest in data sciences and applied mathematics are considered as a plus. This four-year PhD position is founded by Swiss National Science Foundation with a gross salary around 50,000 CHF a year. The position is available immediately. The University is actively seeking to increase the numbers of women in physics and hence women are strongly encouraged to apply. Interested applicants should send (in a single pdf file) a curriculum vitae, academic transcripts, a motivation letter including information on skills and previous experience, names of people who can be contacted for a letter of recommendation, and the contact details to Prof. François Bouchy, at the Astronomy Department of Geneva University, before 30th April 2022.

Download/Website: `http://nccr-planets.ch/` `http://www.exoplanets.ch.ch/`

Contact: `francois.bouchy@unige.ch`

Postdoctoral position in debris disks

Grant M. Kennedy

University of Warwick, UK. Two year position, start date flexible but funding ends mid-July 2024

The Department of Physics seeks to appoint a Research Fellow to work with Dr Grant Kennedy in the area of circumstellar discs. The Research Fellow will primarily work on archival infrared data from missions such as Spitzer, Herschel, and WISE. Some specific goals are to extract photometry from imaging data, use and develop existing disc model and SED fitting codes, and perform statistical debris disc studies using these data. The Research Fellow would also be encouraged to pursue their own research, and have opportunities to co-supervise postgraduate and undergraduate research students.

You must hold, or be about to obtain, a doctoral degree in astrophysics or a related field. Expertise in one or several of the following areas is desirable: image modelling/analysis, photometry, SED fitting, database development, general knowledge in the field of exoplanets and circumstellar discs.

You will be an excellent communicator capable of working effectively both independently and as part of a research team. You will possess excellent planning and time management skills to ensure your research objectives are achieved effectively.

An application form must be completed if you wish to be considered for this post. Applicants should also submit a cover letter with a concise description of your research accomplishments and relevant technical experience, as well as a CV including a full publication list. You will be asked to provide the details of three referees, but reference letters are not needed before the closing date.

If you have not yet been awarded your PhD but are near submission or have recently submitted your PhD, any offers of employment will be made as Research Assistant on level 5 of the University grade structure (£30,497 pa). Upon successful award of your PhD and evidence of this fact, you will be promoted to Research Fellow on the first point of level 6 of the University grade structure (£31,406 pa).

Interviews are expected to be conducted during the second week of May 2022.

Please direct all informal enquiries to Dr Grant Kennedy.

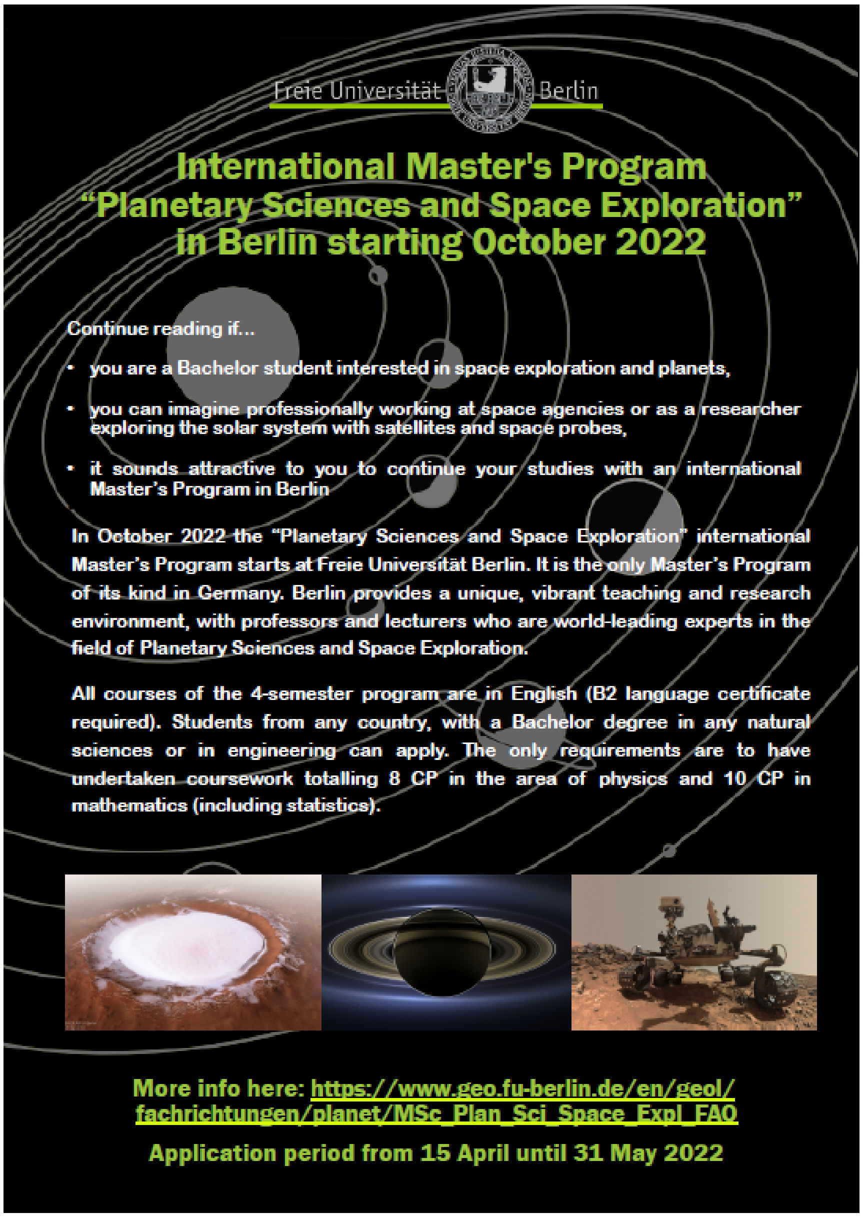
Download/Website: `https://tinyurl.com/msub9h8b`

Contact: `g.kennedy@warwick.ac.uk`

MSc Degree Program on Planetary Sciences and Space Exploration

Lena Noack and Frank Postberg

Freie Universität Berlin, Admission window: April 15th - May 31st, 2022



Download/Website: geo.fu-berlin.de/en/geol/fachrichtungen/planet/MSc_Plan_Sci_Space_Expl_FAQ

Contact: lena.noack@fu-berlin.de

5 Conferences and Workshops

The Origin and Prevalence of Life

Sascha P. Quanz, Cara Magnabosco (co-chairs SOC)
ETH Zurich

ETH Zurich, Switzerland, August 30 to September 2, 2022

We would like to draw your attention to the international Latsis Symposium 2022

"The Origin and Prevalence of Life"

to be held at ETH Zurich from August 30 to September 2, 2022.

The main scientific program of the symposium consists of 7 sessions that will be introduced by distinguished keynote speakers:

Session 1: Planet formation & volatile delivery (Keynote: Conel Alexander)
Session 2: Young Earth (Keynote: David Catling)
Session 3: Emergence of molecules and life (Keynote: Dieter Braun)
Session 4: Biogenesis and first cells (Keynote: Petra Schwille)
Session 5: The rise and evolution of complex life (Keynote: Andy Knoll)
Session 6: Life in extreme environments (Keynote: Jonathan Lunine)
Session 7: Statistics and atmospheres of exoplanets (Keynote: Sara Seager)

Contributed talks and poster presentations for each session are also foreseen.

We plan the symposium in hybrid format, with 250-300 colleagues participating in-person in the main building of ETH Zurich, but the talks will also be live-streamed and recorded to allow for remote participation for a larger audience.

More details - in particular a pre-registration form - can be found at the symposium website, which will continuously be updated:

https://latsis-origin-of-life.ethz.ch

Further information regarding the scientific program, registration and abstract submission will be communicated in due time.

We are very much looking forward to welcoming you in Zurich for four exciting days of inspiring, interdisciplinary science related to the origin and prevalence of life.

Sascha Quanz & Cara Magnabosco

SOC:
Taras Gerya, Cara Magnabosco (co-chair), Joshua Payne, Joern Piel, Sascha P. Quanz (co-chair), Didier Queloz, Markus Reiher, Roland Riek, Maria Schönbächler, Derek Vance, Julia Vorholt

Download/Website: `https://latsis-origin-of-life.ethz.ch`

2022 Sagan Summer Hybrid Workshop: Exoplanet Science in the Gaia Era

E. Furlan, D. Gelino
NASA Exoplanet Science Institute, California Institute of Technology, Pasadena, CA, USA

Hybrid Workshop, July 25-29, 2022

The 2022 Sagan Summer Workshop will take place July 25-29, 2022. This will be a hybrid workshop with both in-person and on-line attendance. As of March 24, our in-person capacity limit has been reached and we have started a waitlist for in-person attendance. We are optimistic that the in-person limit will be increased in the coming weeks. Note that in-person attendees are required to verify their COVID vaccination and booster status before their registration is confirmed. Additionally, in person attendees must comply with any mask mandates and public health guidelines from L. A. County, City of Pasadena, and California Institute of Technology that are in place at the time of the workshop. The workshop website will be updated with this information going forward.

The 2022 Sagan Summer Workshop will focus on the topic of exoplanet science in the Gaia era. The ESA Gaia mission has been mapping the Galaxy for over seven years, measuring very accurate positions and motions of over 1 billion stars. It has already greatly contributed to exoplanet science through the determination of more accurate stellar parameters, which in turn improve planet parameters, the detection of stellar companions, and the identification and characterization of young moving groups. In the near future, the unprecedented astrometric accuracy will result in the discovery of new exoplanets, as well as the characterization of known planets. The workshop will introduce the basics of astrometry, the impact of Gaia astrometry on astrophysics, and the astrometric detection and characterization of exoplanets. The synergy between the different planet detection techniques of astrometry, transits, radial velocities, and imaging will be discussed, as well as future advances in astrometry.

The workshop will cover the topics listed below. Please visit the workshop website for the agenda and list of confirmed speakers.

- Astrometry Fundamentals
- Impact of Astrometry on Stellar Astrophysics with Implications for Exoplanet Science
- Astrometry and Companion Detectionl
- Characterizing Directly Imaged Planets and Young Brown Dwarfs
- Next Steps in Astrometry

There is no registration fee for this workshop and registration is available on the workshop website.

Please contact us with any questions or to be added to the email list.

Download/Website: `http://nexsci.caltech.edu/workshop/2022`
Contact: `sagan_workshop@ipac.caltech.edu`

Europlanet Science Congress (EPSC) 2022

Lena Noack on behalf of the EPSC Committee

Granada, Spain, 18-23 September 2022

We are looking forward to meeting everyone in person this year at EPSC2022 in Granada. The intention of the Europlanet Science Congress 2022 is to cover a broad area of science topics related to planetary science and planetary missions. EPSC will this year be jointly organized with the annual EANA (European Astrobiology Network Association) Conference 2022, and will therefore include a large number of sessions with an Astrobiology focus.

The programme of the congress will contain oral and poster sessions, as well as workshops and panel discussions and provide with ample opportunities for interaction between the participants. The meeting is planned as an in-person meeting, and no virtual participation is foreseen for the scientific sessions. The Scientific Organizing Committee of the EPSC2022 invites all planetary scientists to participate in the congress, submit contributions to the topical sessions and share their research with their colleagues.

The ethos for EPSC2022 is to create a simple, flexible, and inclusive meeting that provides multiple opportunities for interaction, scientific discussion, and networking.

Sessions include, amongst others:

- Formation, evolution, and stability of extrasolar systems
- The hidden newly born planets
- Interiors and Atmospheres of Rocky Planets: Formation, Evolution and Habitability
- Devolatilization During Rocky (Exo)planet Formation: Mechanisms, Simulations, and Observations
- Exoplanet observations, modelling and experiments: Characterization of their atmospheres
- Future instruments to detect and characterise extrasolar planets and their environment
- Connecting stellar high-energy phenomena with exoplanet observations
- Towards better understanding planets and planetary systems diversity
- Atmospheric Habitability and Biosignatures in an Exoplanetary Context
- The emergence of Life in our Solar System and Beyond
- Life at the extreme on Earth and beyond
- Habitability and biosignatures for the search for life in our Solar system

Download/Website: `https://www.epsc2022.eu/`
Contact: `lena.noack@fu-berlin.de`

6 As seen on astro-ph

astro-ph/2203.00222: **On The Hydrosphere Stability of TESS Targets: Applications to 700 d, 256 b, and 203 b** by *Paul Bonney et al.*

astro-ph/2203.00299: **Homogeneous Transit Timing Analyses of Ten Exoplanet Systems** by *Ö. Baştürk et al.*

astro-ph/2203.00370: **K2 and Spitzer phase curves of the rocky ultra-short-period planet K2-141 b hint at a tenuous rock vapor atmosphere** by *S. Zieba et al.*

astro-ph/2203.00415: **The CARMENES search for exoplanets around M dwarfs: Benchmarking the impact of activity in high-precision radial velocity measurements** by *S.V.Jeffers*

astro-ph/2203.00471: **Large Interferometer For Exoplanets (LIFE): II. Signal simulation, signal extraction and fundamental exoplanet parameters from single epoch observations** by *Felix Dannert et al.*

astro-ph/2203.00482: **A retrieval challenge exercise for the Ariel mission** by *Joanna K. Barstow et al.*

astro-ph/2203.00562: **Scaling and phase diagrams of planetary sediment transport** by *Thomas Pähtz, Orencio Duŕan, Francesco Comola*

astro-ph/2203.00692: **Observing planet-driven dust spirals with ALMA** by *Jessica Speedie, Richard A. Booth, Ruobing Dong*

astro-ph/2203.00801: **Architectures of Compact Super-Earth Systems Shaped by Instabilities** by *Max Goldberg, Konstantin Batygin*

astro-ph/2203.00929: **The impact of AGN outflows on the surface habitability of terrestrial planets in the Milky Way** by *A. Ambrifi et al.*

astro-ph/2203.01018: **A Radial Velocity Study of the Planetary System of Pi Mensae: Improved Planet Parameters for PI Mensae c and a Third Planet on a 125-d Orbit** by *Artie P. Hatzes et al.*

astro-ph/2203.01065: **Internal Structure and Magnetic Moment of Rocky Planets. Application to the first exoplanets discovered by TESS** by *Jose-María Rodríguez-Mozos, Andy Moya*

astro-ph/2203.01136: **A search for planetary companions around 800 pulsars from the Jodrell Bank pulsar timing programme** by *Iuliana C. Niţu et al.*

astro-ph/2203.01236: **Convolutional neural networks as an alternative to Bayesian retrievals** by *Francisco Ardevol Martinez et al.*

astro-ph/2203.01334: **Eccentricity Evolution in Gaseous Dynamical Friction** by *Ákos Szölgyén, Morgan MacLeod, Abraham Loeb*

astro-ph/2203.01364: **Birth cluster simulations of planetary systems with multiple super-Earths: initial conditions for white dwarf pollution drivers** by *Katja Stock et al.*

astro-ph/2203.01463: **Confirmation of Water Absorption in the Thermal Emission Spectrum of the Hot Jupiter WASP-77Ab with HST/WFC3** by *Megan Mansfield et al.*

astro-ph/2203.01466: **Successful Recovery of an Observed Meteorite Fall Using Drones and Machine Learning** by *Seamus L. Anderson et al.*

astro-ph/2203.01586: **Gaia-DR2 asteroid observations and INPOP planetary ephemerides** by *P. Deram et al.*

astro-ph/2203.01656: **The Exosphere as a Boundary: Origin and Evolution of Airless Bodies in the Inner Solar System and Beyond Including Planets with Silicate Atmospheres** by *H. Lammer et al.*

astro-ph/2203.01750: **One year of AU Mic with HARPS: I – measuring the masses of the two transiting planets** by *Norbert Zicher et al.*

astro-ph/2203.01839: **Impact of Variable Photospheric Radius on Exoplanet Atmospheric Retrievals** by *Jake Taylor* astro-ph/2203.01866: **Jupiter's inhomogeneous envelope** by *Y. Miguel et al.*

astro-ph/2203.01891: **Feasibility of detecting and characterizing embedded low-mass giant planets in gaps in the VIS/NIR wavelength range** by *A. Krieger, S. Wolf*

astro-ph/2203.02003: **Nodal Precession of WASP-33b for Eleven Years by Doppler Tomographic and Transit Photometric Observations** by *Noriharu Watanabe et al.*

astro-ph/2203.02087: **Scaling K2. V. Statistical Validation of 60 New Exoplanets From K2 Campaigns 2-18** by *Jessie L. Christiansen et al.*

astro-ph/2203.02203: **Planetary Genealogy** by *Christoph Burkhardt*

astro-ph/2203.02293: **The THOR+HELIOS general circulation model: multi-wavelength radiative transfer with accurate scattering by clouds/hazes** by *Russell Deitrick et al.*

astro-ph/2203.02324: **MHD study of planetary magnetospheric response during extreme solar wind conditions: Earth and exoplanet magnetospheres applications** by *J. Varela et al.*

astro-ph/2203.02335: **Cross-sections for heavy atmospheres: H2O self-broadening** by *Lara O. Anisman et al.*

astro-ph/2203.02347: **Non-Local thermal equilibrium spectra of atmospheric molecules for exoplanets** by *Sam O. M. Wright, Ingo Waldmann, Sergei N. Yurchenko*

astro-ph/2203.02366: **A Star-sized Impact-Produced Dust Clump in the Terrestrial Zone of the HD 166191 System** by *Kate Y. L. Su et al.*

astro-ph/2203.02367: **Compositional Mapping of Europa using MCMC Modelling of Near-IR VLT/SPHERE and Galileo/NIMS Observations** by *Oliver King, Leigh N Fletcher, Nicolas Ligier*

astro-ph/2203.02434: **A Comprehensive Analysis of WASP-17b's Transmission Spectrum from Space-Based Observations** by *L. Alderson et al.*

astro-ph/2203.02546: **Nodal Precession and Tidal Evolution of Two Hot-Jupiters: WASP-33 b and KELT-9 b** by *Alexander P. Stephan et al.*

astro-ph/2203.02694: **TOI-1696: a nearby M4 dwarf with a 3R planet in the Neptunian desert** by *Mayuko Mori et al.*

astro-ph/2203.02805: **Stability Constrained Characterization of the 23 Myr-old V1298 Tau System: Do Young Planets Form in Mean Motion Resonance Chains?** by *Roberto Tejada Arevalo, Daniel Tamayo, Miles Cranmer*

astro-ph/2203.02840: **Dielectric properties and stratigraphy of regolith in the lunar South Pole-Aitken basin: Observations from the Lunar Penetrating Radar** by *Jianqing Feng, Matthew. A. Siegler, Mackenzie N. White*

astro-ph/2203.02866: **WASP-35 and HAT-P-30/WASP-51: re-analysis using TESS and ground-based transit photometry** by *Lu Bai et al.*

astro-ph/2203.02936: **A major asymmetric ice trap in a planet-forming disk: III. First detection of dimethyl ether** by *Nashanty G.C. Brunken et al.*

astro-ph/2203.03033: **Spreading pressure bumps in gas-dust discs can stall planet migration via planet-vortex interactions** by *R. O. Chametla, O. Chrenko*

astro-ph/2203.03171: **Assessment of Microbial Habitability Across Solar System Targets** by *Dimitra Atri et al.*

astro-ph/2203.03194: **Uncovering the true periods of the young sub-Neptunes orbiting TOI-2076** by *Hugh P. Osborn et al.*

astro-ph/2203.03213: **Probing Magnetic Fields in Protoplanetary Disk Atmospheres through Polarized Optical/IR Light Scattered by Aligned Grains** by *Haifeng Yang, Zhi-Yun Li*

astro-ph/2203.03349: **Periodic orbits in the 1:2:3 resonant chain and their impact on the orbital dynamics of the Kepler-51 planetary system** by *Kyriaki I. Antoniadou, George Voyatzis* astro-ph/2203.03520: **A dynamo simulation generating Saturn-like small magnetic dipole tilts** by *Rakesh K. Yadav, Hao Cao, Jeremy Bloxham*

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astro-ph/2203.03928: **An APEX search for carbon emission from NGC 1977 proplyds** by *Thomas J. Haworth et al.*

astro-ph/2203.04173: **Analysis of a JWST NIRSpec Lab Time Series: Characterizing Systematics, Recovering Exoplanet Transit Spectroscopy, and Constraining a Noise Floor** by *Zafar Rustamkulov et al.*

astro-ph/2203.04201: **Follow the Water: Finding Water, Snow and Clouds on Terrestrial Exoplanets with Photometry and Machine Learning** by *Dang Pham, Lisa Kaltenegger*

astro-ph/2203.04204: **Generating Realistic Two-Line Elements for Notional Space Vehicles and Constellations** by *Troy Rockwood, Greg Steeger, Matthew Stein*

astro-ph/2203.04230: **The evolution of protoplanetary discs in star formation and feedback simulations** by *Lin Qiao et al.*

astro-ph/2203.04334: **TOI-1670 b and c: An Inner Sub-Neptune with an Outer Warm Jupiter Unlikely to have Originated from High-Eccentricity Migration** by *Quang H. Tran et al.*

astro-ph/2203.04429: **Generating Stellar Obliquity in Systems with Broken Protoplanetary Disks** by *Marguerite Epstein-Martin, Juliette Becker, Konstantin Batygin*

astro-ph/2203.04494: **The Hot Neptune WASP-166 b with ESPRESSO II: Confirmation of atmospheric sodium** by *J. V. Seidel et al.*

astro-ph/2203.04529: **Do twin spectral peaks of olivine particles in the thermal infrared diagnose their sizes and porosities?** by *Hiroshi Kimura et al.*

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astro-ph/2203.05460: **Stellar obliquities in exoplanetary systems** by *Simon H. Albrecht, Rebekah I. Dawson, Joshua N. Winn*

astro-ph/2203.05629: **Formation of Dust Rings and Gaps in Non-ideal MHD Disks Through Meridional Gas Flows** by *Xiao Hu et al.*

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astro-ph/2203.07476: **IMPACTS – A program to calculate the effects of a hypervelocity impact into a Solar System body** by *Keith A. Holsapple*

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astro-ph/2203.08995: **Spatially resolved observations of Europa's surface with Subaru/IRCS at 1.0-1.8 m: Upper limits to the abundances of hydrated Cl-bearing salts** by *Shuya Tan, Yasuhito Sekine, Masayuki Kuzuhara*

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astro-ph/2203.09528: **Kinematic Structures in Planet-Forming Disks** by *Christophe Pinte et al.*

astro-ph/2203.09595: **Planet-Disk Interactions** by *Sijme-Jan Paardekooper et al.*

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astro-ph/2203.09759: **Planet Formation Theory in the Era of ALMA and Kepler: from Pebbles to Exoplanets** by *Joanna Drazkowska et al.*

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astro-ph/2203.09821: **Hydro-, Magnetohydro-, and Dust-Gas Dynamics of Protoplanetary Disks** by *G. Lesur et al.*

astro-ph/2203.09991: **Optical and Near-infrared View of Planet-forming Disks and Protoplanets** by *M. Benisty et al.*

astro-ph/2203.10023: **Geophysical Evolution During Rocky Planet Formation** by *Tim Lichtenberg et al.*

astro-ph/2203.10051: **Martian meteorites reflectance and implications for rover missions** by *Lucia Mandon et al.*

astro-ph/2203.10056: **Chemical Habitability: Supply and Retention of Life's Essential Elements During Planet Formation** by *Sebastiaan Krijt et al.*

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astro-ph/2203.10735: **Modeling the arc and ring structures in the HD 143006 disk** by *Yao Liu (PMO), Mario Flock (MPIA), Min Fang (PMO)*

astro-ph/2203.10797: **Determining the beaming of Io decametric emissions : a remote diagnostic to probe the Io-Jupiter interaction** by *L. Lamy et al.*

astro-ph/2203.10863: **The Isotopic Links from Planet Forming Regions to the Solar System** by *H. Nomura et al.*

astro-ph/2203.10881: **Transit Light-curves for Exomoons: Analytical Formalisms** by *Suman Saha, Sujan Sengupta*

astro-ph/2203.10899: **The Case for Technosignatures: Why They May Be Abundant, Long-lived, Highly Detectable, and Unambiguous** by *Jason T. Wright et al.*

astro-ph/2203.11169: **Short-Lived Radionuclides in Meteorites and the Sun's Birth Environment** by *Steven J. Desch et al.*

astro-ph/2203.11188: **Day-side Fe I Emission, Day-Night Brightness Contrast and Phase Offset of the Exoplanet WASP-33b** by *Miranda K. Herman et al.*

astro-ph/2203.11233: **Grid of pseudo-2D chemistry models for tidally locked exoplanets – II. The role of photochemistry** by *Robin Baeyens et al.*

astro-ph/2203.11243: **Probing Planets with Exomoons: The Cases of Kepler-1708 b and Kepler-1625 b** by *Armen Tokadjian, Anthony L. Piro*

astro-ph/2203.11710: **A systematic study about orbit flips of test particles caused by eccentric von Zeipel-Lidov-Kozai effects** by *Hanlun Lei*

astro-ph/2203.11711: **Milliarcsecond astrometry for the Galilean moons using stellar occultations** by *B. E. Morgado et al.*

astro-ph/2203.11723: **The Equilibrium Temperature of Planets on Eccentric Orbits: Time Scales and Averages** by *Andreas Quirrenbach*

astro-ph/2203.11814: **The current orbit of Methone (S/2004 S 1)** by *Nelson Callegari Jr., Adrián Rodríguez, Demétrio Tadeu Ceccatto*

astro-ph/2203.12167: **Effects of Self-gravity on Mass-loss of the Post-impact Super-Earths** by *Jiang Huang, Wei Zhong, Cong Yu*

astro-ph/2203.12348: **Characteristics of small protoplanetary disc warps in kinematic observations** by *Alison K. Young et al.*

astro-ph/2203.13175: **The gravitational imprint of an interior-orbital resonance in Jupiter-Io** by *Benjamin Idini, David J. Stevenson*

astro-ph/2203.13234: **Carbon monoxide emission lines reveal an inverted atmosphere in the ultra hot Jupiter WASP-33 b and indicate an eastward hot spot** by *Lennart van Sluijs et al.*

astro-ph/2203.13290: **Kepler-1708 b-i is likely undetectable with HST** by *Ben Cassese, David Kipping*

astro-ph/2203.13329: **Mutual Inclination of Ultra-Short-Period Planets with Time Varying Stellar J2-moment** by *Chen Chen, Gongjie Li, Cristobal Petrovich*

astro-ph/2203.13354: **A Method for Generating Closely Packed Orbital Shells and the Implication on Orbital Capacity** by *Miles Lifson et al.*

astro-ph/2203.13389: **Gas disk interactions, tides and relativistic effects in the rocky planet formation at the substellar mass limit** by *Mariana B. Sanchez, Gonzalo C. de Elia, Juan J. Downes*

astro-ph/2203.13582: **Nonlinear behaviour of warped discs around a central object with a quadrupole moment** by *Hongping Deng, Gordon Ogilvie*

astro-ph/2203.13698: **HST/WFC3 transmission spectroscopy of the cold rocky planet TRAPPIST-1h** by *L. J. Garcia et al.*

astro-ph/2203.14444: **The fate of particles in the dynamical environment around Kuiper Belt object (486958) Arrokoth** by *Andre Amarante, Othon Winter*

astro-ph/2203.14929: **Meta-modelling the climate of dry tide locked rocky planets** by *Pierre Auclair-Desrotour, Russell Deitrick, Kevin Heng*

astro-ph/2203.14993: **Characterization of planar symmetric central configurations of four bodies, models, and an application** by *Zalán Czirják, Bálint Érdi, Emese Forgács-Dajka*

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