ExoPlanet News
An Electronic Newsletter

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Contents

1 Editorial

Welcome to the 88th edition of Exoplanet News.

This month sees the usual great set of exoplanet papers published including some remarkable new results. I think I've captured all these, as usual, in the "As seen on astro-ph" section of the newsletter, but please encourage your colleagues to submit their abstracts to Exoplanet News to ensure maximum exposure to the newsletter readership, which now stands at over 1300 subscribers.
I've managed to persuade my university's e-mail exploder to accept attachments over 1Mb in size, so hopefully will not need to reduce the quality of embedded images so much in future. Even so, this month's newsletter is nearly 1.5Mb, so please let me know if this size of attachment causes any issues for you.
Remember that past editions of this newsletter, submission templates and other information can be found at the ExoPlanet News website: http://exoplanet.open.ac.uk. Although note that my updates to the website only become live over-night. So if you want to get the newsletter as soon as it is ready, please subscribe and get it by email on the day it's released.

Best wishes
Andrew Norton
The Open University

2 Abstracts of refereed papers

Ultra Short Period Planets in K2: SuPerPiG Results for Campaigns 0-5

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Astronomical Journal, in press (arXiv:1603.06488)

We have analyzed data from Campaigns 0-5 of the *K2* mission and report 19 ultra-short-period candidate planets with orbital periods of less than 1 day (nine of which have not been previously reported). Planet candidates range in size from 0.7-16 Earth radii and in orbital period from 4.2 to 23.5 hours. One candidate (EPIC 203533312, Kp=12.5) is among the shortest-period planet candidates discovered to date ($P = 4.2$ hours), and, if confirmed as a planet, must have a density of at least $\rho = 8.9\ \mathrm{g/cm^3}$ in order to not be tidally disrupted. Five candidates have nominal radius values in the sub-Jovian desert ($R_P = 3 - 11\ R_\oplus$ and $P \leq 1.5$ days) where theoretical models do not favor their long-term stability; the only confirmed planet in this range is in fact thought to be disintegrating (EPIC 201637175). In addition to the planet candidates, we report on four objects which may not be planetary, including one with intermittent transits (EPIC 211152484) and three initially promising candidates that are likely false positives based on characteristics of their light curves and on radial velocity follow-up. A list of 91 suspected eclipsing binaries identified at various stages in our vetting process is also provided. Based on an assessment of our survey's completeness, we estimate an occurrence rate for ultra-short period planets among *K2* target stars that is about half that estimated from the *Kepler* sample, raising questions as to whether *K2* systems are intrinsically different from *Kepler* systems, possibly as a result of their different galactic location.

Download/Website: `http://arxiv.org/abs/1603.06488`

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Habitable worlds with JWST: transit spectroscopy of the TRAPPIST-1 system?

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MNRAS Letters, in press (arXiv:1605.07352)

The recent discovery of three Earth-sized, potentially habitable planets around a nearby cool star, TRAPPIST-1, has provided three key targets for the upcoming *James Webb Space Telescope (JWST)*. Depending on their atmospheric characteristics and precise orbit configurations, it is possible that any of the three planets may be in the liquid water habitable zone, meaning that they may be capable of supporting life. We find that present-day Earth levels of ozone, if present, would be detectable if *JWST* observes 60 transits for innermost planet 1b and 30 transits for 1c and 1d.

Download/Website: `http://arXiv.org/abs/1605.07352`

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Determining the midplane conditions of circumstellar discs using gas and dust modelling: a study of HD 163296

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Monthly Notices of the Royal Astronomical Society, in press (arXiv:1605.07938)

The mass of gas in protoplanetary discs is a quantity of great interest for assessing their planet formation potential. Disc gas masses are however traditionally inferred from measured dust masses by applying an assumed standard gas to dust ratio of $g/d = 100$. Furthermore, measuring gas masses based on CO observations has been hindered by the effects of CO freeze-out. Here we present a novel approach to study the midplane gas by combining $C^{18}O$ line modelling, CO snowline observations and the spectral energy distribution (SED) and selectively study the inner tens of au where freeze-out is not relevant. We apply the modelling technique to the disc around the Herbig Ae star HD 163296 with particular focus on the regions within the CO snowline radius, measured to be at 90 au in this disc. Our models yield the mass of $C^{18}O$ in this inner disc region of $M_{\mathrm{C^{18}O}}(< 90\,\mathrm{au}) \sim 2 \times 10^{-8}\,\mathrm{M}_{\odot}$. We find that most of our models yield a notably low $g/d < 20$, especially in the disc midplane ($g/d < 1$). Our only models with a more ISM-like g/d require $C^{18}O$ to be underabundant with respect to the ISM abundances and a significant depletion of sub-micron grains, which is not supported by scattered light observations. Our technique can be applied to a range of discs and opens up a possibility of measuring gas and dust masses in discs within the CO snowline location without making assumptions about the gas to dust ratio.

Download/Website: `https://arxiv.org/abs/1605.07938`

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An evaporating planet in the wind: stellar wind interactions with the radiatively braked exosphere of GJ 436 b

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Astronomy & Astrophysics, in press (arXiv:1605.07973)

Observations of the warm Neptune GJ 436b were performed with HST/STIS at three different epochs (2012, 2013, 2014) in the stellar Lyman-α line. They showed deep, repeated transits that were attributed to a giant exosphere of neutral hydrogen. The low radiation pressure from the M-dwarf host star was shown to play a major role in the dynamics of the escaping gas and its dispersion within a large volume around the planet. Yet by itself it cannot explain the specific time-variable spectral features detected in each transit. Here we investigate the combined role of radiative braking and stellar wind interactions using numerical simulations with the EVaporating Exoplanet code (EVE) and we derive atmospheric and stellar properties through the direct comparison of simulated and observed spectra.

The first epoch of observations is difficult to interpret because of the lack of out-of-transit data. In contrast, the results of our simulations match the observations obtained in 2013 and 2014 well. The sharp early ingresses observed in these epochs come from the abrasion of the planetary coma by the stellar wind. Spectra observed at later times during the transit can be produced by a dual exosphere of planetary neutrals (escaped from the upper atmosphere of the planet) and neutralized protons (created by charge-exchange with the stellar wind). We find similar properties at both epochs for the planetary escape rate ($\sim$2.5$\times$10^{8} g s^{-1}), the stellar photoionization rate ($\sim$2$\times$10^{-5}s^{-1}), the stellar wind bulk velocity ($\sim$85 km s^{-1}), and its kinetic dispersion velocity ($\sim$10 km s^{-1}, corresponding to a kinetic temperature of 12 000 K). We also find high velocities for the escaping gas ($\sim$50 - 60 km s^{-1}) that may indicate magnetohydrodynamic (MHD) waves that dissipate in the upper atmosphere and drive the planetary outflow. In 2014 the high density of the stellar wind ($\sim$3$\times$10^{3}cm^{-3}) led to the formation of an exospheric tail that was mainly composed of neutralized protons and produced a stable absorption signature during and after the transit.

The observations of GJ 436 b allow for the first time to clearly separate the contributions of radiation pressure and stellar wind and to probe the regions of the exosphere shaped by each mechanism. The overall shape of the cloud, which is constant over time, is caused by the stability of the stellar emission and the planetary mass loss, while the local changes in the cloud structure can be interpreted as variations in the density of the stellar wind.

Download/Website: `http://exoplanet.open.ac.uk/`

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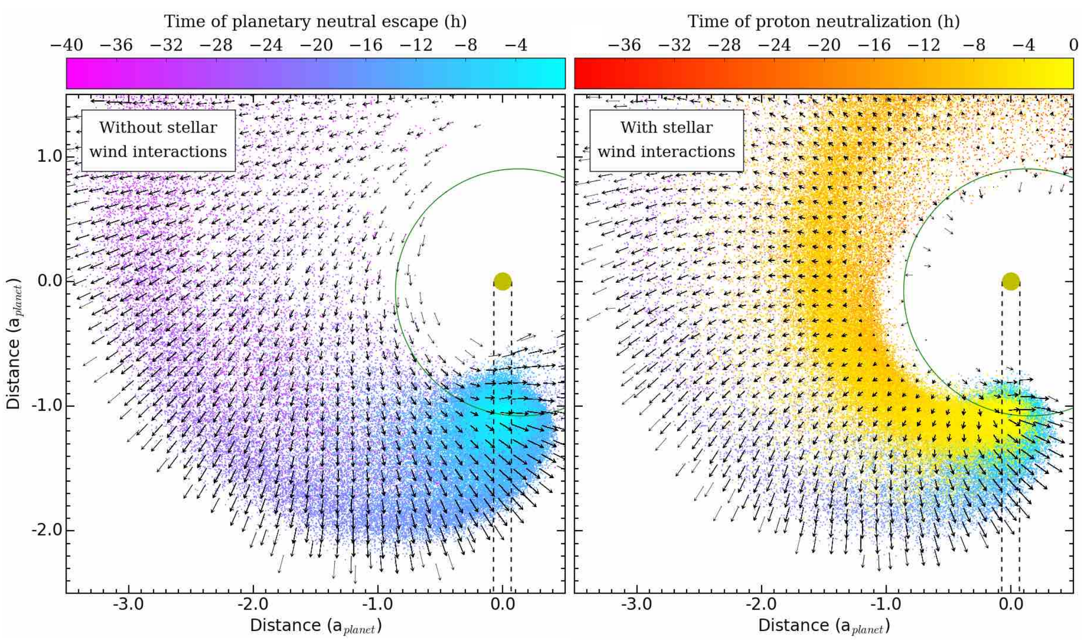

Figure 1: (Bourrier et al.) Views of GJ 436b exosphere (dots) within the orbital plane, seen from the top, at the time of the optical transit. The two panels correspond to two simulations performed without stellar wind interactions (*left panel*) or including them (*right panel*, corresponding to the best fit to the observations). The planet is represented by a small black disk, to scale, between the dashed black lines limiting the line-of-sight toward the stellar disk. Arrows display the average velocity field of the neutral hydrogen atoms in the stellar rest frame, with particles colored as a function of the time they escaped the atmosphere (for planetary neutrals) or were created through charge exchange (for neutralized stellar wind protons). With no stellar wind interactions the dynamics of the escaping gas is initially dominated by the planetary orbital velocity and later constrained by radiative braking. With charge exchange most protons are neutralized in the dense inner coma, abrading at the source planetary neutrals that would have fed the outer regions of the exosphere, but also creating a compact population of neutrals dominated by the radial bulk velocity of the stellar wind.

Variation in the pre-transit Balmer line signal around the hot Jupiter HD 189733b

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The Astronomical Journal, in press

As followup to our recent detection of a pre-transit signal around HD 189733 b, we obtained full pre-transit phase coverage of a single planetary transit. The pre-transit signal is again detected in the Balmer lines but with variable strength and timing, suggesting that the bow shock geometry reported in our previous work does not describe the signal from the latest transit. We also demonstrate the use of the Ca2 H and K residual core flux as a proxy for the stellar activity level throughout the transit. A moderate trend is found between the pre-transit absorption signal in the 2013 data and the Ca2 H flux. This suggests that some of the 2013 pre-transit hydrogen absorption can be attributed to varying stellar activity levels. A very weak correlation is found between the Ca2 H core flux and the Balmer line absorption in the 2015 transit, hinting at a smaller contribution from stellar activity compared to the 2013 transit. We simulate how varying stellar activity levels can produce changes in the Balmer line transmission spectra. These simulations show that the strength of the 2013 and 2015 pre-transit signals can be reproduced by stellar variability. If the pre-transit signature is attributed to circumplanetary material, its evolution in time can be described by accretion clumps spiraling towards the star, although this interpretation has serious limitations. Further high-cadence monitoring at Hα is necessary to distinguish between true absorption by transiting material and short-term variations in the stellar activity level.

Download/Website: `http://arxiv.org/abs/1605.01955`

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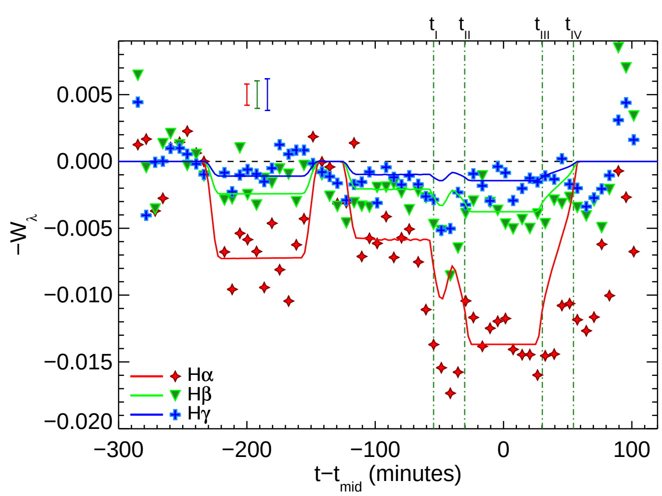

Figure 2: (Cauley et al.) Absorption time series calculated for the individual Balmer line transmission spectra. The average 1σ uncertainties in W_λ for each line are marked with the solid bars in the upper-left. Optical transit contact points are marked with vertical green dashed-dotted lines. The solid lines are model W_λ values. Note the two distinct pre-transit dips in $W_{H\alpha}$ between -220 minutes and -155 minutes and then again between -110 and -60 minutes. The in-transit absorption strength is $\sim$2 times stronger than observed in the 2013 transit and there appears to be sustained absorption for $\sim$30 minutes post-transit. The accretion clump model (solid lines) is able to reproduce the pre-transit absorption depths. However, there are numerous problems with the model and more observations are needed to understand the nature of the pre-transit signature.

A High-Precision NIR Survey for RV variable low-mass stars

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The Astrophysical Journal, published (2016, ApJ, 822, 1; arXiv:1603.05998)

We present the results of a precise near-infrared (NIR) radial velocity (RV) survey of 32 low-mass stars with spectral types K2–M4 using CSHELL at the NASA IRTF in the K-band with an isotopologue methane gas cell to achieve wavelength calibration and a novel iterative RV extraction method. We surveyed 14 members of young ($\approx$25–150 Myr) moving groups, the young field star ε Eridani as well as 18 nearby ($<$25 pc) low-mass stars and achieved typical single-measurement precisions of 8–15 m s^{-1} with a long-term stability of 15–50 m s^{-1}. We obtain the best NIR RV constraints to date on 27 targets in our sample, 19 of which were never followed by high-precision RV surveys. Our results indicate that very active stars can display long-term RV variations as low as $\sim$25–50 m s^{-1} at $\approx$2.3125 μm, thus constraining the effect of jitter at these wavelengths. We provide the first multi-wavelength confirmation of GJ 876 bc and independently retrieve orbital parameters consistent with previous studies. We recovered RV variability for HD 160934 AB and GJ 725 AB that are consistent with their known binary orbits, and nine other targets are candidate RV variables with a statistical significance of 3–5σ. Our method combined with the new iSHELL spectrograph will yield long-term RV precisions of $\lesssim$ 5 m s^{-1} in the NIR, which will allow the detection of Super-Earths near the habitable zone of mid-M dwarfs.

Download/Website: `http://adsabs.harvard.edu/abs/2016arXiv160305998G`

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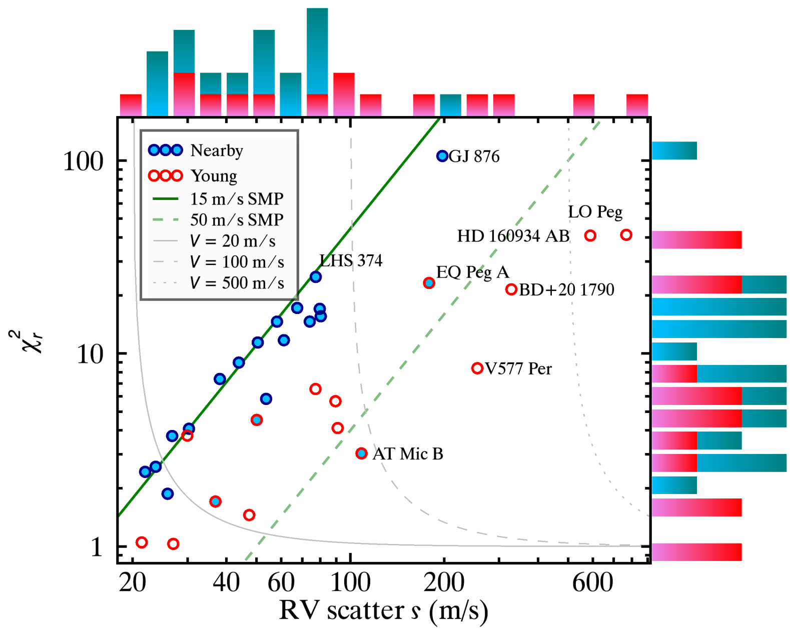

Figure 3: (Gagné et al.) Reduced χ_r^2 with respect to zero variation as a function of the radial velocity (RV) scatter ς for targets in the nearby (filled blue circles) and young (red circles) samples. The solid and dashed green lines correspond to single-measurement precisions S of 15 and 50 m s^{-1}, respectively. The solid, dashed and dotted grey lines correspond to respective RV variability values V of 20, 100 and 500 m s^{-1} ($V = \sqrt{\varsigma^2 - S^2}$, see Section 6. Histogram distributions for the nearby (green bars) and young (pink bars) samples are displayed next to each plot axis. For more details on this figure, see Section 7.1.

Effects of disc asymmetries on astrometric measurements - Can they mimic planets?

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Astronomy & Astrophysics, in press (arXiv:1605.04908)

Astrometry covers a parameter space that cannot be reached by RV or transit methods to detect terrestrial planets on wide orbits. In addition, high accuracy astrometric measurements are necessary to measure the inclination of the planet's orbits. Here we investigate the principles of an artefact of the astrometric approach. Namely, the displacement of the photo-centre due to inhomogeneities in a dust disc around the parent star. Indeed, theory and observations show that circumstellar discs can present strong asymmetries. We model the pseudo-astrometric signal caused by these inhomogeneities, asking whether a dust clump in a disc can mimic the astrometric signal of an Earth-like planet. We show that these inhomogeneities cannot be neglected when using astrometry to find terrestrial planets. We provide the parameter space for which these inhomogeneities can affect the astrometric signals but still not be detected by mid-IR observations. We find that a small cross section of dust corresponding to a cometary mass object is enough to mimic the astrometric signal of an Earth-like planet. Astrometric observations of protoplanetary discs to search for planets can also be affected by the presence of inhomogeneities. Some further tests are given to confirm whether an observation is a real planet astrometric signal or an impostor. Eventually, we also study the case where the cross section of dust is high enough to provide a detectable IR-excess and to have a measurable photometric displacement by actual instruments such as Gaia, IRAC or GRAVITY. We suggest a new method, which consists in using astrometry to quantify asymmetries (clumpiness) in inner debris discs that cannot be otherwise resolved.

Download/Website: `http://arxiv.org/abs/1605.04908`

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Tidal Decay and Stable Roche-Lobe Overflow of Short-Period Gaseous Exoplanets

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Celestial Mechanics and Dynamical Astronomy, in press, arXiv:1603.00392)

Many gaseous exoplanets in short-period orbits are on the verge or are in the process of Roche-lobe overflow (RLO). Moreover, orbital stability analysis shows tides can drive many hot Jupiters to spiral inevitably toward their host stars. Thus, the coupled processes of orbital evolution and RLO likely shape the observed distribution of close-in exoplanets and may even be responsible for producing some of the short-period rocky planets. However, the exact outcome for an overflowing planet depends on its internal response to mass loss, and the accompanying orbital evolution can act to enhance or inhibit RLO. In this study, we apply the fully-featured and robust Modules for Experiments in Stellar Astrophysics (MESA) suite to model RLO of short-period gaseous planets. We show that, although the detailed evolution may depend on several properties of the planetary system, it is largely determined by the core mass of the overflowing gas giant. In particular, we find that the orbital expansion that accompanies RLO often stops and reverses at a specific maximum period that depends on the core mass. We suggest that RLO may often strand the remnant of a gas giant near this orbital period, which provides an observational prediction that can corroborate the hypothesis that short-period gas giants undergo RLO. We conduct a preliminary comparison of this prediction to the observed population of small, short-period planets and find some planets in orbits that may be consistent with this picture. To the extent that we can establish some short-period planets are indeed the remnants of gas giants, that population can elucidate the properties of gas giant cores, the properties of which remain largely unconstrained.

Download/Website: `http://arxiv.org/abs/1603.00392`

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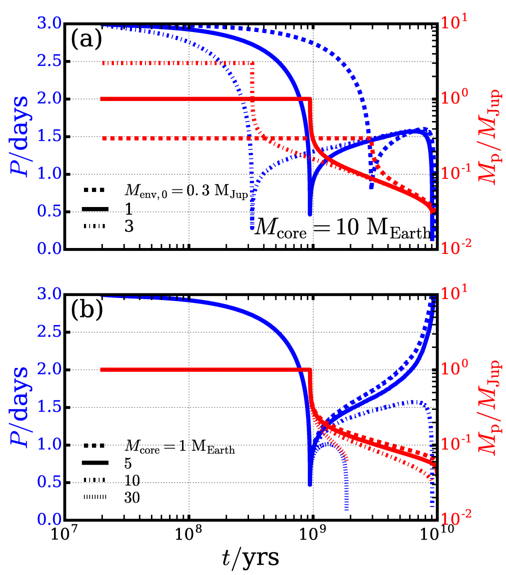

Figure 4: (Jackson et al.) Mass (red lines) and orbital (blue lines) evolution for hot Jupiter systems with initial periods $P_0 = 3$ days and $Q_\star = 10^5$ amd a variety of initial envelope masses $M_{\rm env,\,0}$ and core masses $M_{\rm core}$. The different linestyles indicate different planetary parameters. (a) Hot Jupiters with $M_{\rm env,\,0}$ = 0.3, 1, and 3 $\rm M_{Jup}$ and $M_{\rm core}$ fixed at 10 $\rm M_{Earth}$. (b) Hot Jupiters with $M_{\rm env,\,0}$ = 1 $\rm M_{Jup}$ and $M_{\rm core}$ = 1, 5, 10, and 30 $\rm M_{Earth}$. These calculations assume $\delta\gamma = 0$, i.e. the orbital angular momentum is completely conserved.

Water-rich planets: how habitable is a water layer deeper than on Earth?

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Icarus, published (2016Icar..277..215N)

Water is necessary for the origin and survival of life as we know it. In the search for life-friendly worlds, water-rich planets therefore are obvious candidates and have attracted increasing attention in recent years. The surface H_2O layer on such planets (containing a liquid water ocean and possibly high-pressure ice below a specific depth) could potentially be hundreds of kilometres deep depending on the water content and the evolution of the proto-atmosphere.

We study possible constraints for the habitability of deep water layers and introduce a new habitability classification relevant for water-rich planets (from Mars-size to super-Earth-size planets). A new ocean model has been developed that is coupled to a thermal evolution model of the mantle and core. Our interior structure model takes into account depth-dependent thermodynamic properties and the possible formation of high-pressure ice.

We find that heat flowing out of the silicate mantle can melt an ice layer from below (in some cases episodically), depending mainly on the thickness of the ocean-ice shell, the mass of the planet, the surface temperature and the interior parameters (e.g. radioactive mantle heat sources). The high pressure at the bottom of deep waterice layers could also impede volcanism at the watermantle boundary for both stagnant lid and plate tectonics silicate shells.

We conclude that water-rich planets with a deep ocean, a large planet mass, a high average density or a low surface temperature are likely less habitable than planets with an Earth-like ocean.

Download/Website: `http://authors.elsevier.com/a/1T5bt_Rp9r8z5`

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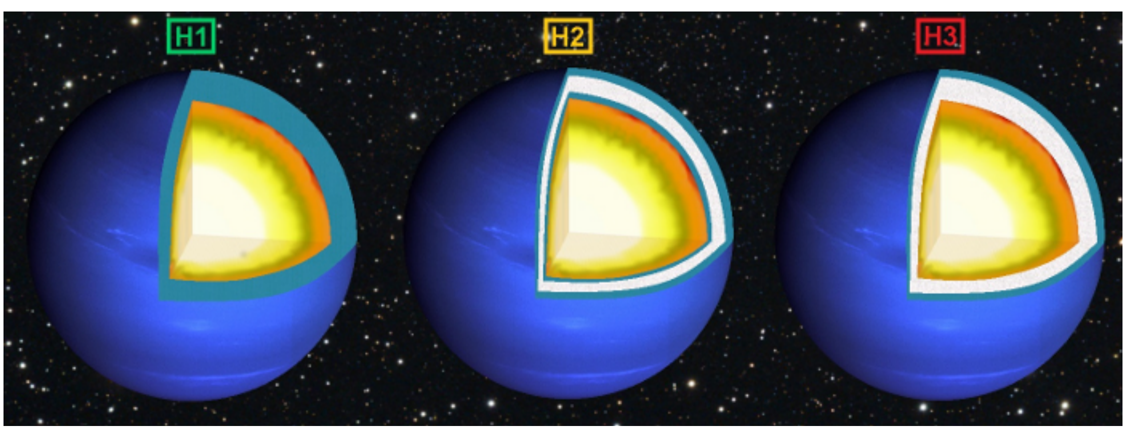

Figure 5: (Noack et al.) Schematic possible interior structures of water-rich planets with liquid water at their surface.

Migration and Growth of Protoplanetary Embryos III: Mass and Metallicity Dependence for FGKM main-sequence stars

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The Astrophysical Journal, in press (arXiv:1605.05294)

Radial velocity and transit surveys have found that the fraction of FGKM stars with close-in super-Earth(s) ($\eta_\oplus$) is around $30\% - 50\%$, independent of the stellar mass M_* and metallicity Z_*. In contrast, the fraction of solar-type stars harboring one or more gas giants (η_J) with masses $M_{\rm p} > 100\ M_\oplus$ is nearly $10\% - 15\%$, and it appears to increase with both M_* and Z_*. Regardless of the properties of their host stars, the total mass of some multiple super-Earth systems exceeds the core mass of Jupiter and Saturn. We suggest that both super-Earths and supercritical cores of gas giants were assembled from a population of embryos that underwent convergent type I migration from their birthplaces to a transition location between viscously heated and irradiation heated disk regions. We attribute the cause for the $\eta_\oplus$-$\eta_{\rm J}$ dichotomy to conditions required for embryos to merge and to acquire supercritical core mass ($M_c \sim 10\ M_\oplus$) for the onset of efficient gaseous envelope accretion. We translate this condition into a critical disk accretion rate, and our analysis and simulation results show that it weakly depends on M_* and decreases with metallicity of disk gas $Z_{\rm d}$. We find that embryos are more likely to merge into supercritical cores around relatively massive and metal-rich stars. This dependence accounts for the observed $\eta_{\rm J}$-M_*. We also consider the $Z_{\rm d}$-Z_* dispersed relationship and reproduce the observed η_J-Z_* correlation.

Download/Website: `http://arxiv.org/abs/1605.05294`

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Did Jupiter's core form in the innermost parts of the Sun's protoplanetary disk?

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[4] Laboratoire Lagrange, UMR7293, Université de Nice Sophia-Antipolis, CNRS, Observatoire de la Cote d'Azur, Boulevard de l'Observatoire, 06304 Nice Cedex 4, France
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Monthly Notices of the Royal Astronomical Society, 2016MNRAS.458.2962R

Jupiter's core is generally assumed to have formed beyond the snow line. Here we consider an alternative scenario, that Jupiter's core may have accumulated in the innermost parts of the protoplanetary disk. A growing body of research suggests that small particles ("pebbles") continually drift inward through the disk. If a fraction of drifting pebbles is trapped at the inner edge of the disk a several Earth-mass core can quickly grow. Subsequently, the core may migrate outward beyond the snow line via planet-disk interactions. Of course, to reach the outer Solar System Jupiter's core must traverse the terrestrial planet-forming region.
We use N-body simulations including synthetic forces from an underlying gaseous disk to study how the outward migration of Jupiter's core sculpts the terrestrial zone. If the outward migration is fast ($\tau_{mig} \sim 10^4$ years), the core simply migrates past resident planetesimals and planetary embryos. However, if its migration is slower ($\tau_{mig} \sim 10^5$ years) the core removes solids from the inner disk by shepherding objects in mean motion resonances. In many cases the disk interior to 0.5-1 AU is cleared of embryos and most planetesimals. By generating a mass deficit close to the Sun, the outward migration of Jupiter's core may thus explain the absence of terrestrial planets closer than Mercury. Jupiter's migrating core often stimulates the growth of another large ($\sim$ Earth-mass) core – that may provide a seed

for Saturn's core – trapped in exterior resonance. The migrating core also may transport a fraction of terrestrial planetesimals, such as the putative parent bodies of iron meteorites, to the asteroid belt.

Download/Website: https://planetplanet.net/2016/02/21/did-the-solar-system-form-inside-out/

Contact: rayray.sean@gmail.com

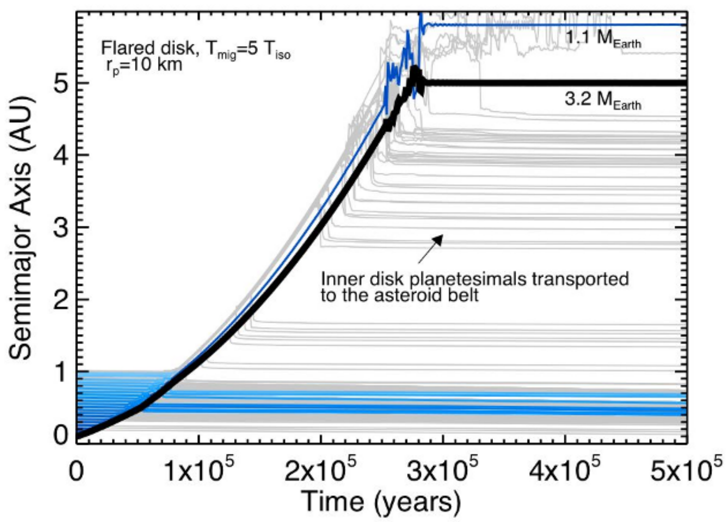

Figure 6: (Raymond et al.) The inner Solar System sculpted by Jupiter's outward-migrating core. Embryos are shown in blue and planetesimals in gray. Embryos were dynamically cleared from the inner parts of the disk, creating a mass deficit similar to the actual one. The core's outward migration also stimulated the formation of a second large core of 1.12 M_E core that survived at 5.8 AU, in 4:5 resonance with Jupiter's core. Finally, planetesimals from very close to the Sun were transported outward by the core's migration and deposited in the asteroid belt.

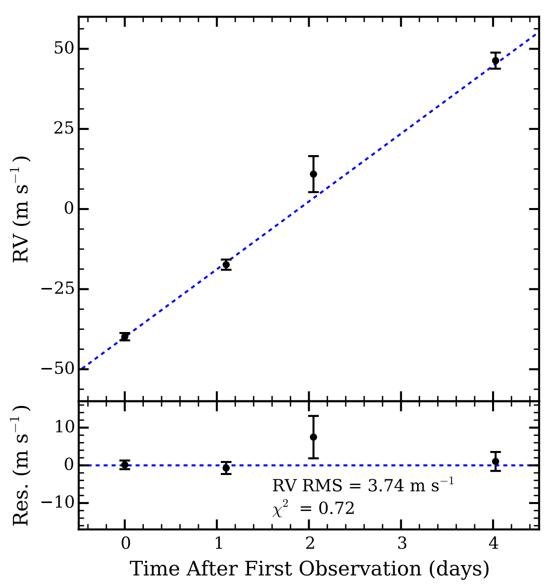

Figure 7: (Gao et al.) The nightly averaged radial velocities (RVs) of the M giant SV Peg observed in October 2010. The top panel shows the raw RVs, while the bottom panel shows the residuals after the subtraction of a linear trend. The slope of the linear trend is consistent with the previously observed variability time scale for this object (i.e. Hinkle et al. 1997).

Retrieval of Precise Radial Velocities from Near-Infrared High Resolution Spectra of Low Mass Stars

P. Gao[1], *P. Plavchan*[2], *J. Gagné*[3,4], *E. Furlan*[5], *M. Bottom*[6], *G. Anglada-Escudé* [7,8], *R. White*[9], *C. L. Davison*[9], *C. Beichman*[5], *C. Brinkworth*[5,10], *J. Johnson*[11], *D. Ciardi*[5], *K. Wallace*[12], *B. Mennesson*[12], *K. von Braun*[13], *G. Vasisht*[12], *L. Prato*[13], *S. R. Kane*[14], *A. Tanner*[15], *T. J. Crawford*[12], *D. Latham*[11], *R. Rougeot*[16], *C. S. Geneser*[2], *J. Catanzarite*[17]

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Publications of the Astronomical Society of the Pacific, in press (arXiv:1603.05997)

Given that low-mass stars have intrinsically low luminosities at optical wavelengths and a propensity for stellar activity, it is advantageous for radial velocity (RV) surveys of these objects to use near-infrared (NIR) wavelengths. In this work we describe and test a novel RV extraction pipeline dedicated to retrieving RVs from low mass stars using NIR spectra taken by the CSHELL spectrograph at the NASA Infrared Telescope Facility, where a methane isotopologue gas cell is used for wavelength calibration. The pipeline minimizes the residuals between the observations and a spectral model composed of templates for the target star, the gas cell, and atmospheric telluric absorption; models of the line spread function, continuum curvature, and sinusoidal fringing; and a parameterization of the wavelength solution. The stellar template is derived iteratively from the science observations themselves without a need for separate observations dedicated to retrieving it. Despite limitations from CSHELL's narrow wavelength range and instrumental systematics, we are able to (1) obtain an RV precision of $35\ \mathrm{m\,s^{-1}}$ for the RV standard star GJ 15 A over a time baseline of 817 days, reaching the photon noise limit for our attained SNR, (2) achieve $\sim 3\ \mathrm{m\,s^{-1}}$ RV precision for the M giant SV Peg over a baseline of several days and confirm its long-term RV trend due to stellar pulsations, as well as obtain nightly noise floors of ∼2–6 $\mathrm{m\,s^{-1}}$, and (3) show that our data are consistent with the known masses, periods, and orbital eccentricities of the two most massive planets orbiting GJ 876. Future applications of our pipeline to RV surveys using the next generation of NIR spectrographs, such as iSHELL, will enable the potential detection of Super-Earths and Mini-Neptunes in the habitable zones of M dwarfs.

Download/Website: `http://arxiv.org/abs/1603.05997`

Contact: `gaoliu2000@gmail.com`

A Resonant Chain of Four Transiting, Sub-Neptune Planets

S.M. Mills[1], *D.C. Fabrycky*[1], *C. Migazewski*[2,3], *E.B. Ford*[4,5,6], *E. Petigura*[7,8], *H. Isaacson*[7]

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Nature, published (doi:10.1038/nature17445)

Surveys have revealed many multi-planet systems containing super-Earths and Neptunes in orbits of a few days to a few months. There is debate whether in situ assembly or inward migration is the dominant mechanism of the formation of such planetary systems. Simulations suggest that migration creates tightly packed systems with planets whose orbital periods may be expressed as ratios of small integers (resonances), often in a many-planet series (chain). In the hundreds of multi-planet systems of sub-Neptunes, more planet pairs are observed near resonances than would generally be expected, but no individual system has hitherto been identified that must have been formed by migration. Proximity to resonance enables the detection of planets perturbing each other. Here we report transit timing variations of the four planets in the Kepler-223 system, model these variations as resonant-angle librations, and compute the long-term stability of the resonant chain. The architecture of Kepler-223 is too finely tuned to have been formed by scattering, and our numerical simulations demonstrate that its properties are natural outcomes of the migration hypothesis. Similar systems could be destabilized by any of several mechanisms, contributing to the observed orbital-period distribution, where many planets are not in resonances. Planetesimal interactions in particular are thought to be responsible for establishing the current orbits of the four giant planets in the Solar System by disrupting a theoretical initial resonant chain similar to that observed in Kepler-223.

Download/Website: `http://www.nature.com/nature/journal/vaop/ncurrent/full/nature17445.html`

Contact: `sean.martin.mills@gmail.com`

3 Conference announcements

Transiting Exoplanets

SOC: C. Hellier, N. Batalha, D. Charbonneau, H. Knutson, D. Pollacco, D. Queloz, H. Rauer;
LOC: C. Hellier, J. Southworth, D.R. Anderson, P.F.L. Maxted, B. Smalley

Keele University, UK, 17$^{\mathrm{th}}$–21$^{\mathrm{st}}$ July 2017

A conference dedicated to the discovery, characterisation and theory of transiting extrasolar planets, including Kepler, K2, CHEOPS, PLATO, WASP, NGTS, HATNet, HATS, KELT, MEarth, SPECULOOS, HST, JWST . . . *and more . . .*

Download/Website: `http://wasp-planets.net/conference/`

Contact: `c.hellier@keele.ac.uk`

4 Jobs and Positions

Postdoctoral Position in Exo-Planetary Science

Prof. Ray Jayawardhana

Applications are invited for a postdoctoral position at York University in Toronto. The successful candidate will work with Professor Ray Jayawardhana and his collaborators on observational and analytical studies of extra-solar planets and related topics such as planet formation and sub-stellar objects. Photometric and spectroscopic characterization of extra-solar planets is of particular interest. Prof. Jayawardhana's research group currently includes two postdocs and two graduate students. Group members use data from VLT, Subaru, Gemini, Keck, CFHT, Kepler, and other major observatories, and are also involved in science planning for the NIRISS instrument on JWST and the SPIRou instrument for CFHT. The successful candidate will also have the opportunity to collaborate with Professor John Moores at York, and with other members of the Technologies for Exo-Planetary Science (TEPS) program, funded by NSERC at $1.65 million, at institutions across Canada and abroad. The position is for two years, with extension to a third year possible, and comes with a competitive salary and funds for research expenses. Start date is flexible, ideally between August-November 2016.

Applicants should send their curriculum vitae, a description of research interests and plans and a list of publications, and should arrange for three letters of recommendation to be sent directly to Marlene Caplan (marlene@yorku.ca). All materials should be submitted electronically. Applications are accepted until the position is filled, and those received before July 1, 2016 will receive full consideration. Early expressions of interest and inquiries are welcome, and should be made to rayjay@yorku.ca

Contact: `rayjay@yorku.ca`

Postdoctoral research position on the follow-up and analysis of high-precision RV surveys

Prof. Stéphane Udry
Observatoire de Genève, Université de Genève, Chemin des Maillettes 51, 1290 Versoix, Switzerland

University of Geneva, starting September 2016

Applications are invited for a postdoctoral research position in the field of exoplanet science, focusing primarily on the detection and characterisation of low-mass exoplanets through high-resolution spectroscopy and state-of-the-art analysis of radial-velocity time series using advanced mathematical and statistical tools. The research will build on the exploitation of data from long-term surveys of large samples of solar-type stars.

Requirements: PhD in astrophysics. The successful applicant is expected to have demonstrated experience in exoplanet detection methods including high-resolution spectroscopy and precise radial-velocity observations, a solid knowledge about physical stellar phenomena, and a strong mathematical background in the signal analysis of time series.

Place: 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 characterisation 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 characterisation of planets inside and outside our Solar System. The applicant will also have the opportunity to develop collaborations with members of PlanetS.

Start: The starting date of the position is negotiable, and could start as early as September 2016.

Duration: The length of a postdoc contract is of 2 years, with possible extension depending on funding.

Salary: Swiss postdoc salaries are extremely competitive (starting at 81 000 CHF a year, commensurable with experience) even considering local costs of living. They are set by standard local regulations (i.e. the salary scale of the University of Geneva).

How to apply: Interested applicants should contact Prof. Stéphane Udry (stephane.udry@unige.ch) and provide in a single pdf file: a curriculum vitae and a list of publications, a one-page motivation letter and a short research statement describing past achievements and future projects. Also please arrange for letters of references (pdf) to be e-mailed to Prof. Stéphane Udry and indicate contact details of up to 3 reference persons.

Complete applications received by June 30, 2016, will receive full considerations. Past this date, applications will be considered depending on availability.

Download/Website: `http://www.exoplanets.ch`

Contact: `Stephane.Udry@unige.ch`

5 Announcements

Fizeau exchange visitors program in optical interferometry – supplemental call for applications

European Interferometry Initiative

www.european-interferometry.eu, application deadline: Jun. 15

The Fizeau exchange visitors program in optical interferometry funds (travel and accommodation) visits of researchers to an institute of his/her choice (within the European Community) to perform collaborative work and training on one of the active topics of the European Interferometry Initiative. The visits will typically last for one month, and strengthen the network of astronomers engaged in technical, scientific and training work on optical/infrared interferometry. The program is open for all levels of astronomers (Ph.D. students to tenured staff), non-EU based missions will only be funded if considered essential by the Fizeau Committee. Applicants are strongly encouraged to seek also partial support from their home or host institutions.

The deadline for applications is June 15. Fellowships can be awarded for missions carried out until the end of 2016! For missions in 2017 please wait for further announcements! The program is funded by OPTICON/FP7.

Please distribute this message also to potentially interested colleagues outside of your community! Looking forward to your applications,
Josef Hron & Laszlo Mosoni, (for the European Interferometry Initiative)

Download/Website: `http://www.european-interferometry.eu`

Contact: `fizeau@european-interferometry.eu`

Call for chapters for book proposal: Habitability of the Universe Before Earth

Richard Gordon & Alexei Sharov

Series: Astrobiology: Exploring Life on Earth and Beyond, 15 November 2016

There was a vast period of time from the origin of our universe to the formation of Earth. The Big Bang is estimated to have occurred 13.6 billion years ago, and the Earth is dated at 4.8 billion years. Evidence for life on Earth goes back to only 4.1 billion years. That leaves a period of about 8.8 billion years of existence before Earth formed, 9.5 billion if we presume a lifeless first billion years on Earth. We consider the times and places before life on Earth that might have provided suitable environments for life. As the universe changed considerably during this vast epoch, there is much time and space to which we can apply our imaginations and observations in estimating where, when, and in what circumstances life might have arisen. Is Earth life de novo, or derived from previous life?

Download/Website: `http://tinyurl.com/AboutDickGordon`, `http://www.grc.nia.nih.gov/branches/lg/dgas/sharov.html`

Contact: `DickGordonCan@gmail.com`, `sharov@comcast.net`

6 As seen on astro-ph

The following list contains all the entries relating to exoplanets that we spotted on astro-ph during May 2016. If you see any that we missed, please let us know and we'll include them in the next issue.

astro-ph/1605.00468 : **Discovery of concentric broken rings at sub-arcsec separations in the HD 141569A gas-rich, debris disk with VLT/SPHERE** by *C. Perrot, et al.*

astro-ph/1605.00616 : **Water loss from Earth-sized planets in the habitable zones of ultracool dwarfs: Implications for the planets of TRAPPIST-1** by *Emeline Bolmont, et al.*

astro-ph/1605.00938 : **Consequences of tidal interaction between disks and orbiting protoplanets for the evolution of multi-planet systems with architecture resembling that of Kepler 444** by *J.C.B. Papaloizou*

astro-ph/1605.01059 : **Predictions for the Detection and Characterization of a Population of Free-Floating Planets with K2 Campaign 9** by *Matthew T. Penny, et al.*

astro-ph/1605.01066 : **Temperature Structure and Atmospheric Circulation of Dry, Tidally Locked Rocky Exoplanets** by *Daniel D.B. Koll, Dorian S. Abbot*

astro-ph/1605.01325 : **Survival of habitable planets in unstable planetary systems** by *Daniel Carrera, Melvyn B. Davies, Anders Johansen*

astro-ph/1605.01453 : **Extreme Asymmetry in the Disk of V1247 Ori** by *Yurina Ohta, et al.*

astro-ph/1605.01564 : **Strong XUV irradiation of the Earth-sized exoplanets orbiting the ultracool dwarf TRAPPIST-1** by *Peter J. Wheatley, et al.*

astro-ph/1605.01618 : **Long-term and large-scale hydrodynamical simulations of migrating planets** by *Pablo Benitez-Llambay, et al.*

astro-ph/1605.01682 : **Maps of Evolving Cloud Structures in Luhman 16AB from HST Time-Resolved Spectroscopy** by *Theodora Karalidi, et al.*

astro-ph/1605.01731 : **A Comprehensive Dust Model Applied to the Resolved Beta Pictoris Debris Disk from Optical to Radio Wavelengths** by *Nicholas P. Ballering, et al.*

astro-ph/1605.01873 : **Gravitoturbulence in magnetised protostellar discs** by *A.Riols, H.Latter*

astro-ph/1605.01955 : **Variation in the pre-transit Balmer line signal around the hot Jupiter HD 189733 b** by *P. Wilson Cauley, et al.*

astro-ph/1605.01991 : **Spin orbit alignment for KELT-7b and HAT-P-56b via Doppler tomography with TRES** by *George Zhou, et al.*

astro-ph/1605.02074 : **Stability and Occurrence Rate Constraints on the Planetary Sculpting Hypothesis for "Transitional" Disks** by *Ruobing Dong, Rebekah Dawson*
astro-ph/1605.02255 : **Kepler exoplanets: a new method of population analysis** by *Wesley A. Traub*
astro-ph/1605.02365 : **Extended Transiting Disks and Rings Around Planets and Brown Dwarfs: Theoretical Constraints** by *J. J. Zanazzi, Dong Lai*
astro-ph/1605.02425 : **The Kilodegree Extremely Little Telescope: Searching for Transiting Exoplanets in the Northern and Southern Sky** by *Jack Soutter, Jonti Horner, Joshua Pepper*
astro-ph/1605.02507 : **On the ultraviolet anomalies of the WASP-12 and HD 189733 systems: Trojan satellites as a plasma source** by *K. G. Kislyakova, et al.*
astro-ph/1605.02683 : **Probability of CME Impact on Exoplanets Orbiting M Dwarfs and Solar-Like Stars** by *C. Kay, M. Opher, M. Kornbleuth*
astro-ph/1605.02708 : **Extrasolar Storms: Pressure-dependent Changes In Light Curve Phase In Brown Dwarfs From Simultaneous Hubble and Spitzer Observations** by *Hao Yang, et al.*
astro-ph/1605.02731 : **Imaging Extrasolar Giant Planets** by *Brendan P. Bowler*
astro-ph/1605.02744 : **Dust and gas density evolution at a radial pressure bump in protoplanetary disks** by *Tetsuo Taki, Masaki Fujimoto, Shigeru Ida*
astro-ph/1605.02764 : **Dynamics of Circumstellar Disks III: The case of GG Tau A** by *Andrew F. Nelson, F. Marzari*
astro-ph/1605.02771 : **The Peculiar Debris Disk of HD 111520 as Resolved by the Gemini Planet Imager** by *Zachary H. Draper, et al.*
astro-ph/1605.02825 : **False positive probabilties for all Kepler Objects of Interest: 1284 newly validated planets and 428 likely false positives** by *Timothy D. Morton, et al.*
astro-ph/1605.03049 : **CNO behaviour in planet-harbouring stars. I Nitrogen abundances in stars with planets** by *L. Suarez-Andres, et al.*
astro-ph/1605.03050 : **Evidence for a correlation between mass accretion rates onto young stars and the mass of their protoplanetary disks** by *C. F. Manara, et al.*
astro-ph/1605.03255 : **The magnetic properties of the planet host star Kepler-78** by *Claire Moutou, et al.*
astro-ph/1605.03584 : **Robo-AO Kepler Planetary Candidate Survey III: Adaptive Optics Imaging of 1629 Kepler Exoplanet Candidate Host Stars** by *Carl Ziegler, et al.*
astro-ph/1605.03595 : **Identifying the "true" radius of the hot sub-Neptune CoRoT-24b by mass loss modelling** by *H. Lammer, et al.*
astro-ph/1605.03867 : **On turbulence driven by axial precession and tidal evolution of the spin-orbit angle of close-in giant planets** by *Adrian J. Barker*
astro-ph/1605.03962 : **SPOTS: The Search for Planets Orbiting Two Stars: II. First constraints on the frequency of sub-stellar companions on wide circumbinary orbits** by *Mariangela Bonavita, et al.*
astro-ph/1605.03984 : **Polarimetry and flux distribution in the debris disk around HD 32297** by *R. Asensio-Torres, et al.*
astro-ph/1605.04066 : **Blueshifted [OI] lines from protoplanetary discs: the smoking gun of X-ray photoevaporation** by *Barbara Ercolano, James Owen*
astro-ph/1605.04291 : **EPIC212521166 b: a Neptune-mass planet with Earth-like density** by *H. P. Osborn, et al.*
astro-ph/1605.04310 : **Dependence of Small Planet Frequency on Stellar Metallicity Hidden by Their Prevalence** by *Wei Zhu, Ji Wang, Chelsea Huang*
astro-ph/1605.04586 : **Circumplanetary disk or circumplanetary envelope?** by *J. Szulagyi, et al.*
astro-ph/1605.04902 : **The First Spectrum of the Coldest Brown Dwarf** by *Andrew Skemer, et al.*
astro-ph/1605.04908 : **Effects of disc asymmetries on astrometric measurements - Can they mimic planets?** by *Quentin Kral, et al.*
astro-ph/1605.04924 : **Habitable Zones of Post-Main Sequence Stars** by *Ramses Ramirez, Lisa Kaltenegger*
astro-ph/1605.05064 : **Constraining the volatile fraction of planets from transit observations** by *Yann Alibert*

astro-ph/1605.05091 : **YETI observations of the young transiting planet candidate CVSO 30 b** by *St. Raetz, et al.*
astro-ph/1605.05093 : **Volatile carbon locking and release in protoplanetary disks. A study of TW Hya and HD 100546** by *M. Kama, et al.*
astro-ph/1605.05294 : **Migration and Growth of Protoplanetary Embryos III: Mass and Metallicity Dependence for FGKM main-sequence stars** by *Beibei Liu, Xiaojia Zhang, Doug Lin*
astro-ph/1605.05315 : **Direct Imaging discovery of a second planet candidate around the possibly transiting planet host CVSO 30** by *T.O.B. Schmidt et al.*
astro-ph/1605.05331 : **Exocometary gas in the HD 181327 debris ring** by *S. Marino, et al.*
astro-ph/1605.05453 : **Line-depth-ratio temperatures for the close binary nu Octantis: new evidence supporting the conjectured retrograde planet** by *David J. Ramm*
astro-ph/1605.05576 : **Eight years of accurate photometric follow-up of transiting giant exoplanets** by *Luigi Mancini, John Southworth*
astro-ph/1605.05618 : **The Collapse of the Wien Tail in the Coldest Brown Dwarf? Hubble Space Telescope Near-Infrared Photometry of WISE J085510.83-071442.5** by *Adam C. Schneider, et al.*
astro-ph/1605.05729 : **Measuring Transit Signal Recovery in the Kepler Pipeline. III. Completeness of the Q1-Q17 DR24 Planet Candidate Catalogue, with Important Caveats for Occurrence Rate Calculations** by *Jessie L. Christiansen, et al.*
astro-ph/1605.05772 : **ALMA Observations of Circumstellar Disks in the Upper Scorpius OB Association** by *Scott A. Barenfeld, et al.*
astro-ph/1605.05837 : **Incidence of debris discs around FGK stars in the solar neighbourhood** by *B. Montesinos, et al.*
astro-ph/1605.06161 : **Bringing ”The Moth” to Light: A Planet-Sculpting Scenario for the HD 61005 Debris Disk** by *Thomas M. Esposito, et al.*
astro-ph/1605.06720 : **The conjectured S-type retrograde planet in nu Octantis: more evidence including four years of iodine-cell radial velocities** by *D. J. Ramm, et al.*
astro-ph/1605.06769 : **The impact of secular resonances on habitable zones in circumstellar planetary systems of known binary stars** by *Akos Bazso, et al.*
astro-ph/1605.06777 : **Constraints on the presence of SiO gas in the debris disk of HD 172555** by *T. L. Wilson et al.*
astro-ph/1605.06879 : **Using Kepler Candidates to Examine the Properties of Habitable Zone Exoplanets** by *Arthur D. Adams, Stephen R. Kane*
astro-ph/1605.06942 : **An extreme planetary system around HD219828. One long-period super Jupiter to a hot-neptune host star** by *N. C. Santos, et al.*
astro-ph/1605.07130 : **Limit cycles can reduce the width of the habitable zone** by *Jacob Haqq-Misra, et al.*
astro-ph/1605.07177 : **High-Precision Radio and Infrared Astrometry of LSPM J1314+1320AB - I: Parallax, Proper Motions, and Limits on Planets** by *Jan Forbrich, et al.*
astro-ph/1605.07185 : **Raman Scattering by Molecular Hydrogen and Nitrogen in Exoplanetary Atmospheres** by *Antonija Oklopcic, Christopher M. Hirata, Kevin Heng*
astro-ph/1605.07211 : **Temperate Earth-sized planets transiting a nearby ultracool dwarf star** by *Michael Gillon, et al.*
astro-ph/1605.07352 : **Habitable worlds with JWST: transit spectroscopy of the TRAPPIST-1 system?** by *Joanna K. Barstow, Patrick G. J. Irwin*
astro-ph/1605.07359 : **Circumstellar multi-planetary systems in binary stars: secular resonances and a semi-analytical approach to determine the location** by *Elke Pilat-Lohinger, Akos Bazso, Barbara Funk*
astro-ph/1605.07603 : **Reduced Activity And Large Particles From the Disintegrating Planet Candidate KIC 12557548b** by *Everett Schlawin, et al.*
astro-ph/1605.07691 : **The Use of Extraterrestrial Resources to Facilitate Space Science and Exploration** by *Ian A. Crawford, Martin Elvis, James Carpenter*

astro-ph/1605.07825 : **Chemical complexity in protoplanetary disks in the era of ALMA and Rosetta** by *Catherine Walsh*

astro-ph/1605.07917 : **A Candidate Young Massive Planet in Orbit around the Classical T Tauri Star CI Tau** by *Christopher M. Johns-Krull, et al.*

astro-ph/1605.07927 : **Population Properties of Brown Dwarf Analogs to Exoplanets** by *Jacqueline K. Faherty, et al.*

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