ExoPlanet News
An Electronic Newsletter

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Contents

1 Editorial

Welcome to the sixty fourth edition of ExoPlanet News. As usual, we have an excellent selection of abstracts this month along with a wide range of postdoc & postgrad job opportunities.

I note that this month saw a milestone for exoplanet research. With the publication of a dozen new transiting exoplanets from the SuperWASP survey earlier this month (arXiv:1310.5607; arXiv:1310.5630; arXiv:1310.5654), the total number of confirmed exoplanets listed at the Extrasolar Planets Encyclopaedia (http://exoplanet.eu) exceeded 1000. With additional Kepler discoveries announced in the last few days (e.g. arXiv:1310.7942; arXiv:1310.5912), the total has leapt up further still.

The next edition of the newsletter is planned for early December 2013, so please send anything relevant over the next few weeks to exoplanet@open.ac.uk, and it will appear then. 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.

Best wishes
Andrew Norton
The Open University

2 Abstracts of refereed papers

Thermal Emission of WASP-14b Revealed with Three *Spitzer* Eclipses

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The Astrophysical Journal, in press

Exoplanet WASP-14b is a highly irradiated, transiting hot Jupiter. Joshi et al. calculate an equilibrium temperature T_{eq} of 1866 K for zero albedo and reemission from the entire planet, a mass of 7.3 $\pm$ 0.5 Jupiter masses (M_J) and a radius of 1.28 $\pm$ 0.08 Jupiter radii (R_J). Its mean density of 4.6 g cm^{-3} is one of the highest known for planets with periods less than 3 days. We obtained three secondary eclipse light curves with the *Spitzer Space Telescope*. The eclipse depths from the best jointly fit model are 0.224% $\pm$ 0.018% at 4.5 μm and 0.181% $\pm$ 0.022% at 8.0 μm. The corresponding brightness temperatures are 2212 $\pm$ 94 K and 1590 $\pm$ 116 K. A slight ambiguity between systematic models suggests a conservative 3.6 μm eclipse depth of 0.19% $\pm$ 0.01% and brightness temperature of 2242 $\pm$ 55 K.

Although extremely irradiated, WASP-14b does not show any distinct evidence of a thermal inversion. In addition, the present data nominally favor models with day night energy redistribution less than $\sim$30%. The current data are generally consistent with oxygen-rich as well as carbon-rich compositions, although an oxygen-rich composition provides a marginally better fit. We confirm a significant eccentricity of e = 0.087 $\pm$ 0.002 and refine other orbital parameters.

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

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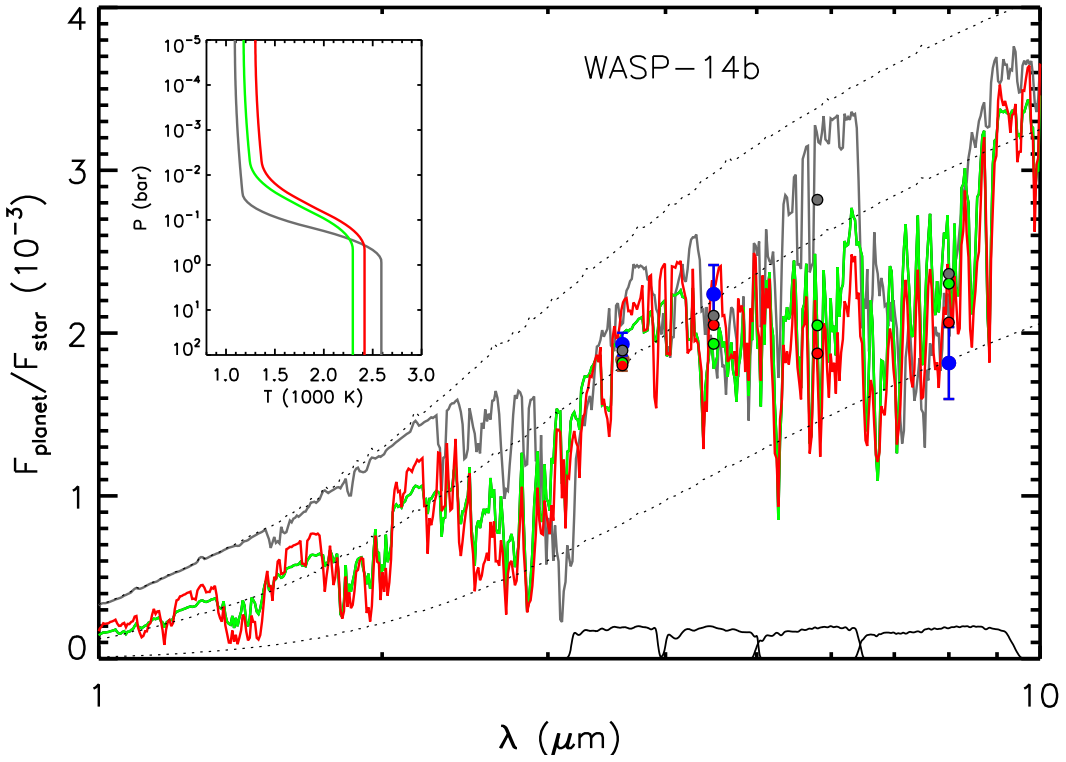

Figure 1: (Blecic et al.) Observations and model spectra for dayside emission from WASP-14b. The blue filled circles with error bars show our observations in *Spitzer* channel 1 (3.6 μm), 2 (4.5 μm), and 4 (8.0 μm). For the 3.6 μm channel, two values are shown, in blue and brown, corresponding to different ramp models used in deriving the eclipse depths. The green, red, and gray curves show model spectra with different chemical compositions and without thermal inversions that explain the data; the corresponding pressure–temperature profiles are shown in the inset. The green model has molecular abundances in thermochemical equilibrium assuming solar elemental abundances. The red model has 10 times lower CO and 6 times higher H_2O compared to solar abundance chemistry, i.e., more oxygen-rich than solar abundances. The gray model has a carbon-rich chemistry (C/O = 1). The green, red, and gray circles show the model spectra integrated in the *Spitzer* IRAC bandpasses. The oxygen-rich (red) model provides a marginally better fit to the data than the solar and carbon-rich models. The black dotted lines show three blackbody planet spectra at 1600 K, 2200 K, and 2600 K.

Discovery of WASP-65b and WASP-75b: Two Hot Jupiters Without Highly Inflated Radii

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Astronomy & Astrophysics, in press arXiv:1307.6532

We report the discovery of two transiting hot Jupiters, WASP-65b ($M_{\rm pl}$ = 1.55 $\pm$ 0.16 $M_{\rm J}$; $R_{\rm pl}$ = 1.11 $\pm$ 0.06 $R_{\rm J}$), and WASP-75b ($M_{\rm pl}$ = 1.07 $\pm$ 0.05 $M_{\rm J}$; $R_{\rm pl}$ = 1.27 $\pm$ 0.05 $R_{\rm J}$). They orbit their host star every $\sim$2.311, and $\sim$2.484 days, respectively. The planet host WASP-65 is a G6 star ($T_{\rm eff}$ = 5600 K, [Fe/H] = -0.07 ± 0.07, age $>$ 8 Gyr); WASP-75 is an F9 star ($T_{\rm eff}$ = 6100 K, [Fe/H] = 0.07 $\pm$ 0.09, age $\sim$ 3 Gyr). WASP-65b is one of the densest known exoplanets in the mass range 0.1 and 2.0 $M_{\rm J}$ ($\rho_{\rm pl}$ = 1.13 $\pm$ 0.08 $\rho_{\rm J}$), a mass range where a large fraction of planets are found to be inflated with respect to theoretical planet models. WASP-65b is one of only a handful of planets with masses of $\sim$1.5 $M_{\rm J}$, a mass regime surprisingly underrepresented among the currently known hot Jupiters. The radius of WASP-75b is slightly inflated ($<$10%) as compared to theoretical planet models with no core, and has a density similar to that of Saturn ($\rho_{\rm pl}$ = 0.52 $\pm$ 0.06 $\rho_{\rm J}$).

Download/Website: `http://arxiv.org/abs/1307.6532`

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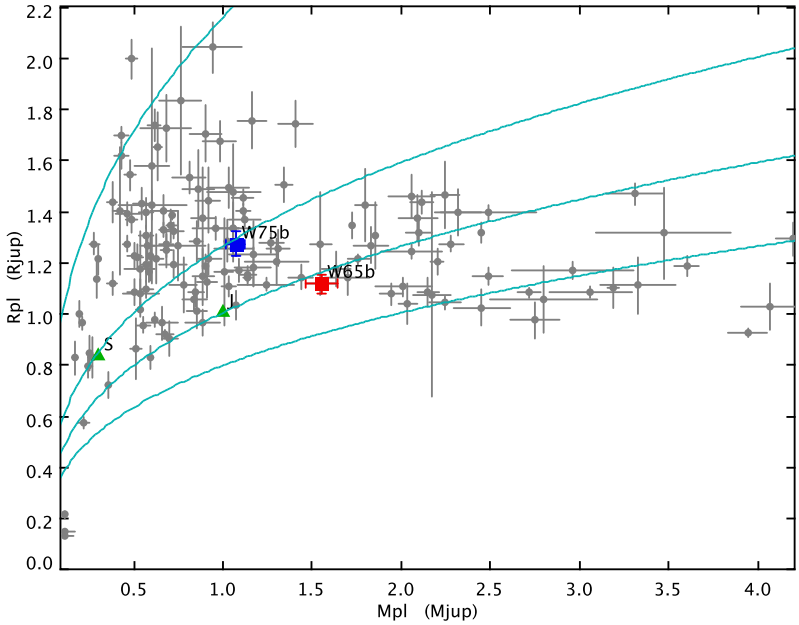

Figure 2: (Gomez Maqueo Chew et al.) Planet Mass–Radius Diagram. We present two newly discovered planets from the WASP survey for transiting planets, WASP-65b (red-filled square), and WASP-75b (blue-filled square). The grey points represent the known exoplanets in the Saturn and Jupiter mass regimes taken from exoplanet.org (23 May 2013) and complemented from the literature. Saturn and Jupiter are marked in the green-filled triangles, and are initialed. The continuous (cyan) lines represent equal density traces of 0.1, 0.5, 1.0, and 2.0 $\rho_{\rm pl}$, from left to right. WASP-65b lies in between the lower-density giant planets and the higher-density high-mass planets.

High Stellar FUV/NUV Ratio and Oxygen Contents in the Atmospheres of Potentially Habitable Planets

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Earth and Planetary Science Letters, in press

Recent observations of several planet-hosting M dwarfs show that most have FUV/NUV flux ratios 1000 times greater than that of the Sun. Here we show that the atmospheric oxygen contents (O2 and O3) of potentially habitable planets in this type of UV environment could be 2 3 orders of magnitude greater than those of their counterparts around Sun-like stars as a result of decreased photolysis of O3, H2O2, and HO2. Thus detectable levels of atmospheric oxygen, in combination with the existence of H2O and CO2, may not be the most promising biosignatures on planets around stars with high FUV/NUV ratios such as the observed M dwarfs.

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The Twenty-Five Year Lick Planet Search

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The Astrophysical JournalSupplement, in press (arXiv:1310.7315)

The Lick planet search program began in 1987 when the first spectrum of τ Ceti was taken with an iodine cell and the Hamilton Spectrograph. Upgrades to the instrument improved the Doppler precision from about $1\,\mathrm{m\,s^{-1}}$ in 1992 to about $3\,\mathrm{m\,s^{-1}}$ in 1995. The project detected dozens of exoplanets with orbital periods ranging from a few days to several years. The Lick survey identified the first planet in an eccentric orbit (70 Virginis) and the first multi-planet system around a normal main sequence star (Upsilon Andromedae). These discoveries advanced our understanding of planet formation and orbital migration. Data from this project helped to quantify a correlation between host star metallicity and the occurrence rate of gas giant planets. The program also served as a test bed for innovation with testing of a tip-tilt system at the coudé focus and fiber scrambler designs to stabilize illumination of the spectrometer optics. The Lick planet search with the Hamilton spectrograph effectively ended when a heater malfunction compromised the integrity of the iodine cell. Here, we present more than 14,000 velocities for 386 stars that were surveyed between 1987 and 2011.

Download/Website: `http://arxiv.org/abs/1310.7315`

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OTS 44: Disk and accretion at the planetary border

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Astronomy & Astrophysics, in press (arXiv:1310.1936)

We discover that the very low-mass brown dwarf OTS 44 (M9.5, $\sim$12 $\mathrm{M}_\odot$) has significant accretion and a substantial disk, which demonstrates that the processes that accompany canonical star formation occur down to a central mass of a few Jupiter masses. We discover in VLT/SINFONI spectra that OTS 44 has strong, broad, and variable Pa β emission that is evidence for active accretion at the planetary border. We also detect strong Hα emission of OTS 44 in a literature spectrum and determine an Hα EW of -141 Å, which indicates active accretion. Both the Pa β and Hα emission lines have broad profiles with wings extending to velocities of about $\pm$200 $\mathrm{km\,s^{-1}}$. We determine the mass accretion rate of OTS 44 based on Hα to $7.6\times10^{-12}\,\mathrm{M_\odot\,yr^{-1}}$. This result shows that OTS 44 has a relatively high mass-accretion rate considering its small central mass. This mass rate is nevertheless consistent with the general decreasing trend found for stars of several solar masses down to brown dwarfs. Furthermore, we determine the properties of the disk surrounding OTS 44 through radiative transfer modeling of flux measurement from the optical to the far-IR (Herschel) by applying a Bayesian analysis. We find that OTS 44 has a highly flared disk (β >1.2) with a mass of $9.1\,^{+1.7}_{-5.5}\times10^{-5}\,\mathrm{M_\odot}$, i.e. $\sim$0.1 $\mathrm{M_{Jup}}$ or 30 M_{Earth}. We show that the ratio of the disk-to-central-mass of about 10^{-2} found for objects between 0.03 $\mathrm{M_\odot}$ and 14 $\mathrm{M_\odot}$ is also valid for OTS 44 at a mass of $\sim$0.01 $\mathrm{M_\odot}$. Our observations are in line with an isolated star-like mode of the formation of brown dwarfs down to 0.01 $\mathrm{M_\odot}$.

Download/Website: `http://www.mpia.de/homes/joergens/publications/ots44.pdf`

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Trawling for transits in a sea of noise: A Search for Exoplanets by Analysis of WASP Optical Lightcurves and Follow-up (SEAWOLF)

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Monthly Notices of the Royal Astronomical Society, in press,

Studies of transiting Neptune-size planets orbiting close to nearby bright stars can inform theories of planet formation because mass and radius and therefore mean density can be accurately estimated and compared with interior models. The distribution of such planets with stellar mass and orbital period relative to their Jovian-mass counterparts can test scenarios of orbital migration, and whether "hot" (period < 10 d) Neptunes evolved from "hot" Jupiters as a result of mass loss. We searched 1763 late K and early M dwarf stars for transiting Neptunes by analyzing photometry from the Wide Angle Search for Planets and obtaining high-precision ($\leq 10^{-3}$) follow-up photometry of stars with candidate transit signals. One star in our sample (GJ 436) hosts a previously reported hot Neptune. We identified 92 candidate signals among 80 other stars and carried out 146 observations of predicted candidate transits with 1–2 m telescopes. Data on 70 WASP signals rules out transits for 39 of them; 28 other signals are ambiguous and/or require more data. Three systems have transit-like events in follow-up photometry and we plan additional follow-up observations. On the basis of no confirmed detections in our survey, we place an upper limit of 10.2% on the occurrence of hot Neptunes around late K and early M dwarfs (95% confidence). A single confirmed detection would translate to an occurrence of $5.3 \pm 4.4\%$. The latter figure is similar to that from Doppler surveys, suggesting that GJ 436b may be the only transiting hot Neptune in our sample. Our analysis of *Kepler* data for similar but more distant late-type dwarfs yields an occurrence of $0.32 \pm 0.21\%$. Depending on which occurrence is applicable, we estimate that the Next Generation Transit Survey will discover either ∼60 or ∼1000 hot Neptunes around late K and early M-type dwarfs.

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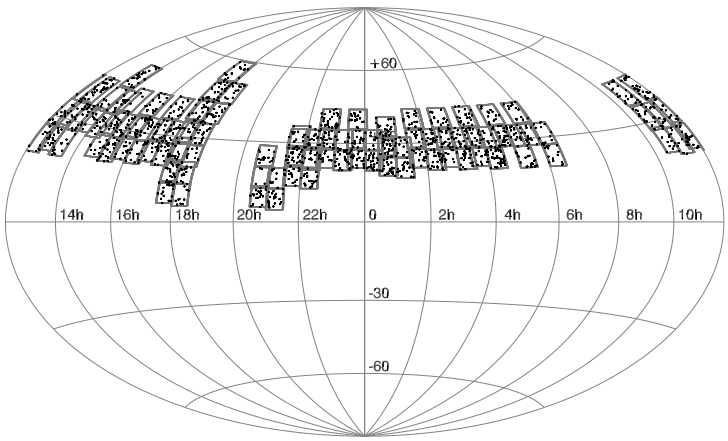

Figure 3: (Gaidos et al.) Locations of the 2004 inaugural fields of the WASP-North survey and K and M dwarf stars in the SEAWOLF survey.

A semi-empirical stability criterion for real planetary systems

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Monthly Notices of the Royal Astronomical Society, in press arXiv:1309.6861

We test a crossing orbit stability criterion for eccentric planetary systems, based on Wisdom's criterion of first-order mean motion resonance overlap. We show that this criterion fits the stability regions in real exoplanet systems quite well. In addition, we show that elliptical orbits can remain stable even for regions where the apocentre distance of the inner orbit is larger than the pericentre distance of the outer orbit, as long as the initial orbits are aligned. The analytical expressions provided here can be used to put rapid constraints on the stability zones of multiplanetary systems. As a byproduct of this research, we further show that the amplitude variations of the eccentricity can be used as a fast-computing stability indicator.

Download/Website: `http://adsabs.harvard.edu/doi/10.1093/mnras/stt1831`

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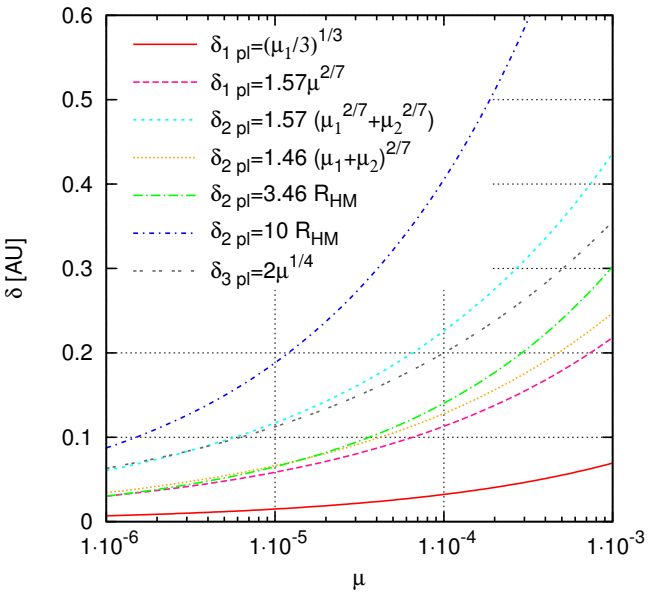

Figure 4: (Giuppone, Morais & Correia) Comparison of δ_i for the different instability criteria described in this paper as a function of the mass-ratio to the star μ. The planets have equal masses, the central star has $1M_\odot$, and the inner planet' semi-major axis is $a_i = 1$ AU. In red we plot the contribution of two individual Hill-regions. The green line is calculated using the mutual Hill radius as deduced by Gladman for two-planets on circular orbits. In blue, we show the 10 mutual Hill radius estimated from some numerical works. The pink line shows δ_i using Wisdom resonance overlap criterion for a single planet. The light-blue line shows the semi-empirical criterion proposed in this paper which in this case is a factor 1.76 larger than the resonance overlap criterion for 2 planets obtained by Deck et al 2013 (in orange). Finally, in gray we show Quillen's 3-body criterion (see the text for a detailed analysis of the comparison).

Direct Imaging Detection of Methane in the Atmosphere of GJ 504 b

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Astrophysical Journal Letters, in press (arXiv:1310.4183)

Most exoplanets detected by direct imaging so far have been characterized by relatively hot ($> \sim$1000 K) and cloudy atmospheres. A surprising feature in some of their atmospheres has been a distinct lack of methane, possibly implying non-equilibrium chemistry. Recently, we reported the discovery of a planetary companion to the Sun-like star GJ 504 using Subaru/HiCIAO within the SEEDS survey. The planet is substantially colder (<600 K) than previously imaged planets, and has indications of fewer clouds, which implies that it represents a new class of planetary atmospheres with expected similarities to late T-type brown dwarfs in the same temperature range. If so, one might also expect the presence of significant methane absorption, which is characteristic of such objects. Here, we report the detection of deep methane absorption in the atmosphere of GJ 504 b, using the Spectral Differential Imaging mode of HiCIAO to distinguish the absorption feature around 1.6 μm. We also report updated JHK photometry based on new $K_{\rm s}$-band data and a re-analysis of the existing data. The results support the notion that GJ 504 b has atmospheric properties distinct from other imaged exoplanets, and will become a useful reference object for future planets in the same temperature range.

Download/Website: `http://arxiv.org/abs/1310.4183`

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The Extremely Red, Young L Dwarf PSO J318.5−22: A Free-Floating Planetary-Mass Analog to Directly Imaged Young Gas-Giant Planets

Michael C. Liu[1], *Eugene A. Magnier*[1], *Niall R. Deacon*[2], *Katelyn N. Allers*[3], *Trent J. Dupuy*[4], *Michael C. Kotson*[1], *Kimberly M. Aller*[1], *W. S. Burgett*[1], *K. C. Chambers*[1], *P. W. Draper,*[5] *K. W. Hodapp*[1], *R. Jedicke*[1], *N. Kaiser*[1], *R.-P. Kudritzki,*[1] *N. Metcalfe,*[5] *J. S. Morgan*[1], *P. A. Price*[6], *J. L. Tonry,*[1] *R. J. Wainscoat*[1]

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[6] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA

Astrophysical Journal Letters, in press (arXiv:1310.0457)

We have discovered using Pan-STARRS1 an extremely red late-L dwarf, which has $(J-K)_{MKO} = 2.84$ and $(J-K)_{2MASS} = 2.78$, making it the reddest known field dwarf and second only to 2MASS J1207−39b among substellar companions. Near-IR spectroscopy shows a spectral type of L7±1 and reveals a triangular H-band continuum and weak alkali (K1 and Na1) lines, hallmarks of low surface gravity. Near-IR astrometry from the Hawaii Infrared Parallax Program gives a distance of 24.6±1.4 pc and indicates a much fainter J-band absolute magnitude than field L dwarfs. The position and kinematics of PSO J318.5−22 point to membership in the β Pic moving group. Evolutionary models give a temperature of 1160^{+30}_{-40} K and a mass of $6.5^{+1.3}_{-1.0}$ $M_{\rm Jup}$, making PSO J318.5−22 one of the lowest mass free-floating objects in the solar neighborhood. This object adds to the growing list of low-gravity field L dwarfs and is the first to be strongly deficient in methane relative to its estimated temperature. Comparing their spectra suggests that young L dwarfs with similar ages and temperatures can have different spectral signatures of youth. For the two objects with well constrained ages (PSO J318.5−22 and 2MASS J0355+11), we find their temperatures are ≈400 K cooler than field objects of similar spectral type but their luminosities are comparable, i.e., these young L dwarfs are very red and unusually cool but not "underluminous." Altogether, PSO J318.5−22 is the first free-floating object with the colors, magnitudes, spectrum, luminosity, and mass that overlap the young dusty planets around HR 8799 and 2MASS J1207−39.

Download/Website: `http://arxiv.org/abs/1310.0457`

Contact: `mliu@ifa.hawaii.edu`

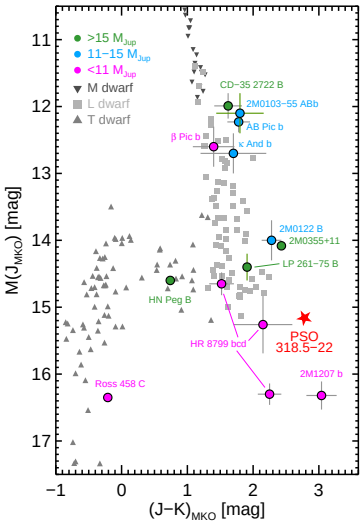

Figure 5: (Liu et al.) PSO J318.5−22 compared to known substellar objects based on the compilations of Dupuy & Liu (2012), Bowler et al. (2013), and references therein. Young substellar companions are highlighted, with the AB Pic b data from Biller et al. (2013). PSO J318.5−22 is very red and faint compared to field L dwarfs, with magnitudes and colors comparable to the planets around HR 8799 and 2MASS J1207−39. (Its measurements uncertainties are smaller than the symbol size.)

The blue sky of GJ3470b: the atmosphere of a low-mass planet unveiled by ground-based photometry

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[2] INAF – Osservatorio Astronomico di Padova
[3] INAF – Osservatorio Astrofisico di Catania
[4] INAF – Osservatorio Astronomico di Palermo
[5] INAF – Osservatorio Astrofisico di Arcetri
[6] INAF – Istituto di Astrofisica Spaziale e Fisica Cosmica

Astronomy & Astrophysics, in press, arXiv:1308.6765

GJ3470b is a rare example of a "hot Uranus" transiting exoplanet orbiting a nearby M1.5 dwarf. It is crucial for atmospheric studies because it is one of the most inflated low-mass planets known, bridging the boundary between "super-Earths" and Neptunian planets. We present two new ground-based light curves of GJ3470b gathered by the LBC camera at the Large Binocular Telescope. Simultaneous photometry in the ultraviolet ($\lambda_c = 357.5$ nm) and optical infrared ($\lambda_c = 963.5$ nm) allowed us to detect a significant change in the effective radius of GJ3470b as a function of wavelength. This can be interpreted as a signature of scattering processes occurring in the planetary atmosphere, which should be cloud-free and with a low mean molecular weight. The unprecedented accuracy of our measurements demonstrates that the photometric detection of Earth-sized planets around M dwarfs is achievable using 8-10m size ground-based telescopes. We provide updated planetary parameters and a greatly improved orbital ephemeris for any forthcoming study of this planet.

Download/Website: `http://dx.doi.org/10.1051/0004-6361/201321971`

Contact: `valerio.nascimbeni@unipd.it`

Supernova enrichment and dynamical histories of solar-type stars in clusters

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Monthly Notices of the Royal Astronomical Society, in press (arXiv: 1310.3270)

We use N-body simulations of star cluster evolution to explore the hypothesis that short-lived radioactive isotopes found in meteorites, such as ^{26}Al, were delivered to the Sun's protoplanetary disc from a supernova at the epoch of Solar System formation. We cover a range of star cluster formation parameter space and model both clusters with primordial substructure, and those with smooth profiles. We also adopt different initial virial ratios – from cool, collapsing clusters to warm, expanding associations. In each cluster we place the same stellar population; the clusters each have 2100 stars, and contain one massive 25 $M_\odot$ star which is expected to explode as a supernova at about 6.6 Myr. We determine the number of Solar (G)-type stars that are within 0.1 – 0.3 pc of the 25 $M_\odot$ star at the time of the supernova, which is the distance required to enrich the protoplanetary disc with the ^{26}Al abundances found in meteorites. We then determine how many of these G-dwarfs are unperturbed 'singletons'; stars which are never in close binaries, nor suffer sub-100 au encounters, and which also do not suffer strong dynamical perturbations.
The evolution of a suite of twenty initially identical clusters is highly stochastic, with the supernova enriching over 10 G-dwarfs in some clusters, and none at all in others. Typically only $\sim$25 per cent of clusters contain enriched, unperturbed singletons, and usually only 1 – 2 per cluster (from a total of 96 G-dwarfs in each cluster). The initial conditions for star formation do not strongly affect the results, although a higher fraction of supervirial (expanding) clusters would contain enriched G-dwarfs if the supernova occurred earlier than 6.6 Myr. If we sum together simulations with identical initial conditions, then $\sim$1 per cent of all G-dwarfs in our simulations are enriched, unperturbed singletons.

Download/Website: `http://arxiv.org/abs/1310.3270`

Contact: `rparker@phys.ethz.ch`

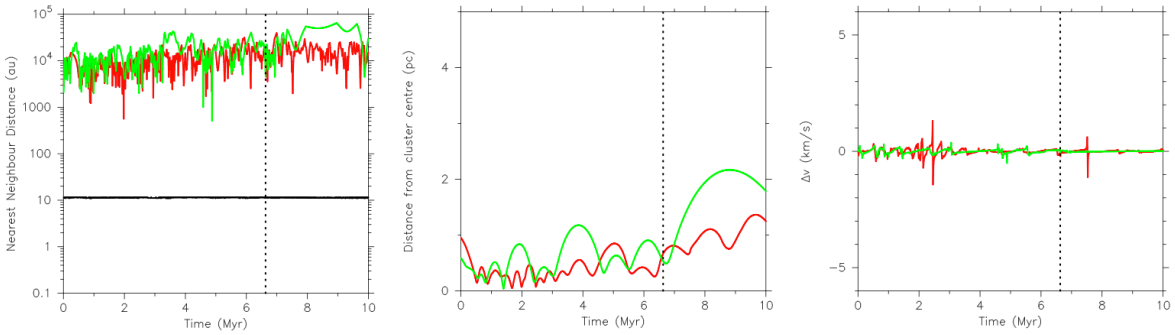

Figure 6: (Parker et al.) The dynamical histories of supernova enriched G-dwarfs in a typical simulation. On the left we show the nearest neighbour distance; in the middle we show the distance from the cluster centre; and on the right we show the change in velocity vector, for each of these stars as a function of time. The supernova time is shown by the vertical dotted line. Of the three stars that are enriched, two are singletons (shown by the red and green lines), but one suffers at least one significant velocity kick ($>1\,\mathrm{km\,s^{-1}}$) during the first 10 Myr of the cluster's evolution (the red line in the righthand panel).

Planet Hunters VI: The First Kepler Seven Planet Candidate System and 13 Other Planet Candidates from the Kepler Archival Data

J. R. Schmitt[1], *J. Wang*[1], *D. A. Fischer*[1], *K. J. Jek*[2], *J. C. Moriarty*[1], *T. S. Boyajian*[1], *M. E. Schwamb*[3], *C. Lintott*[4,5], *A. M. Smith*[5], *M. Parrish*[5], *K. Schawinski*[6], *S. Lynn*[5], *R. Simpson*[4], *M. R. Omohundro*[2], *T. Winarski*[2], *S. J. Goodman*[2], *T. Jebson*[2], *D. LaCourse*[2]

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[4] Oxford Astrophysics, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH
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[6] Institute for Astronomy, Department of Physics, ETH Zurich, Wolfgang-Pauli-Strasse 16, CH-8093 Zurich, Switzerland

The Astronomical Journal, submitted (arXiv:1310.5912)

We report the discovery of 14 new transiting planet candidates in the *Kepler* field from the Planet Hunters citizen science program. None of these candidates overlap with *Kepler* Objects of Interest (KOIs), and five of the candidates were missed by the *Kepler* Transit Planet Search (TPS) algorithm. The new candidates have periods ranging from $124 - 904$ days, eight residing in their host star's habitable zone (HZ) and two (now) in multiple planet systems. We report the discovery of one more addition to the six planet candidate system around KOI-351, marking the *first seven planet candidate system* from *Kepler*. Additionally, KOI-351 bears some resemblance to our own solar system, with the inner five planets ranging from Earth to mini-Neptune radii and the outer planets being gas giants; however, this system is very compact, with all seven planet candidates orbiting ≤ 1 AU from their host star. We perform a numerical integration of the orbits and show that the system remains stable for over 100 million years. A Hill stability test also confirms the feasibility for the dynamical stability of the KOI-351 system.

Download/Website: `http://arxiv.org/abs/1310.5912`

Contact: `joseph.schmitt@yale.edu`

Magnesium in the atmosphere of the planet HD209458 b : Observations of the thermosphere-exosphere transition region

A. Vidal-Madjar[1], C. M. Huitson[2], V. Bourrier[1], J.-M. Désert[3,4,1], G. Ballester[5], A. Lecavelier des Etangs[1], D. K. Sing[2], D. Ehrenreich[6], R. Ferlet[1], G. Hébrard[1,7], J. C. McConnell[8]

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[8] Department of Earth and Space Science and Engineering, York University, Toronto, Canada

Astronomy & Astrophysics, in press (arXiv:1310.8104)

The planet HD 209458 b is one of the most well studied hot-Jupiter exoplanets. The upper atmosphere of this planet has been observed through ultraviolet/optical transit observations with H I observation of the exosphere revealing atmospheric escape. At lower altitudes just below the thermosphere, detailed observations of the Na I absorption line has revealed an atmospheric thermal inversion. This thermal structure is rising toward high temperatures at high altitudes, as predicted by models of the thermosphere, and could reach $\sim$10 000 K at the exobase level. Here, we report new near ultraviolet Hubble Space Telescope / Space Telescope Imaging Spectrograpgh (HST/STIS) observations of atmospheric absorptions during the planetary transit of HD 209458 b.

We report absorption in atomic magnesium (Mg I), while no signal has been detected in the lines of singly ionized magnesium (Mg II). We measure the Mg I atmospheric absorption to be $6.2\pm2.9\%$ in the velocity range from -62 to -19 km/s. The detection of atomic magnesium in the planetary upper atmosphere at a distance of several planetary radii gives a first view into the transition region between the thermosphere and the exobase, where atmospheric escape takes place. We estimate the electronic densities needed to compensate for the photo-ionization by dielectronic recombination of Mg+ to be in the range of 10^8-10^9 cm^{-3}. Our finding is in excellent agreement with model predictions at altitudes of several planetary radii.

We observe Mg I atoms escaping the planet, with a maximum radial velocity (in the stellar rest frame) of -60 km/s. Because magnesium is much heavier than hydrogen, the escape of this species confirms previous studies that the planet's atmosphere is undergoing hydrodynamic escape. We compare our observations to a numerical model that takes the stellar radiation pressure on the Mg I atoms into account. We find that the Mg I atoms must be present at up to $\sim$7.5 planetari radii altitude and estimate an Mg I escape rate of $\sim3\times10^7$ g s^{-1}. Compared to previous evaluations of the escape rate of H I atoms, this evaluation is compatible with a magnesium abundance roughly solar. A hint of absorption, detected at low level of significance, during the post-transit observations, could be interpreted as a Mg I cometary-like tail. If true, the estimate of the absorption by Mg I would be increased to a higher value of about $8.8\pm2.1\%$.

Contact: alfred@iap.fr

3 PhD theses

The effects of tidal interactions on the properties and evolution of hot-Jupiter planetary systems

D. J. A. Brown
SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, Fife KY16 9SS, UK

Ph.D. Thesis, Accepted following minor corrections

Thanks to a range of discovery methods that are sensitive to different regions of parameter space, we now know of over 900 planets in over 700 planetary systems. This large population has allowed exoplanetary scientists to move away from a focus on simple discovery, and towards efforts to study the bigger pictures of planetary system formation and evolution.
The interactions between planets and their host stars have proven to be varied in both mechanisms and scope. In particular, tidal interactions seem to affect both the physical and dynamical properties of planetary systems, but characterising the broader implications of this has proven challenging. In this thesis I present work that investigates different aspects of tidal interactions, in order to uncover the scope of their influence of planetary system evolution.
I compare two different age calculation methods using a large sample of exoplanet and brown dwarf host stars, and find a tendency for stellar model fitting to supply older age estimates than gyrochronology, the evaluation of a star's age through its rotation (Barnes 2007). Investigating possible sources of this discrepancy suggests that angular momentum exchange through the action of tidal forces might be the cause.
I then select two systems from my sample, and investigate the effect of tidal interactions on their planetary orbits and stellar spin using a forward integration scheme. By fitting the resulting evolutionary tracks to the observed eccentricity, semi-major axis and stellar rotation rate, and to the stellar age derived from isochronal fitting, I am able to place constraints on tidal dissipation in these systems. I find that the majority of evolutionary histories consistent with my results imply that the stars have been spun up through tidal interactions as the planets spiral towards their Roche limits.
I also consider the influence of tidal interactions on the alignment between planetary orbits and stellar spin, presenting new measurements of the projected spin-orbit alignment angle, λ, for six hot Jupiters. I consider my results in the context of the full ensemble of measurements, and find that they support a previously identified trend in alignment angle with tidal timescale, implying that tidal realignment might be responsible for patterns observed in the λ distribution.

Download/Website: `PDF copies available on request`

Contact: `d.j.a.brown@warwick.ac.uk`

4 Announcements

NEAT double-blind experiment : find another Earth . . . yourself!

Guillem Anglada-Escudé[1]*, Fabien Malbet*[2]*, Alain Leger*[3]

[1] School of Physics and Astronomy. Queen Mary, University of London. London, United Kingdom
[2] Laboratoire d'Astrophysique de Grenoble, Université Joseph Fourier/CNRS. Grenoble, France
[3] Institut d'Astrophysique Spatiale, Université Paris-Sud. Orsay, France

Pre-announcement, Official call to be issued before Nov-15th

The Near Earth Astrometric Telescope (NEAT) is a mission concept that will be submitted to the next ESA call for its M4 mission (by mid, or end 2014). Its goal is to make a complete survey of Earth-mass planets around nearby sun-like stars (D $<$ 20 pc), and characterize the architectures of planetary systems with low mass planets in their habitable zones. Detection of these planets in advance will be crucial to optimally design ambitious direct-imaging and spectroscopic mission concepts (e.g., Darwin, TPF or NWO) by:

- Building a target list of potentially habitable planets around nearby stars, saving the time these missions would lose studying stars without relevant planets.
- Determining the mass of these planets, a key piece of information to estimate the physical conditions at the surface of the planet(s) where biosignature gases would have been detected.

In order to demonstrate the exoEarth planet finding capabilities of a pointed astrometric mission, an open call to participate in a Double-Blind Test excercise will be issued early November 2013. A double-blind test experiment consists on a team generating synthetic NEAT observations (us) while other teams (you) analyze the data and try finding the injected planets. We will generate observations on a sample of our actual $\sim$200 closest F, G, and K neighbors. The data will contain signals of hypothetic planetary systems generated using the latest planet-formation models, and results from ground and space-based surveys.
If you are interested in participating, please send an e-mail to `Fabien.Malbet@obs.ujf-grenoble.fr`. The official announcement will be released not later than Nov-15th and the data-analysis teams will be invited to participate in a dedicated NEAT-workshop by Spring 2014 in Grenoble(France). You can participate as an individual or as a member of a team. You do not need to be an astronomer either. In addition to assessing the planet finding capabilities of NEAT, we are also interested in investigating different data-analysis approaches to deal with astrometric time-series. On request, we can provide you the contact of other individuals that may be interested in making a team with you.
In the figure, we show the expected astrometric signal data (continuous sampling) for the recently proposed 5-planet system around the Sun-like star Tau Ceti. Parallax and proper motion have been removed to improve visualization. No noise was added and all variability comes from motion caused by putative planets. Detecting multi-planetary systems is challenging! The results of the double-blind test will be used to set the top-level requirements for the NEAT instrument. Data-analysis teams will also be invited to contribute in the NEAT proposal.

Download/Website: `http://neat.obs.ujf-grenoble.fr`

Contact: `guillem.anglada@gmail.com, Fabien.Malbet@obs.ujf-grenoble.fr, alain.leger@ias.u-psud.fr`

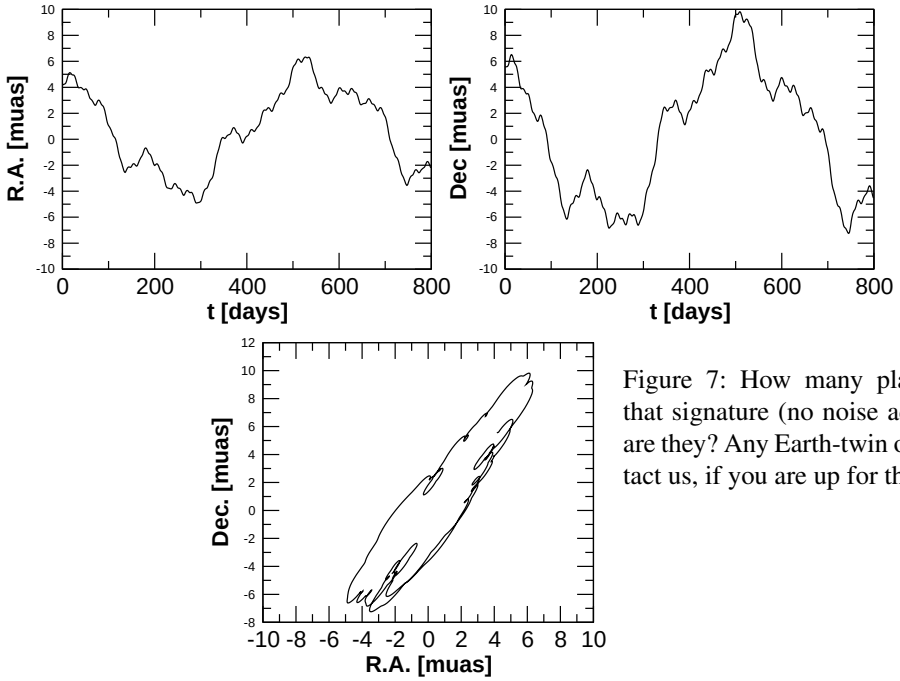

Figure 7: How many planets produce that signature (no noise added)? Which are they? Any Earth-twin on-sight? Contact us, if you are up for the challenge!

5 Jobs and Positions

Assistant, Associate, or Senior Research Scientist

T. Swindle
Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721, USA

Tucson, Arizona, Start date negotiable

The Lunar and Planetary Laboratory at The University of Arizona expects to fill up to 2 positions at the level of Assistant, Associate, or Senior Research Scientist. These ranks are equivalent to the corresponding professorial ranks, but without a commitment for state support or teaching responsibility. Research Scientists report to the director of the Lunar and Planetary Laboratory.
Salary and position title will be based on the qualifications of the selected candidate(s), who will be responsible for raising 100% of their salaries and research funds through their own extramural grants and contracts. To be considered for an appointment at the rank of Assistant Research Scientist, candidates must demonstrate solid scientific accomplishments and clear promise of continued achievement. Candidates for the position of Associate or Senior Research Scientist must demonstrate an internationally recognized record of distinguished scientific achievement and leadership in planetary and solar-system science.
For full position details and to apply online, please see www.hr.arizona.edu and reference job no. 53732. The University of Arizona is an EEO/AA Employer-M/W/D/V

Download/Website: `http://www.hr.arizona.edu/`

Contact: `tswindle@lpl.arizona.edu`

Postdoctoral Position in Astrophysics: The formation and evolution of mean-motion resonances in planetary systems

Prof. Ewa Szuszkiewicz
Institute of Physics and CASA*, University of Szczecin, Wielkopolska 15, 70-451 Szczecin, POLAND

Institute of Physics and CASA, 1^{st} of January 2014*

A two-year postdoctoral position funded by the Polish National Science Centre through a grant MAESTRO led by Prof. Ewa Szuszkiewicz, is available at the Astronomy and Astrophysics Group of the Faculty of Mathematics and Physics of the University of Szczecin, Poland, starting from the 1st of January 2014. The successful candidate will join the team of Prof. Szuszkiewicz working on the project "The formation and evolution of mean-motion resonances in planetary systems" and will have the possibility of participating in international schools and conferences. Short visits at the University of Toruń and at the DAMTP, University of Cambridge, are also planned.
High-quality candidates are sought with a strong background in astrophysics and numerical simulations. Previous experience in hydrodynamical and magnetohydrodynamical astrophysical calculations is required. Familiarity with N-body techniques is desirable. The successful candidate must hold a PhD degree or equivalent by the starting date of the position.
The Faculty of Mathematics and Physics of the University of Szczecin offers an excellent environment for performing cutting-edge research in astronomy, mathematics and physics, as well as in the interdisciplinary studies of astrobiology. The Centre for Advanced Studies in Astrobiology and Related Topics (CASA*) has its headquarters there. CASA* represents Poland in the European Astrobiology Network Association (EANA). The Astronomy and Astrophysics Group participates in the projects ASTROGRID-PL (devoted to the formation of an integrated IT platform dedicated to astronomical research), and POLFAR (POlish Low Frequency Array). The Faculty of Mathematics and Physics has also very good computational facilities including a HPC cluster equipped with CPUs and GPUs.
Interested applicants should send a cover letter accompanied with a CV and a brief statement of past research and research interests to Prof. Szuszkiewicz at the e-mail address: szusz@fermi.fiz.univ.szczecin.pl. They should also include the e-mail addresses of 3-4 referees willing to write a letter of reference on their behalf. The deadline for applications is the 30th of November.
Enquiries about the postdoctoral position and the project should be sent to Prof. Ewa Szuszkiewicz at szusz@fermi.fiz.univ.szczecin.pl

Contact: `szusz@fermi.fiz.univ.szczecin.pl`

Postdoctoral Researcher in Exoplanet Studies

Simon Albrecht
University Aarhus

University Aarhus, Starting in 2014

3 year postdoc position in the field of exoplanet research at the Stellar Astrophysics Centre (SAC), Aarhus University, Denmark

The aim of the Stellar Astrophysics Centre (SAC) is to perform a coherent study of stars and planetary systems. From an observational point of view the study of the physics of stars and planetary systems is undergoing a revolution, thanks to recent and coming observational facilities, including the Kepler mission, the Transiting Exoplanet Survey Satellite (TESS), and the Danish-led SONG network. The goal of the Centre is to ensure that full use is made of these possibilities to perform a coherent study of stars, and their associated planetary systems, through the integration of several normally separate fields.

The Department of Physics and Astronomy plays a leading role in the asteroseismic use of data from the NASA Kepler mission and in the ground-based SONG network. We also have access to telescopes through the Danish membership of European Southern Observatory (ESO) and the Nordic Optical Telescope (NOT). The Centre recently made a new staff hire in the field of exoplanet research (Simon Albrecht) to strengthen its research profile in this field.

Areas of work for the successful applicant may include work on detection of planetary systems as well as detailed studies of exoplanet system architecture, system evolution, and exoplanet atmospheres. However, the successful candidate is encouraged to pursue an independent research program in connection with the research carried out by the members of the SAC.

SAC has established direct research collaborations with research groups from MIT, University of Sydney, University of Birmingham, NASA Ames Space Center and University of Freiburg, which form an integral part of the Centre. There is an extensive exchange of scientists with our collaborators, with many shorter and longer visits to, and by, them. The many visitors and the postdoc and PhD programme at SAC provide a vibrant working environment and we invite the successful applicant to be a part of this environment.

Candidates must have a Ph.D. in astronomy, astrophysics, physics, or equivalent, by the date of their appointment. The starting date is expected to be in 2014, but the exact date is negotiable. The duration of the position is up to three years: an initial two-year appointment and one annual renewal contingent on satisfactory performance.

Questions regarding this job offer should be directed to Associate Professor Simon Albrecht (albrecht@phys.au.dk) or Associate Professor Hans Kjeldsen (hans@phys.au.dk).

Applicants should submit a cover letter, a CV, a list of publications, and a statement explaining their past and current research (maximum 3 pages) as well as a research proposal (maximum 3 pages).

Deadline: All applications must be made online and received by: 15/12/2013

Download/Website: `http://www.au.dk/en/about/job/nat/academicpositions/`

Contact: `albrecht@phys.au.dk`

PhD Positions in Astrophysics: The formation and evolution of mean-motion resonances in planetary systems

Prof. Ewa Szuszkiewicz
Institute of Physics and CASA*, University of Szczecin, Wielkopolska 15, 70-451 Szczecin, POLAND

Institute of Physics and CASA, positions available immediately*

Two four-year PhD positions funded by the Polish National Science Centre through a grant MAESTRO led by Prof. Ewa Szuszkiewicz, are available at the Astronomy and Astrophysics Group of the Faculty of Mathematics and Physics of the University of Szczecin, Poland, starting as soon as possible. The successful candidates will join the team of Prof. Szuszkiewicz working on the project "The formation and evolution of mean-motion resonances in planetary systems" and will have the possibility of participating in international schools and conferences. Short visits at the University of Toruń and at the DAMTP, University of Cambridge, are also planned.
High-quality candidates are sought with a strong background in astrophysics and numerical simulations. The successful candidate must hold a MSc degree or equivalent by the starting date of the position. The PhD programme consists mostly of research work, but the opportunity to acquire complementary skills will be provided.
The Faculty of Mathematics and Physics of the University of Szczecin offers an excellent environment for performing cutting-edge research in astronomy, mathematics and physics, as well as in the interdisciplinary studies

of astrobiology. The Centre for Advanced Studies in Astrobiology and Related Topics (CASA*) has its headquarters there. CASA* represents Poland in the European Astrobiology Network Association (EANA). The Astronomy and Astrophysics Group participates in the projects ASTROGRID-PL (devoted to the formation of an integrated IT platform dedicated to astronomical research), and POLFAR (POlish Low Frequency Array). The Faculty of Mathematics and Physics has also very good computational facilities including a HPC cluster equipped with CPUs and GPUs.
Interested applicants should send a cover letter accompanied with CV, transcripts of study records (with grades) and a brief statement of past research and research interests to szusz@fermi.fiz.univ.szczecin.pl. They should also include the e-mail addresses of 2-3 referees willing to write a letter of reference on their behalf. The deadline for applications is the 20th of November 2013. Enquiries about the PhD scholarships and the project should be sent to Prof. Ewa Szuszkiewicz at szusz@fermi.fiz.univ.szczecin.pl

Contact: szusz@fermi.fiz.univ.szczecin.pl

PhD positions in Star and Planet Formation and Exoplanets

Prof. Michael R. Meyer; Prof. Hans Martin Schmid
Star and Planet Formation Research Group, ETH Zurich Institute for Astronomy, Wolfgang-Pauli-Strasse 27, CH-8093 Zurich, Switzerland

ETH Zurich Institute for Astronomy, After 1st December 2013

The Institute for Astronomy of the Swiss Federal Institute of Technology (ETH Zurich) Star and Planet Formation Research Group invites applications for new PhD positions related to i) the direct detection and characterization of extra-solar planets (with Prof. M.R. Meyer); ii) calibration and scientific exploitation of the ZIMPOL/SPHERE instrument to be commissioned in 2014 on the VLT (with Prof. H.M. Schmid); and iii) interdisciplinary research on planet formation theory utilizing astronomical, cosmochemical, and geophysical constraints (with Prof. M.R. Meyer).
Salaries for PhD students start at CHF 52,500. Students will have the opportunity to study experimental and theoretical aspects of astronomy through formal coursework, conducting research with local experts in planet formation and exoplanet science as well as our international network of collaborators, and utilize state-of-the-art facilities. Successful applicants are expected to have a Master of Science degree in Physics, Astronomy, or related discipline, and to have already participated in one (or more) research projects (preferably in astrophysics).
Switzerland is a member of ESO and ESA, and successful applicants will have full access to their facilities, including data from the GTO Program of the SPHERE Project. The Institute for Astronomy maintains a network of workstations, as well as a wide range of high performance computing options. Members of the Institute also play a leading role in the interdisciplinary PLANET-Z initiative linking research groups at the ETH Zurich in astronomy, earth science, and computational astrophysics at the University of Zurich. Qualified applicants will be able to explore research opportunities in the Laboratory for Astronomical Instrumentation.
Applications are invited from all nationalities and should consist of a CV (1-2 pages), description of relevant research experience (2 pages), academic transcripts, scores from relevant standardized tests (e.g. TOEFL, Physics GRE) a personal statement of interests and goals (1 page), and the names of three referees that can be contacted if necessary. Materials should be sent electronically in a single pdf file to eth-astro-star-planet@phys.ethz.ch. Review of applications will begin December 1, 2013 and will continue until all positions are filled.
The ETH Zurich will provide benefits for maternity leave, retirement, accident insurance, and relocation costs.

Download/Website: http://www.pa.ethz.ch/

Contact: Marianne Chiesi (marianne.chiesi@phys.ethz.ch)

PhD position on Earth-like exoplanet modelling

Daphne M. Stam
Aerospace Engineering, Technical University Delft

Aerospace Engineering, TU Delft, Spring 2014

Rocky exoplanets in the habitable zones of stars are prime targets for the search for extraterrestrial life. Whether conditions for life are present on a planet will depend on the properties of the atmosphere and surface. The aim of this project is to identify observables that are characteristic for conditions for life and life itself, for different types of potentially habitable planets. The detectability will be investigated through numerical simulations of flux and polarisation spectra of different planets. Special attention will be given to the detection of circularly polarised light due to molecules displaying homochirality, a common characteristic of organics on Earth, and to the formation and the micro- and macroscopic properties of clouds. Simulated spectra for an Earth-like planet will be compared to available Earthshine measurements and will be used for the design of LOUPE, a moon-based spectropolarimeter for observing the Earth as an exoplanet, in close collaboration with the Experimental Astrophysics group of prof. Christoph Keller at the Astronomical Observatory of Leiden.
This PhD-project is part of the new research network 'PEPSci' that aims at research on the interface of Astronomy and Earth Sciences, and that is funded by the Netherlands Organisation for Scientific Research (NWO).
Applicants are expected to have a university degree (MSc) in physics, astrophysics, applied mathematics, Earth and planetary sciences, or a closely related area, with a strong background in numerical modelling. Experience with the interpretation of observations from telescopes or space instrumentation would be an asset. Applicants must be proficient in spoken and written English. The successful candidate will be granted a temporary employment contract with the university for a period of 4 years, with an evaluation at the end of the first year.
For further information please contact Dr. Daphne Stam (d.m.stam@tudelft.nl). To apply, please send your CV, a brief description of research interests, a list of courses in the BSc and MSc programme including marks, a list of published papers or reports, and the names and email-addresses of 2 references by 15 December 2013 to Mrs. N. van Wingaarden, n.vanwingaarden@tudelft.nl.
When applying for this position, please refer to vacancy number LR13-19.

Download/Website: `http://www.nwo.nl/en/research-and-results/programmes/planetary+and+exoplanetary+research+programme`

Contact: `d.m.stam@tudelft.nl`

Two PhD positions on exoplanet research

Ignas Snellen & Christoph Keller
Leiden Observatory, Leiden University, Postbus 9513,2300 RA, Leiden, The Netherlands

Leiden, NL, September 2014

Leiden Observatory invites applications for two PhD positions to work at the forefront of extrasolar planet research, 1) to work with the Multi-site All Sky CAmeRA, MASCARA to find the brightest transiting exoplanet systems in the sky, and 2) to study gas and dust from hot, rocky exoplanets.

Project 1 (supervision - Ignas Snellen): In a few months, the first station of the Multi-site All-Sky CAmeRA MASCARA will become operational. Its aim is to find the brightest transiting exoplanets in the sky, between V=4-8, which will be highly valuable for atmospheric characterization. This PhD project will focus on the first data - selecting the best candidates, conduct follow-up observations, and discover the true exoplanets. See also http://mascara.strw.leidenuniv.nl.

Project 2 (Supervision - Ignas Snellen & Christoph Keller): This PhD project will focus on two new ways in which we can learn about the surface and interiors of close-in rocky exoplanets: I) through sputtering, a process well known from Mercury in our own solar system, in which surface elements are released into space through a heavy bombardment by the intense stellar wind plasma, and II) through the disintegrating of the most extremely irradiated planets, which subsequently release large amounts of gas and dust into an exospheric tail. The first of these disintegrating planets, discovered by Kepler, KIC 22557548b, shows a highly variable tail.

For these projects we seek excellent and enthusiastic candidates, who are highly interested in observational astronomy. Leiden Observatory is the oldest university astronomy department in the world, and the largest astronomy department in the Netherlands. It hosts 60+ graduate students of many nationalities. Leiden Observatory has a large and lively exoplanet community, actively involved in many areas of exoplanet detection and characterization. Leiden is a charming university town with international flair.

Applicants should have, or soon obtain, a masters degree in astronomy or in physics with a strong astronomy component. Applications are accepted only through our online application site - http://www.strw.leidenuniv.nl/phd/apply.php. The deadline for applications and all letters of recommendation is December 15, 2013.

Download/Website: `http://www.strw.leidenuniv.nl`

Contact: `snellen@strw.leidenuniv.nl, keller@strw.leidenuniv.nl`

6 Obituary

Figure 8: Sun Hong Rhie 1955–2013

Obituary for Sun Hong Rhie

D.P Bennett[1]*, C.S. Bennett*[2]

[1] Department of Physics, University of Notre Dame, 225 Nieuwland Science Hall, Notre Dame, IN 46556, USA
[2] Goddard Space Flight Center, Greenbelt, MD 20771, USA

Granger, IN, USA, October 25, 2013

Dr. Sun Hong Rhie, a former research professor of physics at Notre Dame, died at home on October 14, 2013. She was 58 years old.

Rhie was born to Lee Sin Woo and Kim Soon Im on March 1, 1955, near Chiri Mountain in Gurae, South Korea. She excelled in school, and on her college pre-entrance exam, Rhie received the highest score among women in all of South Korea. She received a bachelors degree in physics from Seoul National University in 1978. She immigrated to the United States in 1980 and did graduate work at UCLA before moving to Stanford in 1982. There, she met and married another grad student, David Bennett. She received her PhD in physics from Stanford in 1988, and their daughter Clara was born later the same year.

Rhies early research work focused on elementary particle physics theory and cosmology, but she made the greatest impact in the field of gravitational lensing. Rhie was one of the first to focus on planetary microlensing in the microlensing survey data, pointing out that the first microlensing event discovered, MACHO-LMC-1, was a potential planetary microlensing event even before it was published in October, 1993. Her paper on this was later published in a conference proceedings.

In 1994 and 1995, NASA held a study of potential future exoplanet detection and characterization programs known as the Exploring Neighboring Planetary Systems (ExNPS) review. At the time, enthusiasm for Kepler was limited, as hot-Jupiters were not yet discovered, and the ExNPS team was considering a ground-based microlensing survey as a method to detect Earth-mass planets, but no one had yet calculated planetary microlensing light curves with finite source effects. So, it was not known if microlensing would be sensitive to Earth-mass planets. Rhie collaborated with Bennett, to perform these calculations, and show that microlensing was sensitive planets below an Earth-mass planet (Bennett & Rhie 1996) if main sequence source stars were used. But, it was later realized that it would be difficult to detect Earth-mass planets from the ground, except in high magnification microlensing events, due to the high density of stars in the Galactic bulge fields where microlensing is observed.

In 1997, Rhie and Bennet founded the Microlensing Planet Search (MPS) collaboration, which survived until 2003, when the main telescope used by MPS, the Mt. Stromlo $74''$, was destroyed in a fire. MPS was the first to observe a high-magnification microlensing event with high cadence sampling and demonstrated the very high sensitivity to planetary signals (Rhie et al. 2000) previously predicted by Griest & Safizadeh (1998). This paper also presented the planet detection efficiency calculation method that is used today. This paper also included the Microlensing Observations in Astrophysics (MOA) Collaboration, and it led the MOA Collaboration to shift its focus from dark matter to exoplanets.

In 2000, after an important discussion with John Mather, Rhie and Bennett developed the space- microlensing planet search survey concept (Bennett & Rhie 2002). The original concept, known as the Galactic Exoplanet Survey Telescope (GEST), was proposed to the NASA Discovery and Exploer programs, and an infrared version of this program, the Microlensing Planet Finder (MPF) was submitted to the Discovery program and to the 2010t New Worlds, New Horizons decadal survey. The New Worlds, New Horizons survey selected MPF, along with two other proposed space telescopes, to make the Wide Field Infrared Survey Telescope (WFIRST). Without Rhies efforts in the early 2000s, it is likely that the space-based microlensing exoplanet survey concept would not have been sufficiently developed to be selected in the 2010 decadal survey.

Some of Rhie's most original work was in gravitational lensing theory, but much of this was published only on arXiv.org, so it is not very well known. She was the first to solve the triple-lens equation (Rhie 2002), which is needed to model triple lens microlensing events (two planets and a star or two stars and a planet). In a series of papers, she explored systems of N point-mass lenses. She was able to show that such systems must have at least $N + 1$ images, and she came up with the correct number, $5N - 5$, for the maximum number of images (Rhie 2003) for such a system, (with $N > 1$). She also showed how to construct lens systems to obtain the maximum number,

$5N-5$, of images, but she could only conjecture, and not prove, that $5N-5$ was the maximum number of images. Several years later, Khavinson and Neumann (2006) proved that $5N-5$ was the maximum number, but they did so in the context of an extension of the Fundamental Theorem of Algebra, a problem of pure mathematics. But Khavinson and Neumann were unsure if their $5N-5$ upper limit could be realized, but when Rhie's $5N-5$ image solution was brought to their attention, they realized that $5N-5$ was a "sharp" upper bound. This remarkable story of the solution of an important mathematics problem with the combination of Rhie and Khavinson and Neumann's work was the subject of an American Mathematical Society press release in 2008, and the methods developed by Rhie now enjoy wide use in the world of pure mathematics.

In her later years, Rhie was afflicted with schizophrenia. It contributed to friction with colleagues and journal referees. This is why much of her later theoretical work was never published in peer-reviewed journals and has enjoyed less recognition than it deserved. Over time, schizophrenia limited Rhie's ability to continue the work that she loved. Treatment had side effects that interfered with intellectual work, and she expressed much frustration with the lack of medical and scientific understanding of this devastating disease.

Rhie is survived by her husband, David Bennett; their daughter, Clara Bennett; her mother, Kim Soon Im; her sister Lee In Sook; and her brothers Lee Sang Hwa, Lee Sang Young, and Lee Sang Deuk.

Contact: bennett@nd.edu

7 As seen on astro-ph

The following list contains all the entries relating to exoplanets that we spotted on astro-ph during October 2013. If you see any that we missed, please let us know and we'll include them in the next issue.

astro-ph/1310.0008: **MOA-2011-BLG-322 - a "second generation survey" microlensing planet** by *Y. Shvartzvald, et al.*

astro-ph/1310.0011: **Warm Spitzer and Palomar Near-IR Secondary Eclipse Photometry of Two Hot Jupiters: WASP-48b and HAT-P-23b** by *Joseph G. O'Rourke, et al.*

astro-ph/1310.0083: **HST hot Jupiter Transmission Spectral Survey: A detection of Na and strong optical absorption in HAT-P-1b** by *N. Nikolov, et al.*

astro-ph/1310.0156: **How Empty are Disk Gaps Opened by Giant Planets?** by *Jeffrey Fung, Ji-Ming Shi, Eugene Chiang*

astro-ph/1310.0351: **On the corotation torque for low-mass eccentric planets** by *Stephen M. Fendyke, Richard P. Nelson*

astro-ph/1310.0457: **The Extremely Red, Young L Dwarf PSO J318-22: A Free-Floating Planetary-Mass Analog to Directly Imaged Young Gas-Giant Planets** by *Michael C. Liu, et al.*

astro-ph/1310.0477: **MAMA: An Algebraic Map for the Secular Dynamics of Planetesimals in Tight Binary Systems** by *A. M. Leiva, J. A. Correa-Otto, C. Beaugé*

astro-ph/1310.0593: **The effects of stellar winds and magnetic fields on exoplanets** by *A. A. Vidotto*

astro-ph/1310.0599: **Planetary protection in the extreme environments of low-mass stars** by *A. A. Vidotto et al.*

astro-ph/1310.0696: **The PLATO 2.0 Mission** by *H. Rauer, et al.*

astro-ph/1310.0748: **Characterizing small planets transiting small stars with SPIRou** by *A. Santerne, et al.*

astro-ph/1310.1108: **Early evolution of clumps formed via gravitational instability in protoplanetary disks; precursors of Hot Jupiters?** by *Marina Galvagni, Lucio Mayer*

astro-ph/1310.1391: **The planets around NN Ser: still there** by *T.R. Marsh, et al.*

astro-ph/1310.1393: **Testing large-scale vortex formation against viscous layers in three-dimensional discs** by *Min-Kai Lin*

astro-ph/1310.1395: **The Great Escape III: Placing post-main-sequence evolution of planetary and binary systems in a Galactic context** by *Dimitri Veras, et al.*

astro-ph/1310.1405: **Astrometric Detection of Giant Planets Around Nearby M Dwarfs: The Gaia Potential** by *A. Sozzetti, et al.*

astro-ph/1310.1584: **Grain Size segregation in debris discs** by *Philippe Thebault, Quentin Kral, Jean-Charles Augereau*

astro-ph/1310.1914: **Searching for transits in the WTS with difference imaging light curves** by *Jesus Zendejas, et al.*

astro-ph/1310.1994: **Extrasolar planets and brown dwarfs around A–F type stars. VIII. A giant planet orbiting the young star HD113337** by *S. Borgniet, et al.*

astro-ph/1310.2009: **Planetary Populations in the Mass-Period Diagram: A Statistical Treatment of Exoplanet Formation and the Role of Planet Traps** by *Yasuhiro Hasegawa, Ralph E. Pudritz*

astro-ph/1310.2064: **An Independent Planet Search In The Kepler Dataset. II. An extremely low-density super-Earth mass planet around Kepler-87** by *Aviv Ofir, et al.*

astro-ph/1310.2087: **Crowding Out of Giants by Dwarfs: An Origin for the Lack of Companion Planets in Hot Jupiter Systems** by *Masahiro Ogihara, Shu-ichiro Inutsuka, Hiroshi Kobayashi*

astro-ph/1310.2133: **Astrophysical false positives in exoplanet transit surveys: why do we need bright stars ?** by *A. Santerne, et al.*

astro-ph/1310.2179: **Magnetic and Gravitational Disk-Star Interactions: An Interdependence of PMS Stellar Rotation Rates and Spin-Orbit Misalignments** by *Konstantin Batygin, Fred C. Adams*

astro-ph/1310.2211: **Three-Dimensional Radiation-Hydrodynamics Calculations of the Envelopes of Young Planets Embedded in Protoplanetary Disks** by *Gennaro D'Angelo, Peter Bodenheimer*

astro-ph/1310.2428: **A Super-Jupiter orbiting a late-type star: A refined analysis of microlensing event OGLE-2012-BLG-0406** by *Y. Tsapras, et al.*

astro-ph/1310.2577: **Evolution of Planetary Orbits with Stellar Mass Loss and Tidal Dissipation** by *Fred C. Adams, Anthony M. Bloch*

astro-ph/1310.2590: **High Stellar FUV/NUV Ratio and Oxygen Contents in the Atmospheres of Potentially Habitable Planets** by *Feng Tian, et al.*

astro-ph/1310.2634: **Growing dust grains in protoplanetary discs - I. Radial drift with toy growth models** by *Guillaume Laibe, Jean-Francois Gonzalez, Sarah T. Maddison*

astro-ph/1310.2637: **Growing dust grains in protoplanetary discs - II. The Radial drift barrier problem** by *Guillaume Laibe*

astro-ph/1310.2638: **Growing dust grains in protoplanetary discs - III. Vertical settling** by *Guillaume Laibe, et al.*

astro-ph/1310.2642: **KOI-152's Low Density Planets** by *Daniel Jontof-Hutter, et al.*

astro-ph/1310.2949: **Exoplanet Transit Spectroscopy Using WFC3: WASP-12 b, WASP-17 b, and WASP-19 b** by *Avi Mandell, et al.*

astro-ph/1310.3151: **Chemistry in Protoplanetary Disks** by *Thomas Henning, Dmitry Semenov*

astro-ph/1310.3168: **Long-term evolution of three-planet systems to the post-Main Sequence and beyond** by *Alexander Mustill, Dimitri Veras, Eva Villaver*

astro-ph/1310.3269: **Evidence for Water in the Rocky Debris of a Disrupted Extrasolar Minor Planet** by *J. Farihi, B.T. Gänsicke, D. Koester*

astro-ph/1310.3342: **Water in Protoplanetary Disks: Deuteration and Turbulent Mixing** by *Kenji Furuya, et al.*

astro-ph/1310.3611: **Assessing Circumbinary Habitable Zones using Latitudinal Energy Balance Modelling** by *Duncan Forgan*

astro-ph/1310.3706: **MOA-2011-BLG-293Lb: First Microlensing Planet possibly in the Habitable Zone** by *V. Batista, et al.*

astro-ph/1310.3790: **A Simple Procedure to Extend the Gauss Method of Determining Orbital Parameters**

from Three to N Points by *Taghi Mirtorabi*

astro-ph/1310.3851: **Sustainability and the Astrobiological Perspective: Framing Human Futures in a Planetary Context** by *Adam Frank, Woodruff Sullivan*

astro-ph/1310.3893: **Optical transmission photometry of the highly inflated exoplanet WASP-17b** by *J. Bento, et al.*

astro-ph/1310.4172: **The Gemini NICI Planet-Finding Campaign: The Companion Detection Pipeline** by *Zahed Wahhaj, et al.*

astro-ph/1310.4183: **Direct Imaging Detection of Methane in the Atmosphere of GJ 504 b** by *M. Janson, et al.*

astro-ph/1310.4208: **Kepler-like Multi-Plexing for Mass Production of Microlens Parallaxes** by *Andrew Gould, Keith Horne*

astro-ph/1310.4398: **Modelling Accretion in Transitional Disks** by *Tobias W.A. Müller, Wilhelm Kley*

astro-ph/1310.4503: **Stellar Spin-Orbit Misalignment in a Multiplanet System** by *Daniel Huber, et al.*

astro-ph/1310.4796: **A Near-Infrared Transmission Spectrum for the Warm Saturn HAT-P-12b** by *Michael R. Line, et al.*

astro-ph/1310.4841: **Swansong Biospheres II: The final signs of life on terrestrial planets near the end of their habitable lifetimes** by *Jack T. O'Malley-James, et al.*

astro-ph/1310.5048: **Extreme orbital evolution from hierarchical secular coupling of two giant planets** by *Jean Teyssandier, et al.*

astro-ph/1310.5397: **Photometric observation of HAT-P-16b in the near-UV** by *Kyle A. Pearson, Jake D. Turner, Thomas A.G. Sagan*

astro-ph/1310.5607: **Three irradiated and bloated hot Jupiters: WASP-76b, WASP-82b & WASP-90b** by *R.G. West, et al.*

astro-ph/1310.5630: **Transiting hot Jupiters from WASP-South, Euler and TRAPPIST: WASP-95b to WASP-101b** by *Coel Hellier, et al.*

astro-ph/1310.5654: **Three sub-Jupiter-mass planets: WASP-69b & WASP-84b transit active K dwarfs and WASP-70Ab transits the evolved primary of a G4+K3 binary** by *D. R. Anderson, et al.*

astro-ph/1310.5771: **Characterization of the KOI-94 System with Transit Timing Variation Analysis: Implication for the Planet-Planet Eclipse** by *Kento Masuda, et al.*

astro-ph/1310.5865: **Radiation Magnetohydrodynamics In Global Simulations Of Protoplanetary Disks** by *M. Flock, et al.*

astro-ph/1310.5868: **Constraining the Atmospheric Composition of the Day-Night Terminators of HD 189733b : Atmospheric Retrieval with Condensates** by *Jae-Min Lee, et al.*

astro-ph/1310.5912: **Planet Hunters VI: The First Kepler Seven Planet Candidate System and 13 Other Planet Candidates from the Kepler Archival Data** by *Joseph R. Schmitt, et al.*

astro-ph/1310.6044: **Counter-orbiting Planets Were Flipped Over by a Coplanar Outer Object** by *Gongjie Li, et al.*

astro-ph/1310.6048: **A Ground-based Optical Transmission Spectrum of WASP-6b** by *Andrés Jordán, et al.*

astro-ph/1310.6248: **The Planetary System to KIC 11442793: A Compact Analogue to the Solar System** by *J. Cabrera, et al.*

astro-ph/1310.6697: **The effect of an ordered azimuthal magnetic field on a migrating planet in a non-turbulent disc** by *M.L. Comins, et al.*

astro-ph/1310.6745: **Two timescale dispersal of magnetized protoplanetary disks** by *Philip J. Armitage, Jacob B. Simon, Rebecca G. Martin*

astro-ph/1310.6764: **EXONEST: Bayesian Model Selection Applied to the Detection and Characterization of Exoplanets Via Photometric Variations** by *Ben Placek, Kevin H. Knuth, Daniel Angerhausen*

astro-ph/1310.7026: **Modeling Self-Subtraction in Angular Differential Imaging: Application to the HD 32297 Debris Disk** by *Thomas M. Esposito, et al.*

astro-ph/1310.7092: **Multiple spiral patterns in the transitional disk of HD 100546** by *A. Boccaletti, et al.*

astro-ph/1310.7101: **Possible solution to the riddle of HD 82943 multi-planet system: the three-planet reso-**

nance 1:2:5? by *Roman V. Baluev, Cristian Beaugé*

astro-ph/1310.7315: **The Twenty-Five Year Lick Planet Search** by *Debra A. Fischer, Geoffrey W. Marcy, Julien F. P. Spronck*

astro-ph/1310.7328: **HD 285507b: An Eccentric Hot Jupiter in the Hyades Open Cluster** by *S. N. Quinn et al.*

astro-ph/1310.7427: **Imaged sub-stellar companions: not as eccentric as they appear? The effect of an unseen inner mass on derived orbits** by *Tim D. Pearce, Mark C. Wyatt, Grant M. Kennedy*

astro-ph/1310.7483: **Confirmation of the planet around HD 95086 by direct imaging** by *J. Rameau, et al.*

astro-ph/1310.7585: **Spitzer and z' Secondary Eclipse Observations of the Highly Irradiated Transiting Brown Dwarf KELT-1b** by *Thomas G. Beatty, et al.*

astro-ph/1310.7586: **Trawling for transits in a sea of noise: A Search for Exoplanets by Analysis of WASP Optical Lightcurves and Follow-up (SEAWOLF)** by *E. Gaidos, et al.*

astro-ph/1310.7830: **The Metal-Rich Stars Get Richer in Planets For All But Planets With** $R_P \leq 2R_E$ by *Ji Wang, Debra A. Fischer*

astro-ph/1310.7927: **Resonant periodic orbits in the exoplanetary systems** by *K. I. Antoniadou, G. Voyatzis*

astro-ph/1310.7942: **Densities and Eccentricities of 163 Kepler Planets from Transit Time Variations** by *Sam Hadden, Yoram Lithwick*

astro-ph/1310.7952: **A Spitzer Search for Transits of Radial Velocity Detected Super-Earths** by *J. A. Kammer, et al.*

astro-ph/1310.7987: **An Earth-sized planet with an Earth-like density** by *Francesco Pepe, et al.*

astro-ph/1310.7988: **A Rocky Composition for an Earth-sized Exoplanet** by *Andrew W. Howard, et al.*

astro-ph/1310.8104: **Magnesium in the atmosphere of the planet HD209458b: Observations of the thermosphere-exosphere transition region** by *A. Vidal-Madjar, et al.*

astro-ph/1310.8299: **A UV-to-MIR monitoring of DR Tau: exploring how water vapor in the planet formation region of the disk is affected by stellar accretion variability** by *Andrea Banzatti, et al.*

astro-ph/1310.8577: **Optimized Principal Component Analysis on Coronagraphic Images of the Fomalhaut System** by *T. Meshkat, et al.*

astro-ph/1310.8627: **Shedding Light on the Eccentricity Valley: Gap Heating and Eccentricity Excitation of Giant Planets in Protoplanetary Disks** by *David Tsang, Neal J. Turner, Andrew Cumming*