ExoPlanet News
An Electronic Newsletter

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Contents

1 Editorial

Welcome to the sixty fifth edition of ExoPlanet News. As usual, we have an excellent selection of abstracts this month. However, I think this must be a record number of conference and workshop announcements – eight in total for 2014 – including a UK exoplanet community meeting, a session at the UK NAM, an IAU Symposium, a conference in Vietnam, a solar system formation workshop, the STScI spring symposium, the 9th meeting of the NASA ExoPAG, and a session at the EGU General Assembly.

The Exoplanet Newsletter will take a break over Christmas, as usual, so the next edition of the newsletter is planned for early February 2014. Please send anything relevant before then to exoplanet@open.ac.uk, and it will appear in the next edition. 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

Structures in the protoplanetary disk of HD142527 seen in polarized scattered light

H. Avenhaus[1], *S. P. Quanz*[1], *H. M. Schmid*[1], *M. R. Meyer*[1], *A. Garufi*[1], *S. Wolf*[2], *C. Dominik*[3],

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The Astrophysical Journal, in press (arXiv:1311.7088)

We present H- and K_s-band polarized differential images (PDI) of the Herbig Ae/Be star HD142527, revealing its optically thick outer disk and the nearly empty gap. The very small inner working angle (∼0.1") and high resolution achievable with an 8m-class telescope, together with a careful polarimetric calibration strategy, allow us to achieve images that surpass the quality of previous scattered light images. Previously known substructures are resolved more clearly and new structures are seen. Specifically, we are able to resolve 1. half a dozen spiral structures in the disk, including previously known outer-disk spirals as well as new spiral arms and arcs close to the inner rim of the disk; 2. peculiar holes in the polarized surface brightness at position angles of ∼0° and ∼160°; 3. the inner rim on the eastern side of the disk; 4. the gap between the outer and inner disk, ranging from the inner working angle of 0.1" out to between 0.7 and 1.0", which is nearly devoid of dust. We then use a Markov-chain Monte-Carlo algorithm to determine several structural parameters of the disk, using very simple assumptions, including its inclination, eccentricity, and the scale height of the inner rim. We compare our results to previous work on this object, and try to produce a consistent picture of the system and its transition disk.

Download/Website: `http://arxiv.org/abs/1311.7088`

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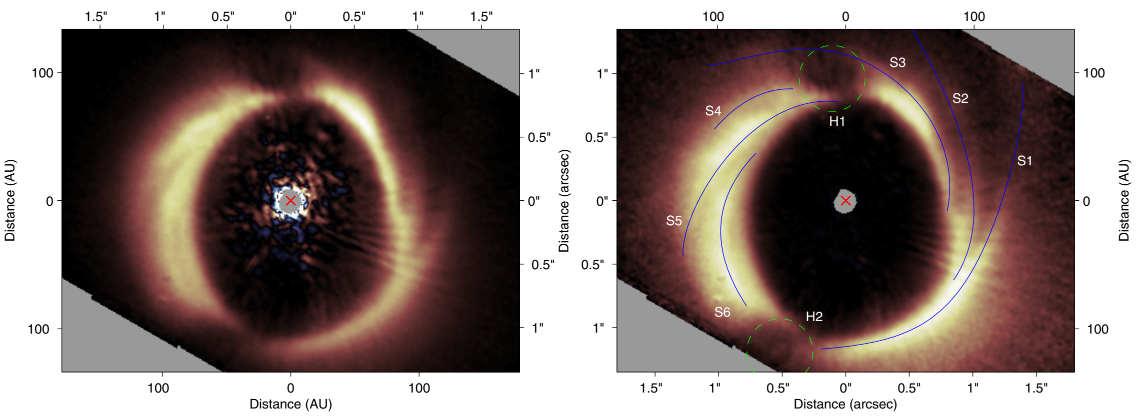

Figure 1: (Avenhaus et al.) The disk of HD142527 in H-band polarized scattered light. North is up and east is to the left. The image on the right has been scaled by r^2, i.e. the distance to the stellar position squared to compensate for the drop-off in illumination from the star for this nearly face-on disk and to better bring out structures in the disk, while no scaling has been applied to the image on the left. Both images are shown in linear stretch. Notable are the very large and almost completely empty gap down to the inner working angle, as well as the spiral arms and the two holes in the outer in the northern (H1) and southeastern (H2) direction. For a detailed description, see the full paper.

SOPHIE velocimetry of *Kepler* transit candidates: X KOI-142 c: first radial velocity confirmation of a non-transiting exoplanet discovered by transit timing

S. C. C. Barros [1], *R. F. Díaz* [1,7], *A. Santerne* [1,2] , *G. Bruno* [1], *M. Deleuil* [1], *J.-M. Almenara* [1], *A. S. Bonomo* [5], *F. Bouchy* [1], *C. Damiani* [1], *G. Hébrard* [3,4] , *G. Montagnier*[3,4], *C. Moutou* [6,1]

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Astronomy & Astrophysics letters, in press (arXiv:1311.4335)

The exoplanet KOI-142b (Kepler-88b) shows transit timing variations (TTVs) with a semi-amplitude of $\sim$ 12 hours, which earned it the nickname "king of transit variations". Only the transit of planet b was detected in the *Kepler* data with an orbital period of $\sim$ 10.92 days and a radius of $\sim$ $0.36\mathrm{R_{Jup}}$. The TTVs together with the transit duration variations of KOI-142b were analysed recently, finding a unique solution for a companion-perturbing planet. An outer non-transiting companion was predicted, KOI-142c, with a mass of $0.626 \pm 0.03\mathrm{M_{Jup}}$ and a period of $22.3397^{+0.0021}_{-0.0018}$ days, which is close to the 2:1 mean-motion resonance with the inner transiting planet. We report an independent confirmation of KOI-142c using radial velocity observations with the SOPHIE spectrograph at the Observatoire de Haute-Provence. We derive an orbital period of 22.10 ± 0.25 days and a minimum planetary mass of $0.76^{+0.32}_{0.16}\mathrm{M_{Jup}}$, both in good agreement with the predictions by previous transit timing analysis. Therefore, this is the first radial velocity confirmation of a non-transiting planet discovered with TTVs, providing an independent validation of the TTVs technique.

Download/Website: `http://arxiv.org/abs/1311.4335`

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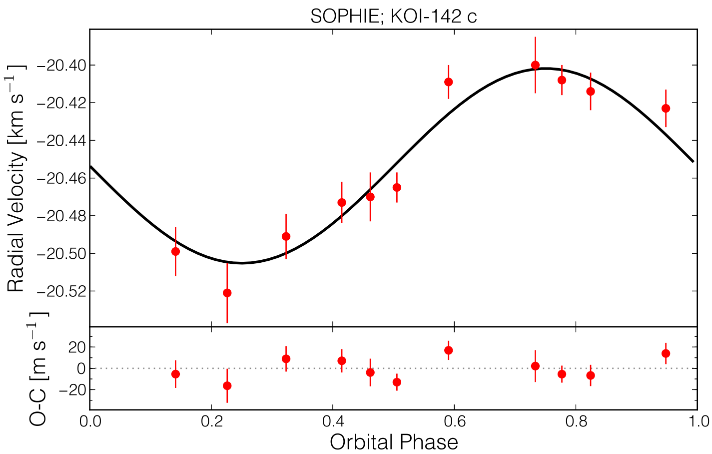

Figure 2: (Barros et al.) Phase folded SOPHIE radial velocities of KOI-142 and the corresponding residuals. The overplotted black curve is the most probable fit model.

On the Outer Edges of Protoplanetary Dust Disks

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The Astrophysical Journal, in press (arXiv:1311.5222)

The expectation that aerodynamic drag will force the solids in a gas-rich protoplanetary disk to spiral in toward the host star on short timescales is one of the fundamental problems in planet formation theory. The nominal efficiency of this radial drift process is in conflict with observations, suggesting that an empirical calibration of solid transport mechanisms in a disk is highly desirable. However, the fact that both radial drift and grain growth produce a similar particle size segregation in a disk (such that larger particles are preferentially concentrated closer to the star) makes it difficult to disentangle a clear signature of drift alone. We highlight a new approach, by showing that radial drift leaves a distinctive "fingerprint" in the dust surface density profile that is directly accessible to current observational facilities. Using an analytical framework for dust evolution, we demonstrate that the combined effects of drift and (viscous) gas drag naturally produce a sharp outer edge in the dust distribution (or, equivalently, a sharp decrease in the dust-to-gas mass ratio). This edge feature forms during the earliest phase in the evolution of disk solids, before grain growth in the outer disk has made much progress, and is preserved over longer timescales when both growth and transport effects are more substantial. The key features of these analytical models are reproduced in detailed numerical simulations, and are qualitatively consistent with recent millimeter-wave observations that find gas/dust size discrepancies and steep declines in dust continuum emission in the outer regions of protoplanetary disks.

Download/Website: `http://arxiv.org/abs/1311.5222v1`

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Coagulation Calculations of Icy Planet Formation Around 0.1–0.5 $M_\odot$ Stars: Super-Earths From Large Planetestimals

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The Astrophysical Journal, in press (arXiv:1311.0296)

We investigate formation mechanisms for icy super-Earth mass planets orbiting at 2–20 AU around 0.1–0.5 $M_\odot$ stars. A large ensemble of coagulation calculations demonstrates a new formation channel: disks composed of large planetesimals with radii of 30–300 km form super-Earths on time scales of $\sim$ 1 Gyr. In other gas-poor disks, a collisional cascade grinds planetesimals to dust before the largest planets reach super-Earth masses. Once icy Earth-mass planets form, they migrate through the leftover swarm of planetesimals at rates of 0.01–1 AU Myr^{-1}. On time scales of 10 Myr to 1 Gyr, many of these planets migrate through the disk of leftover planetesimals from semimajor axes of 5–10 AU to 1–2 AU. A few per cent of super-Earths might migrate to semimajor axes of 0.1–0.2 AU. When the disk has an initial mass comparable with the minimum mass solar nebula scaled to the mass of the central star, the predicted frequency of super-Earths matches the observed frequency.

Download/Website: `http://lanl.arxiv.org/abs/1311.0296`

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The Planetary System to KIC 11442793: A Compact Analogue to the Solar System

J. Cabrera[1], *Sz. Csizmadia*[1], *H. Lehmann*[2], *R. Dvorak*[3], *D. Gandolfi*[4,5], *H. Rauer*[1,6], *A. Erikson*[1], *C. Dreyer*[1], *Ph. Eigmüller*[1], *A. Hatzes*[2]

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The Astrophysical Journal, in press (arXiv:1310.6248)

We announce the discovery of a planetary system with 7 transiting planets around a Kepler target, a current record for transiting systems. Planets b, c, e and f are reported for the first time in this work. Planets d, g and h were previously reported in the literature, although here we revise their orbital parameters and validate their planetary nature. Planets h and g are gas giants and show strong dynamical interactions. The orbit of planet g is perturbed in such way that its orbital period changes by 25.7h between two consecutive transits during the length of the observations, which is the largest such perturbation found so far. The rest of the planets also show mutual interactions: planets d, e and f are super-Earths close to a mean motion resonance chain (2:3:4), and planets b and c, with sizes below 2 Earth radii, are within 0.5% of the 4:5 mean motion resonance. This complex system presents some similarities to our Solar System, with small planets in inner orbits and gas giants in outer orbits. It is, however, more compact. The outer planet has an orbital distance around 1 AU, and the relative position of the gas giants is opposite to that of Jupiter and Saturn, which is closer to the expected result of planet formation theories. The dynamical interactions between planets are also much richer.

Download/Website: `http://www.dlr.de/exoplanets`

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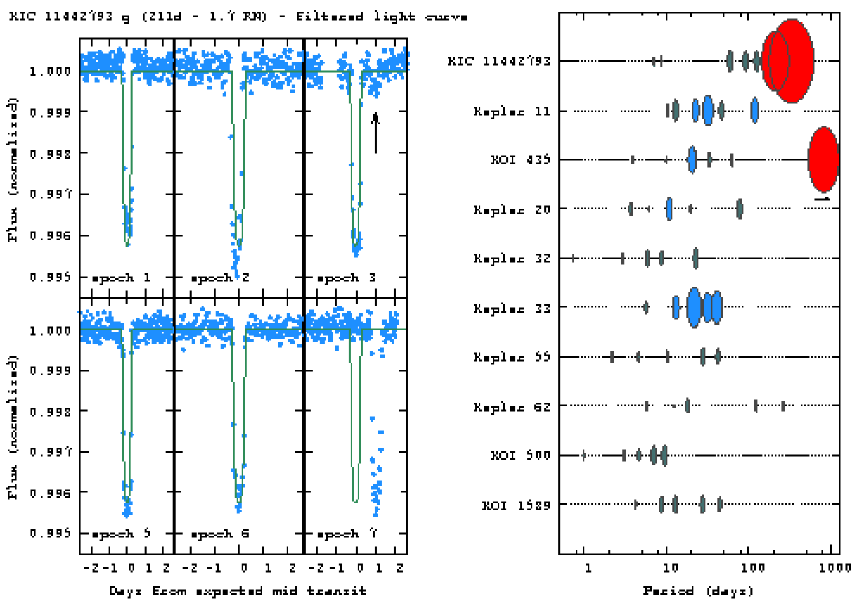

Figure 3: (Cabrera et al.) Left: Individual observed transit events of planet g and the expected position of those transits assuming a constant period, marked with a line. Note the irregularities in the transit depth and duration at epochs 1 and 2 and the displacement from the expected position of epoch 7. Right: Comparison of different multiple systems. Color codes separate Earth and Super-Earth planets (up to 4 Earth radii, shown in green), Neptune-sized planets (between 4 and 8 Earth radii, shown in blue), and gas giants (larger than 8 Earth radii, shown in red).

Estimating Stellar Radial Velocity Variability from Kepler and GALEX: Implications for the Radial Velocity Confirmation of Exoplanets

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The Astrophysical Journal, in press (arXiv:1311.3344)

We cross-match the GALEX and Kepler surveys to create a unique dataset with both ultraviolet (UV) measurements and highly precise photometric variability measurements in the visible light spectrum. As stellar activity is driven by magnetic field modulations, we have used UV emission from the magnetically heated gas in the stellar atmosphere to serve as our proxy for the more well-known stellar activity indicator, R'_{HK}. The R'_{HK} approximations were in turn used to estimate the level of astrophysical noise expected in radial velocity (RV) measurements and these were then searched for correlations with photometric variability. We find significant scatter in our attempts to estimate RV noise for magnetically active stars, which we attribute to variations in the phase and strength of the stellar magnetic cycle that drives the activity of these targets. However, for stars we deem to be magnetically quiet, we do find a clear correlation between photometric variability and estimated levels of RV noise (with variability up to ~ 10 m s^{-1}). We conclude, that for these quiet stars, we can use photometric measurements as a proxy to estimate the RV noise expected. As a result, the procedure outlined in this paper may help select targets best-suited for RV follow-up necessary for planet confirmation.

Download/Website: `http://arxiv.org/abs/1311.3344`

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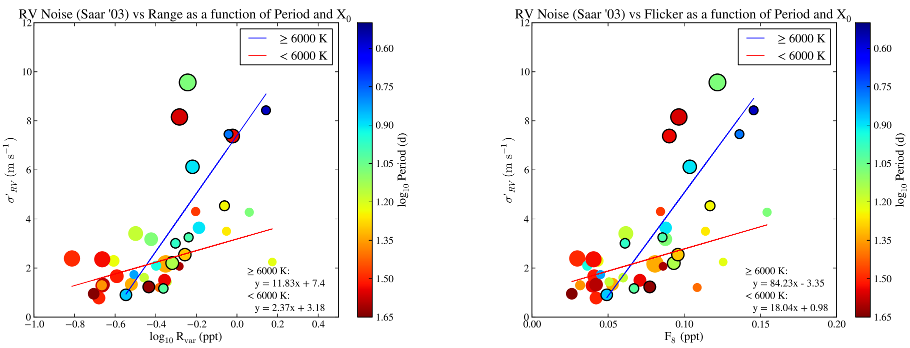

Figure 4: (Cegla et al.) Predicted RV noise (σ'_{RV}) for magnetically quiet stars (i.e. those on the flicker floor) vs photometric variability measurements F_8 (rms <8 hr; top) and R_{var} (large amplitude modulation; bottom) as a function of X_0 (number of zero crossings per day; symbol size) and stellar rotation period (colour). A black perimeter indicates targets with temperature > 6000 K. Linear fits have been made to both hot and cool stars, shown in blue and red, respectively. As the flicker floor is presumed to trace log g, it is likely that this gradient in σ'_{RV} is due to increased granulation noise as stars evolve. The larger astrophysical noise in the hotter stars is attributed to the presence of larger, brighter, longer-lived granules with faster velocities and greater photometric contrast. We caution that the above correlations stem relationships between σ'_{RV} and R'_{HK}, the latter being estimated from FUV-V. The reason for increased FUV flux relative to the V-band along the flicker floor (which drives the increasing trend in σ'_{RV}) is further discussed in the text.

Small vs large dust grains in transitional disks: do different cavity sizes indicate a planet?

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Astronomy & Astrophysics, accepted (arXiv:1311.4195)

Transitional disks represent a short stage of the evolution of circumstellar material. Studies of dust grains in these objects can provide pivotal information on the mechanisms of planet formation. Dissimilarities in the spatial distribution of small (micron-size) and large (millimeter-size) dust grains have recently been pointed out. Constraints on the small dust grains can be obtained by imaging the distribution of scattered light at near-infrared wavelengths. We aim at resolving structures in the surface layer of transitional disks (with particular emphasis on the inner 10 - 50 AU), thus increasing the scarce sample of high resolution images of these objects. We obtained VLT/NACO near-IR high-resolution polarimetric differential imaging observations of SAO 206462 (HD135344B). This technique allows one to image the polarized scattered light from the disk without any occulting mask and to reach an inner working angle of 0.1”. A face-on disk is detected in H and Ks bands between 0.1” and 0.9”. No significant differences are seen between the H and Ks images. In addition to the spiral arms, these new data allow us to resolve for the first time an inner cavity for small dust grains. The cavity size (about 28 AU) is much smaller than what is inferred for large dust grains from (sub)mm observations (39 to 50 AU). The interaction between the disk and potential orbiting companion(s) can explain both the spiral arm structure and the discrepant cavity sizes for small and large dust grains. One planet may be carving out the gas (and, thus, the small grains) at 28 AU, and generating a pressure bump at larger radii (39 AU), which holds back the large grains. We analytically estimate that, in this scenario, a single giant planet (with a mass between 5 and 15 Jupiter masses) at 17 to 20 AU from the star is consistent with the observed cavity sizes.

Download/Website: `http://arxiv.org/pdf/1311.4195v1.pdf`

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Runaway greenhouse effect on exomoons due to irradiation from hot, young giant planets

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The International Journal of Astrobiology, accepted (arXiv:1311.0292)

The *Kepler* space telescope has detected transits of objects as small as the Earth’s Moon, and moons as small as 0.2 Earth masses can be detected in the *Kepler* data by transit timing and transit duration variations of their host planets. Such massive moons around giant planets in the stellar habitable zone (HZ) could serve as habitats for extraterrestrial life. We here assess the danger of exomoons to be in a runaway greenhouse (RG) state due to extensive heating from the planet. We apply pre-computed evolution tracks for giant planets to calculate the incident planetary radiation on the moon as a function of time. The total energy budget of stellar flux, illumination from the planet, and tidal heating in the satellite is compared to the critical flux for the moon to experience an RG effect. Irradiation from a 13-Jupiter-mass planet onto an Earth-sized moon at a distance of ten Jupiter radii can drive an RG state on the moon

for about 200 Myr. If stellar illumination equivalent to that received by Earth from the Sun is added, the RG holds for about 500 Myr. After 1 Gyr, the planet's habitable edge has moved inward to about 6 planetary radii. Exomoons in orbits with eccentricities of 0.1 experience strong tidal heating; they must orbit a 13-Jupiter-mass host beyond 29 or 18 Jupiter radii after 100 Myr (at the inner and outer boundaries of the stellar HZ, respectively), and beyond 13 Jupiter radii (in both cases) after 1 Gyr to be habitable. If a roughly Earth-sized moon would be detected in orbit around a giant planet, and if this binary would orbit in the stellar HZ, then it will be crucial to recover the moon's orbital history. If such a moon around a 13-Jupiter-mass planet has been closer than 20 Jupiter radii to its host during the first few hundred million years at least, then it might have lost substantial amounts of its initial water reservoir

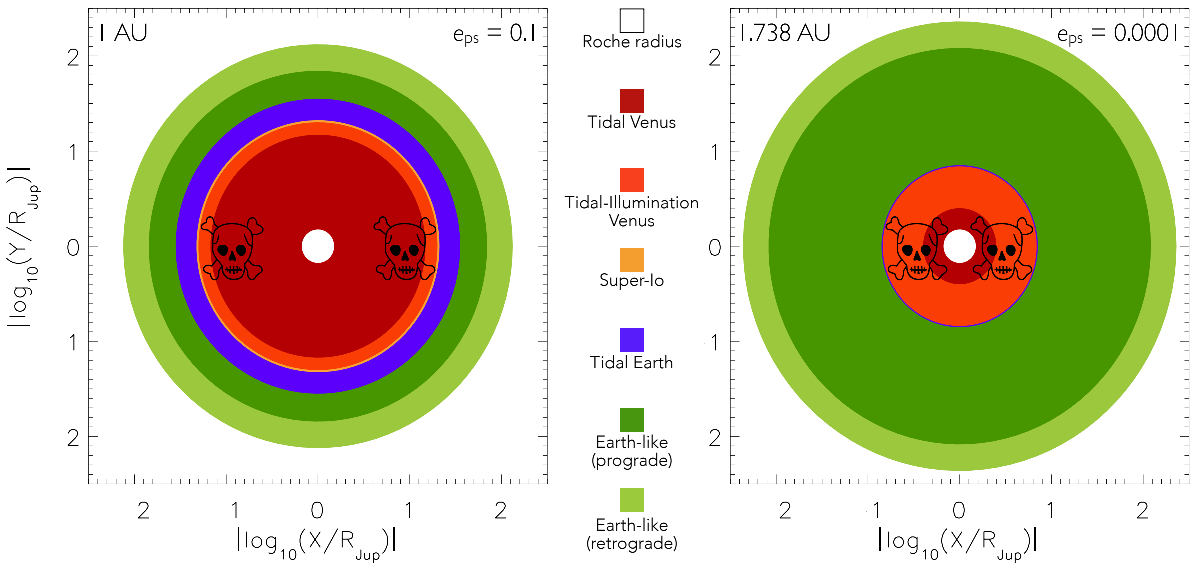

Figure 5: (Heller & Barnes) Circumplanetary exomoon menageries for Earth-sized moons around a 13 Jupiter-mass planet with a Sun-like host star at an age of 500 Myr. The planet's center is at (0,0), respectively. Distances are shown on a logarithmic scale. *Left*: The planet-moon binary orbits at 1 AU from the star and the satellite has an orbital eccentricity of $e_{ps} = 0.1$, inducing strong tidal heating. *Right*: The binary is at the outer edge of the stellar HZ at 1.738 AU and $e_{ps} = 0.0001$. Starting from the planet in the center, the white circle visualizes the Roche radius, and exomoon types are denoted in the legend. Moons of Tidal Venus (red) and Tidal-Illumination Venus (orange) type are in a runaway greenhouse state and uninhabitable. Dark green depicts the planetary Hill sphere for prograde Earth-like moons, light green for retrograde Earth-like moons. Note the larger Hill radii at the outer edge of the HZ (*right*)!

Spectro-Thermometry of M dwarfs and their candidate planets: too hot, too cool, or just right?

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The Astrophysical Journal, in press (arXiv:1311.0003)

We use moderate-resolution spectra of nearby late K and M dwarf stars with parallaxes and interferometrically determined radii to refine their effective temperatures, luminosities, and metallicities. We use these revised values to calibrate spectroscopic techniques to infer the fundamental parameters of more distant late-type dwarf stars. We demonstrate that, after masking out poorly modeled regions, the newest version of the PHOENIX atmosphere models accurately reproduce temperatures derived bolometrically. We apply methods to late-type hosts of transiting planet candidates in the *Kepler* field, and calculate effective temperature, radius, mass, and luminosity with typical errors of 57 K, 7%, 11%, and 13%, respectively. We find systematic offsets between our values and those from previous analyses of the same stars, which we attribute to differences in atmospheric models utilized for each study. We investigate which of the planets in this sample are likely to orbit in the circumstellar habitable zone. We determine that four candidate planets (KOI 854.01, 1298.02, 1686.01, and 2992.01) are inside of or within 1σ of a conservative definition of the habitable zone, but that several planets identified by previous analyses are not (e.g. KOI 1422.02 and KOI 2626.01). Only one of the four habitable-zone planets is Earth sized, suggesting a downward revision in the occurrence of such planets around M dwarfs. These findings highlight the importance of measuring accurate stellar parameters when deriving parameters of their orbiting planets.

Download/Website: `http://arxiv.org/abs/1311.0003`

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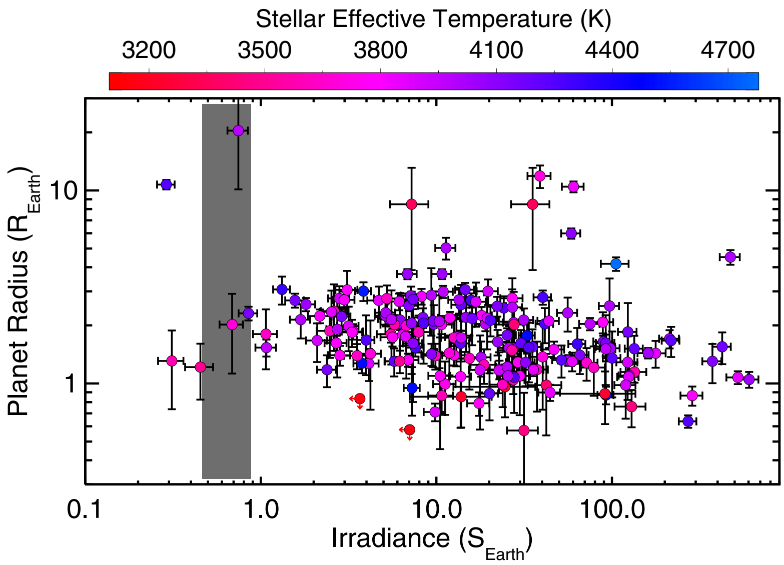

Figure 6: (Mann, Gaidos & Ansdell) The R_P of *Kepler* planets around M dwarf stars versus estimated S (both in terrestrial units). Points are color-coded by their stellar $T_{\rm eff}$ following the same color scheme as Figures 2, 5, and 6. The R_P and S values of KOIs 2704.01 and 2704.02 are assigned upper limits because the late M host stars is outside our range of calibrated stellar parameters. The bounds of the HZ for a $T_{\rm eff}$=3800 K star are shown as a shaded region.

Exploring atmospheres of hot mini-Neptunes and extrasolar giant planets orbiting different stars with application to HD 97658b, WASP-12b, CoRoT-2b, XO-1b and HD 189733b

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The Astrophysical Journal, in press (arXiv:1311.0201)

We calculated an atmospheric grid for hot mini-Neptune and giant exoplanets, that links astrophysical observable parameters- orbital distance and stellar type- with the chemical atmospheric species expected. The grid can be applied to current and future observations to characterize exoplanet atmospheres and serves as a reference to interpret atmospheric retrieval analysis results. To build the grid, we developed a 1D code for calculating the atmospheric thermal structure and link it to a photochemical model that includes disequilibrium chemistry (molecular diffusion, vertical mixing and photochemistry). We compare thermal profiles and atmospheric composition of planets at different semimajor axis ($0.01 \leq a \leq 0.1$AU) orbiting F, G, K and M stars. Temperature and UV flux affect chemical species in the atmosphere. We explore which effects are due to temperature and which due to stellar characteristics, showing the species most affected in each case. CH_4 and H_2O are the most sensitive to UV flux, H displaces H_2 as the most abundant gas in the upper atmosphere for planets receiving a high UV flux. CH_4 is more abundant for cooler planets. We explore vertical mixing, to inform degeneracies on our models and in the resulting spectral observables. For lower pressures observable species like H_2O or CO_2 can indicate the efficiency of vertical mixing, with larger mixing ratios for a stronger mixing. By establishing the grid, testing the sensitivity of the results and comparing our model to published results, our paper provides a tool to estimate what observations could yield. We apply our model to WASP-12b, CoRoT-2b, XO-1b, HD189733b and HD97658b.

Download/Website: `http://arxiv.org/pdf/1311.0201v2.pdf`

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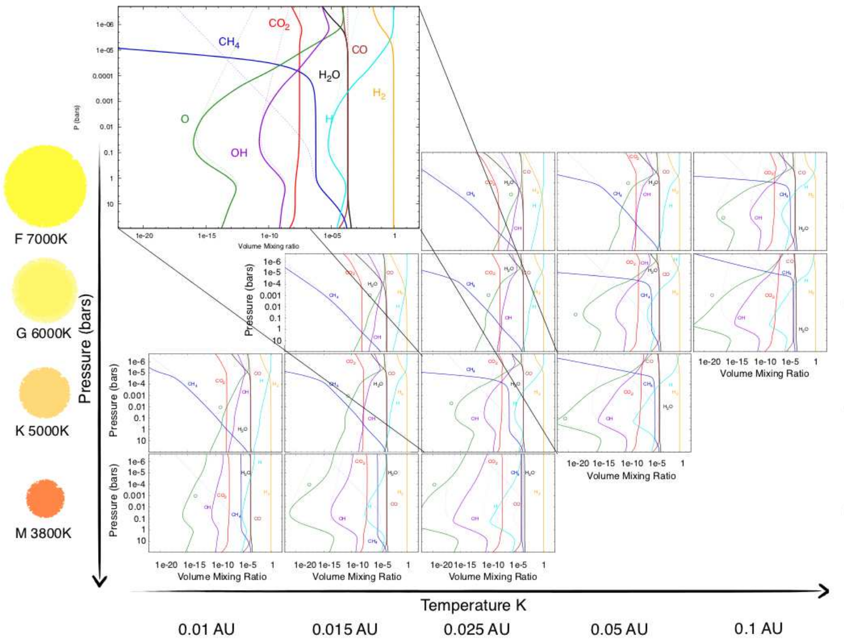

Figure 7: (Miguel & Kaltenegger) Grid of parameter space exploration of extrasolar giant planets for different distance and host stars. Photochemical mixing ratios (in solid lines) and thermochemical equilibrium (dotted lines) vs. pressure are shown in each panel.

RUN DMC: An Efficient, Parallel Code for Analyzing Radial Velocity Observations Using N-Body Integrations and Differential Evolution Markov Chain Monte Carlo

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Astrophysical Journal Supplement Series, in press (arXiv:1311.5229)

In the 20+ years of Doppler observations of stars, scientists have uncovered a diverse population of extrasolar multi-planet systems. A common technique for characterizing the orbital elements of these planets is Markov chain Monte Carlo (MCMC), using a Keplerian model with random walk proposals and paired with the Metropolis-Hastings algorithm. For approximately a couple of dozen planetary systems with Doppler observations, there are strong planetplanet interactions due to the system being in or near a mean-motion resonance (MMR). An N-body model is often required to accurately describe these systems. Further computational difficulties arise from exploring a high-dimensional parameter space ($\sim$7 number of planets) that can have complex parameter corelations, particularly for systems near a MMR. To surmount these challenges, we introduce a differential evolution MCMC (DEMCMC) algorithm applied to radial velocity data while incorporating self-consistent N-body integrations. Our Radial velocity Using N-body DEMCMC (RUN DMC) algorithm improves upon the random walk proposal distribution of the traditional MCMC by using an ensemble of Markov chains to adaptively improve the proposal distribution. RUN DMC can sample more efficiently from high-dimensional parameter spaces that have strong correlations between model parameters. We describe the methodology behind the algorithm, along with results of tests for accuracy and performance. We find that most algorithm parameters have a modest effect on the rate of convergence. However, the size of the ensemble can have a strong effect on performance. We show that the optimal choice depends on the number of planets in a system, as well as the computer architecture used and the resulting extent of parallelization. While the exact choices of optimal algorithm parameters will inevitably vary due to the details of individual planetary systems (e.g., number of planets, number of observations, orbital periods and signal-to-noise of each planet), we offer recommendations for choosing the DEMCMC algorithms algorithmic parameters that result in excellent performance for a wide variety of planetary systems.

Download/Website: `http://arxiv.org/abs/1311.5229`

Contact: `benelson@psu.edu`

The Atomic and Molecular Content of Disks Around Very Low-mass Stars and Brown Dwarfs

I. Pascucci[1], *G. Herczeg*[2], *J. S. Carr*[3], *S. Bruderer*[4]

[1] Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721, USA
[2] Kavli Institute for Astronomy and Astrophysics, Peking University, Beijing, 100871, PR China
[3] Naval Research Laboratory, Code 7211, Washington, DC 20375, USA
[4] Max Planck Institute for Extraterrestrial Physics, Giessenbachstrasse 1, 85748 Garching, Germany

The Astrophysical Journal, in press (arXiv:1311.1228)

There is growing observational evidence that disk evolution is stellar-mass dependent. Here, we show that these dependencies extend to the atomic and molecular content of disk atmospheres. We analyze a unique dataset of high-resolution *Spitzer*/IRS spectra from 8 very low-mass star and brown dwarf disks. We report the first detections of Ne^+, H_2, CO_2, and tentative detections of H_2O toward these faint and low-mass disks. Two of our [NeII] 12.81 micron emission lines likely trace the hot ($\geq$5,000 K) disk surface irradiated by X-ray photons from the central stellar/sub-stellar object. The H_2 S(2) and S(1) fluxes are consistent with arising below the fully or partially ionized surface traced by the [NeII] emission, in gas at $\sim$600 K. We confirm the higher C_2H_2/HCN flux and column

density ratio in brown dwarf disks previously noted from low-resolution IRS spectra. Our high-resolution spectra also show that the HCN/H_2O fluxes of brown dwarf disks are on average higher than those of T Tauri disks. Our LTE modeling hints that this difference extends to column density ratios if H_2O lines trace warm ≥ 600 K disk gas. These trends suggest that the inner regions of brown dwarf disks have a lower O/C ratio than those of T Tauri disks which may result from a more efficient formation of non-migrating icy planetesimals. A O/C=1, as inferred from our analysis, would have profound implications on the bulk composition of rocky planets that can form around very low-mass stars and brown dwarfs.

Download/Website: `http://adsabs.harvard.edu/abs/2013arXiv1311.1228P`

Contact: `pascucci@lpl.arizona.edu`

Prevalence of Earth-size planets orbiting Sun-like stars

Erik A. Petigura[1,2], *Andrew W. Howard*[2], *Geoffrey W. Marcy*[1]

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Proceedings of the National Academy of Sciences, arXiv:1311.6806

Determining whether Earth-like planets are common or rare looms as a touchstone in the question of life in the universe. We searched for Earth-size planets that cross in front of their host stars by examining the brightness measurements of 42,000 stars from National Aeronautics and Space Administrations Kepler mission. We found 603 planets, including 10 that are Earth size (1-2 Earth-radii) and receive comparable levels of stellar energy to that of Earth (within a factor of four). We account for Keplers imperfect detectability of such planets by injecting synthetic planet-caused dimmings into the Kepler brightness measurements and recording the fraction detected. We find that $11 \pm 4\%$ of Sun-like stars harbor an Earth-size planet receiving between one and four times the stellar intensity as Earth. We also find that the occurrence of Earth-size planets is constant with increasing orbital period (P), within equal intervals of logP up to $\sim$ 200 d. Extrapolating, one finds $5.7^{+1.7}_{-2.2}\%$ of Sun-like stars harbor an Earth-size planet with orbital periods of 200-400 d.

Download/Website: `www.pnas.org/cgi/doi/10.1073/pnas.1319909110`

Contact: `epetigura@berkeley.edu`

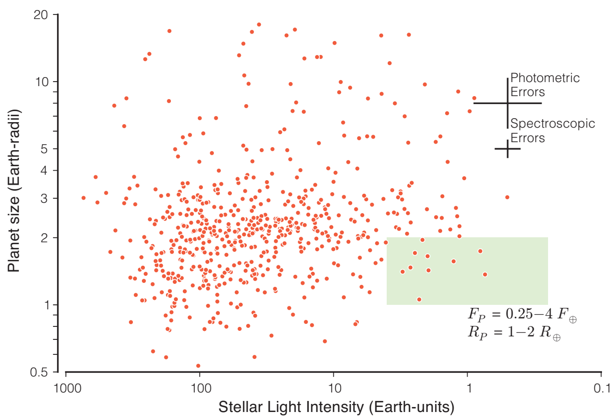

Figure 8: (Petigura, Howard & Marcy) 2D domain of planet size and stellar light intensity, incident flux, hitting the planet, on a logarithmic scale. Red circles show the 603 detected planets in our survey of 42,557 bright Sun-like stars ($Kp = 10 - 15$ mag, GK spectral type). The highlighted region shows the 10 Earth-size planets that receive an incident stellar flux comparable to the Earth: flux = 0.25 – 4.0 times the flux received by the Earth from the Sun. Our uncertainties on stellar flux and planet radii are indicated at the top right.

Electrostatic activation of prebiotic chemistry in substellar atmospheres

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International Journal of Astrobiology, in press (arXiv:1311.4408)

Charged dust grains in the atmospheres of exoplanets may play a key role in the formation of prebiotic molecules, necessary to the origin of life. Dust grains submerged in an atmospheric plasma become negatively charged and attract a flux of ions that are accelerated from the plasma. The energy of the ions upon reaching the grain surface may be sufficient to overcome the activation energy of particular chemical reactions that would be unattainable via ion and neutral bombardment from classical, thermal excitation. As a result, prebiotic molecules or their precursors could be synthesised on the surface of dust grains that form clouds in exoplanetary atmospheres. This paper investigates the energization of the plasma ions, and the dependence on the plasma electron temperature, in the atmospheres of substellar objects such as gas giant planets. Calculations show that modest electron temperatures of ≈ 1 eV ($\approx 10^4$ K) are enough to accelerate ions to sufficient energies that exceed the activation energies required for the formation of formaldehyde, ammonia, hydrogen cyanide and the amino acid glycine.

Download/Website: `http://arxiv.org/abs/1311.4408`

Contact: `craig.stark@st-andrews.ac.uk`

3 PhD Theses

A Pathway to Earth-like Worlds: Overcoming Astrophysical Noise

H. M. Cegla

Astrophysics Research Centre, School of Mathematics & Physics, Queen's University, University Rd, Belfast BT7 1NN, UK

Ph.D Thesis, Accepted following minor corrections

In the next decade, instrumental precision will no longer be the primary hindrance in the discovery and confirmation of exoplanets. Consequently, it is astrophysical noise that poses the most severe stumbling block on the pathway to habitable Earth-like worlds. Astrophysical noise arising from inhomogeneities on the stellar surface can mask or mimic planetary signals. For this reason, magnetically active stars are often avoided in planetary searches. However, even 'quiet' stars suffer from the effects of granulation, making it the fundamental limitation in the hunt for Earth-analogs. As a result, this thesis is dedicated to over-coming astrophysical noise, with a primary focus on mitigating the effects of stellar surface magneto-convection in spectroscopic observations.

In this thesis, I develop a multi-component parameterisation of granulation that can be used to reconstruct stellar line asymmetries and radial velocity shifts due to photospheric convective motions across the stellar disc. The parameterisation consists of four components: granules, magnetic and non-magnetic intergranular lanes, and magnetic bright points. These components are constructed by averaging Fe I 6302 Å line profiles output from detailed radiative transport calculations of the solar photosphere. Each of the four categories adopted are based on magnetic field and continuum intensity limits determined from examining 3D solar magnetohydrodynamic simulations (coupled with 1D radiative transport) with an average magnetic flux of 200 G. I demonstrate that, on average, these four components can accurately reconstruct granulation produced from modelling 12 x 12 Mm^2 areas on the solar surface, to better than $\sim \pm$ 20 cm s^{-1}. I also establish the applicability of this parameterisation across magnetic stellar activity levels by successfully reconstructing profiles from a 50 G simulation. This parameterisation is then used to construct Sun-as-a-star observations to identify how the convective plasma motions on the stellar surface alter the disc-integrated profiles. I find that the velocity asymmetry (a measurement comparing the spectral information

content of the blue wing to the red wing) and brightness measurements are the best suited diagnostics for reducing granulation noise to a level sufficient for the confirmation of habitable, terrestrial-mass planets.
In addition, I identify a potential new source of astrophysical noise, and establish tentative links between photometric variability and radial velocity variations in quiet stars; both of which are important steps on the pathway to Earth-like alien worlds.

Download/Website: `PDF copies available upon request`

Contact: `h.cegla@qub.ac.uk; hcegla01@qub.ac.uk`

4 Jobs and Positions

Tenure-Track Faculty

Theoretical Astrophysics Program
University of Arizona

Tucson, Arizona, USA, August 2014

The University of Arizona's Theoretical Astrophysics Program invites applications for a tenure-track faculty position to begin in Fall 2014. The Theoretical Astrophysics Program is an interdisciplinary program that fosters academic and scientific links among the Departments of Astronomy, Physics and Planetary Sciences at the University, to complement with a strong theory program the world-renowned astronomical facilities in Tucson, AZ. The Program consists of five core faculty and about 25 affiliate members working in a range of topics spanning solar system astrophysics to cosmology. In addition to the typical facilities available at a research university, the UA's Research Data Center provides our faculty access to local high-end supercomputing resources including distributed, shared-memory and GPU architectures. Review of applications will begin in December 2013 and will continue until the position is filled. For full position details and to apply online, please see www.hr.arizona.edu and reference job #53843. The University of Arizona is an EEO/AA employer - M/W/D/V.

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

Contact: `renu@lpl.arizona.edu`

5 Conference announcements

UK Exoplanet Community Meeting

Didier Queloz[1], *Isabelle Baraffe*[2], *Andrew Collier Cameron*[3], *Keith Horne*[3], *Hugh Jones*[4], *Richard Nelson*[5], *Don Pollacco*[6], *Giovanna Tinetti*[7]

[1] Cambridge University
[2] Exeter University
[3] St-Andrews University
[4] Hertfordshire University
[5] QueenMary London University
[6] Warwick University
[7] University College London

Cambridge, 14 – 16 April 2014

UK research activities within the field of exoplanets have significantly expanded in the last few years. Many members of this growing community are actively engaged in space missions, the development of ground-based facilities, intensive use of available resources, and new theoretical developments.

The purpose of this meeting is to encourage interactions between groups and researchers working on these topics, and to help foster new collaborations. We hope active groups and individuals will attend and present their research, especially PhD students and postdocs. Topics addressing general aspects relevant for the community may be proposed as well (eg. the road map, space mission support,etc.).

The meeting is intended for the UK community, but not restricted to it. Participants from abroad are welcome to attend and to submit abstracts. The meeting will be held from Monday 14 April to Wednesday 16 April, from noon to noon.

Registration will be open on the 6th January 2014. Notice that the number of participants will be limited.

For more information you are invited to visit the conference web-site. Pre-registration is available and encouraged.

Download/Website: `http://www.mrao.cam.ac.uk/research/exoplanets/exo-meeting-2014`

Contact: `karen@mrao.cam.ac.uk`

Proposed session for the UK National Astronomy Meeting 2014: Atmospheres on planets and brown dwarfs: bridging the gap

Joanna Barstow[1], *Sarah Casewell*[2], *Gaby Provan*[2], *Ben Burningham*[3]

[1] Department of Physics, University of Oxford, Keble Road, Oxford, OX1 3RH, UK
[2] Department of Physics and Astronomy, University of Leicester, University Road, Leicester, LE1 7RH
[3] Centre for Astrophysics Research, University of Hertfordshire, College Lane, Hatfield, AL10 9AB, UK

Portsmouth, 23rd—26th June 2014

The session will bring together astronomers from both the brown dwarf and exoplanet fields to discuss scientific comparisons of both brown dwarfs and exoplanets, and to promote synergy of spectral modelling techniques from the data-led Bayesian and Optimal Estimation approaches developed for solar system planetary science to the physically detailed *ab initio* models that have evolved from stellar physics. These methods are highly complementary, and so we hope that this session will enable the community to discuss ways of combining the approaches. In addition, we hope to discuss the implications of new exoplanet and brown dwarf science for the studies of solar system atmospheres and magnetospheres.

If you would be interested in speaking at or attending such a session, please let us know using the contact details provided.

Contact: `jo.barstow@astro.ox.ac.uk`

Complex Planetary Systems - IAU Symposium 310

Anne Lemaitre, Anne-Sophie Libert
NaXys Center, University of Namur

Namur, Belgium, 7-11 July 2014

All the planetary systems, from the Earth-Moon system to the extrasolar ones, are complex systems, requiring several levels of expertise and of interdisciplinarity to be clearly understood. The Symposium aims to bring forward the latest findings obtained in that perspective and to generate new collaborations for the future. Any astronomer involved in planetary systems, at any level, is invited to participate to the meeting and to propose its own expertise in future complex challenges.

Key topics of the Symposium:
- Solar System: formation, migration, models
- Formation of extrasolar systems: tides, dissipation, resonances
- Dynamics of exoplanets: rotational and orbital motions
- Rotation models and internal structure of planets and satellites
- Giant planets systems: Jupiter, Saturn, Uranus
- Earth-Moon system: formation, satellites and debris
- Small bodies system: evolution and history
- Dynamics of asteroids: rotation, binary, satellites
- Complex algorithms and tools.

SOC: A. Lemaitre (chair), C. Beaugé, A. Celletti, V. Dehant, Z. Knezevic (editor of the proceedings), J. Laskar, A. Milani, A. Morbidelli, D. Nesvorny, D. Scheeres, K. Tsiganis

LOC: A.-S. Libert (chair), T. Carletti, A. Compère, A. Lemaitre, Ch. Lhotka, J. Navarro, B. Noyelles, M. Sansottera, A. Vienne

Download/Website: `www.cps-iau.be`
Contact: `cps-iau@unamur.be`

Exoplanetary Science

Michel Mayor
Observatoire de Geneve, Geneva, Switzerland

Quy Nhon, Vietnam, April 20-26, 2014

This is a first announcement and a call for contributions, to an international conference entitled ”Exoplanetary Science”. This conference is in in the ”Rencontres du Vietnam” series, and will take place during the week 20-26 April, 2014.
The conference will be organized in the coastal university town of Quy Nhon, Vietnam, in the newly inaugurated ICISE (International Centre for Interdisiciplinary Science and Education). The conference will be centred on the emerging discipline of exoplanetary science, and will concentrate in particular on the impact of new observational and theoretical results, and the promise of new projects. It will be a mix of plenary sessions for invited talks, as well as parallel sessions for contributed papers. The scientific programme is under construction; if you need information which is not as yet available on our site, you can contact Ludwik Celnikier, at the email address: ludwik.celnikier@obspm.fr
The site will be updated systematically; you should check regularly for new information. The site includes a registration form, as well as a form for submitting abstracts. The main topics will include (non-exhaustive list):

- space projects after COROT/KEPLER/Spitzer: GAIA, TESS, CHEOPS, PLATO or ECHO
- ground based projects: EPICS, ESPRESSO, SPHERE, HARPS-N, Spectroscopy IR
- New instruments for transit observations: MEARTH

Download/Website: http://vietnam.in2p3.fr/2014/exo/
Contact: Ludwik.celnikier@obspm.fr, Michel.Mayor@unige.ch, jtrantv@gmail.com

Workshop: The Formation of the Solar System

SOC:Melvyn Davies, Matthieu Gounelle, Michael Meyer, Susanne Pfalzner, Simon Portegies Zwart, Ingo Thies

MPIfR, Bonn, Germany, 13rd-15th May, 2014

With more than 900 confirmed exoplanets, it is becoming clear that there are many planetary systems with rather different properties to that of the Solar System. This poses the question how our own Solar System formed. The answer to this question is not straight forward, because it is based on hints from the current state on what happened in the past. It turns out that this is an interdisciplinary endeavour, requiring knowledge of supernovae explosions, meteorites, cosmochemistry, structure and evolution of circumstellar discs, star cluster dynamics, and the early dynamical evolution of planetary systems. The goal of this workshop is to provide a platform for information exchange between these different disciplines, putting together the puzzle pieces of the Solar System formation history.
The workshop focusses on:

- Cosmochemical constraints on the physical/chemical conditions in the Solar Nebula
- Time scales of the dust and planetesimal growth for the Solar System
- Models of the Kuiper belt formation
- The role of the stellar environemt, with emphasis on star cluster dynamics
- Early planetary system development
- Future evolution of the Solar System
- Contributions from related fields are welcome.

The workshop will be limited to 40 participants, early registration is recommended.
Download/Website: /https://indico.mpifr-bonn.mpg.de/theFormationOfTheSolarSystem
Contact: spfalzner@mpifr.de

The 2014 STScI Spring Symposium: Habitable Worlds Across Time and Space

John H. Debes, Chair

Space Telescope Science Institute, Baltimore, Maryland, April 28 - May 1st, 2014

Within a matter of years, humanity will know for the first time the frequency of terrestrial planets in orbit around other stars. This knowledge will pave the way for joining research from astronomy, Earth science, and biology to understand the past, present, and future of the Earth within its larger context as one of many habitable worlds throughout the Galaxy. Such work seeks to understand the formation and fate of the Earth as well as predict where and when different bodies will be suitable for both simple and complex forms of life.

In this four-day symposium, scientists from diverse fields will discuss the formation and long-term evolution of terrestrial bodies throughout the various phases of stellar and Galactic evolution. A particular focus will be in how the specific conditions and challenges for habitability on Earth extend to other bodies in the Solar System and beyond. This symposium will include discussions about sites for Galactic habitability that have not yet been given much attention, such as around post-main sequence stars. The existence of these overlooked environments may provide motivation for novel astronomical observations with existing and next generation ground and space-based observatories.

Invited speakers will cover the following topics:
-Terrestrial planet formation, volatile delivery, and the formation of moons
-Early Earth geochemistry, atmosphere, and the origins of life
-The frequency of terrestrial planets across stellar mass
-The limits to Earth-like life
-Habitability of planets and moons during all phases of stellar evolution
-Habitability in low-luminosity environments

A second announcement containing the procedures for abstract submission and on-line registration will be issued in early January 2014.

For more information on the Symposium, including a list of confirmed speakers, please check the website:
Download/Website: `http://www.stsci.edu/institute/conference/habitable-worlds`
Contact: `hwats2014@stsci.edu.`

NASA Exoplanet Exploration Program Analysis Group Meeting 9

Scott Gaudi, Douglas Hudgins

Washington, DC, January 4+5, 2013

NASA's Exoplanet Exploration Program Analysis Group (ExoPAG) will hold its ninth meeting on Saturday+Sunday, January 4+5, 2014, just prior to, and at the same venue as, the 223rd AAS meeting, in Washington, DC. ExoPAG meetings are open to the entire scientific community, and offer an opportunity to participate in discussions of scientific and technical issues in exoplanet exploration, and to provide input into NASA's Exoplanet Exploration Program (ExEP). All interested members of the astronomical and planetary science communities are invited to attend and participate.

The most up-to-date agenda, as well as details of the meeting logistics, can be found on the ExoPAG website listed below. Agenda topics include a mini workshop on the potential for characterization of exoplanets with JWST, reports from the active Study Analysis Groups (SAGs), a joint meeting of the ExoPAG and Cosmic Origins Program Analysis Group (COPAG), and a discussion of the community's near-term strategy for exoplanet exploration.

Questions can be sent to Scott Gaudi, ExoPAG Executive Committee Chair (gaudi@astronomy.ohio-state.edu), and/or Dr. Douglas Hudgins, ExoPAG Executive Secretary (Douglas.M.Hudgins@nasa.gov). News and information about NASA's ExoPAG and the ExoPAG 9 meeting, including hotel information, can be found on the ExoPAG web site below.

Download/Website: `http://exep.jpl.nasa.gov/exopag`

Contact: `gaudi@astronomy.ohio-state.edu`

Observations and Modeling of Low Mass Low Density (LMLD) Exoplanets

J. Cabrera[1], *L. Grenfell*[1], *N. Nettelmann*[2]

[1] Institut für Planetenforschung, Deutsches Zentrum für Luft- und Raumfahrt e.V., Rutherfordstr. 2, D-12489 Berlin, Germany
[2] University of California, Santa Cruz, Dept. of Astronomy and Astrophysics High Street 1156, ISB room 291, CA-95064, USA

EGU 2014 Vienna, 27 April - 02 May 2014

We are very pleased to announce the start of the abstract submission for the EGU General Assembly 2014 (EGU2014); 27 April - 02 May 2014; Vienna; Austria. You are cordially invited to browse through the sessions at: http://meetingorganizer.copernicus.org/EGU2014/sessionprogramme
In particular; we would like to draw your attention to the session "Observations and Modeling of Low Mass Low Density (LMLD) Exoplanets" with number PS6.3 inside the PS6 "Exoplanet" program; within the Program "Planetary and Solar System Sciences": http://meetingorganizer.copernicus.org/EGU2014/session/15518
Low Mass Low Density (LMLD) planets are an exciting emerging class of exoplanets and we expect a plethora of new data in the near future. How these worlds formed and what they are made of are hotly debated issues. Suggestions for the nature of e.g. GJ1214b include (i) a super-Earth with a remnant hydrogen-helium envelope and an aerosol/haze/cloud layer; (ii) a hot steam atmosphere; or (iii) a mini-Neptune with a high mean molecular weight atmosphere. The purpose of this session is to bring together expertise from the observational (e.g. transmission spectra) and modeling (population synthesis; aerosol formation; photochemical-climate; atmospheric parameter retrieval; interior modeling and EOS; etc.) communities related to LMLD science. Papers are welcome e.g. on what observational data can we gather now and (based on near-term missions) in the near future in order to address the composition question (e.g. how well does the Rayleigh slope have to be measured in order to constrain potential haze layers; what resolution is required to distinguish solar composition from higher metallicities such as steam atmospheres etc.). Key modeling issues include addressing the assumptions of the population synthesis models (e.g. effect of model results to input conditions such as planetesimal size; influence of escape processes; etc.); whereas for the photochemical and aerosol modeling; key issues include better constraining chemical input (e.g. absorption coefficients and rate constants) in hot; steamy and/or solar-like atmospheres.
The deadline for the receipt of abstracts is 16 January 2014; 13:00 CET.
Further information about the EGU General Assembly 2014 can be found at: http://www.egu2014.eu
Please don't hesitate to contact us for more information.
Juan Cabrera; John Lee Grenfell; Nadine Nettelmann

Download/Website: `http://meetingorganizer.copernicus.org/EGU2014/session/15518`

Contact: `juan.cabrera@dlr.de; lee.grenfell@dlr.de; nadine.nettelmann@uni-rostock.de`

6 As seen on astro-ph

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

astro-ph/1311.0003 : **Spectro-Thermometry of M dwarfs and their candidate planets: too hot, too cool, or just right?** by *Andrew W. Mann, Eric Gaidos, Megan Ansdell*

astro-ph/1311.0011 : **On the Minimum Core Mass for Giant Planet Formation at Wide Separations** by *Ana-Maria A. Piso, Andrew N. Youdin*

astro-ph/1311.0024 : **The Role of Carbon in Extrasolar Planetary Geodynamics and Habitability** by *Cayman T. Unterborn, et al.*

astro-ph/1311.0201 : **Exploring atmospheres of hot mini-Neptunes and extrasolar giant planets orbiting different stars with application to HD 97658b, WASP-12b, CoRoT-2b, XO-1b and HD 189733b** by *Yamila Miguel, Lisa Kaltenegger et al.*

astro-ph/1311.0248 : **Detection of Potential Transit Signals in Sixteen Quarters of Kepler Mission Data** by *Peter Tenenbaum, et al.*

astro-ph/1311.0280 : **The TRENDS High-Contrast Imaging Survey. V. Discovery of an Old and Cold Benchmark T-dwarf Orbiting the Nearby G-star HD 19467** by *Justin R. Crepp, et al.*

astro-ph/1311.0292 : **Runaway greenhouse effect on exomoons due to irradiation from hot, young giant planets** by *René Helle, Rory Barnes*

astro-ph/1311.0296 : **Coagulation Calculations of Icy Planet Formation Around 0.1–0.5 $M_\odot$ Stars: Super-Earths From Large Planetestimals** by *Scott J. Kenyon, Benjamin C. Bromley*

astro-ph/1311.0329 : **Understanding the Mass-Radius Relation for Sub-Neptunes: Radius as a Proxy for Composition** by *Eric D. Lopez, Jonathan J. Fortney*

astro-ph/1311.0972 : **Atmospheric escape by magnetically driven wind from gaseous planets** by *Yuki A. Tanaka, Takeru K. Suzuki, Shu-ichiro Inutsuka*

astro-ph/1311.1050 : **Speeding up low-mass planetary microlensing simulations and modelling: the Caustic Region Of INfluence (CROIN)** by *Matthew T. Penny*

astro-ph/1311.1142 : **Giant Planet Formation, Evolution, and Internal Structure** by *Ravit Helled, et al.*

astro-ph/1311.1170 : **Characterizing Distant Worlds with Asterodensity Profiling** by *David M. Kipping*

astro-ph/1311.1201 : **Detectability of Free Floating Planets in Open Clusters with JWST** by *Fabio Pacucci, Andrea Ferrara, Elena D'Onghia*

astro-ph/1311.1203 : **Metallicities of Kepler Stars: LAMOST vs. KIC** by *Subo Dong, Zheng Zheng, Zhaohuan Zhu*

astro-ph/1311.1207 : **Predictions for Shepherding Planets in Scattered Light Images of Debris Disks** by *Timothy J. Rodigas, Renu Malhotra, Philip M. Hinz*

astro-ph/1311.1214 : **Secular chaos and its application to Mercury, hot Jupiters, and the organization of planetary systems** by *Yoram Lithwick, Yanqin Wu*

astro-ph/1311.1228 : **The Atomic and Molecular Content of Disks Around Very Low-mass Stars and Brown Dwarfs** by *Ilaria Pascucci, et al.*

astro-ph/1311.1819 : **The Dispersal of Protoplanetary Disks** by *Richard Alexander, et al.*

astro-ph/1311.2048 : **TTVs analysis of Southern Stars: the case of WASP-4** by *R. Petrucci, et al.*

astro-ph/1311.2083 : **The UM, a fully–compressible, non–hydrostatic, deep atmosphere GCM, applied to hot Jupiters** by *N. J. Mayne, et al.*

astro-ph/1311.2085 : **Directly Imaged L-T Transition Exoplanets in the Mid-Infrared** by *Andrew J. Skemer, et al.*

astro-ph/1311.2417 : **Orbital and physical properties of planets and their hosts: new insights on planet formation and evolution** by *V. Zh. Adibekyan, et al.*

astro-ph/1311.2521 : **Resource Letter Exo-1: Exoplanets** by *Michael Perryman*

astro-ph/1311.2916 : **Influence of the C/O ratio on titanium and vanadium oxides in protoplanetary disks** by *M. Ali-Dib, et al.*
astro-ph/1311.2942 : **Planet Packing in Circumbinary Systems** by *Kaitlin M. Kratter, Andrew Shannon*
astro-ph/1311.2947 : **Herschel Observations of Debris Discs Orbiting Planet-hosting Subgiants** by *Amy Bonsor, et al.*
astro-ph/1311.2977 : **Resolved Imaging of the HR 8799 Debris Disk with Herschel** by *Brenda C. Matthews et al.*
astro-ph/1311.3021 : **Revisiting the proposed circumbinary multi-planet system NSVS14256825** by *Tobias C. Hinse, et al.*
astro-ph/1311.3039 : **On the radius of habitable planets** by *Yann Alibert*
astro-ph/1311.3101 : **Possible climates on terrestrial exoplanets** by *Francois Forget, Jeremy Leconte*
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