Infinite Worlds

BAA's Sir Patrick Moore award for work on the ExoClock project. See News for details

The e-magazine of the

Exoplanets Division
of the
Asteroids and Remote Planets Section

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Contents

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EXoPLanet Orbit REsearch - EXPLORE

Below is a slightly modified version of the recently circulated EXPLOIT document. In future EXPLORE information will be included in this emagazine rather than distributed separately.

EXoPLanet Orbit REsearch – EXPLORE

EXoPLanet Object of InTerest One – EXPLOIT 100 V2

WASP-12b

Updated 2011 December 23

Index

1.0 Why this target?

A something for everyone target;

101. Introduces newcomers to and allows them to contribute to the ExoClock Project by observing transits. It's reasonable transit depth makes it suitable for small telescopes. Numerous opportunities for observing in 2023. See 3.0 below.
102. Using remote telescopes – the MicroObservatory Telescope Network. See 4.0 below
103. Monitoring changes in orbital parameters to measure decay – 5.0 below
104. Searching for additional planets. Out-of-transit observations may detect a possible additional planet, c, - 6.0 below
105. Modelling. Using data from the paper by Sarah Millholland and Gregory Laughlin, see 6.0 below, calculate the orbital parameters of planet c

2.0 WASP-12b data

WASP-12b, a 'Hot Jupiter' is located about 1410.6 light-years (432.5 pc) away. Discovered in 2008. WASP-12 is 1.4 times more massive and 1.7 times bigger compared with our Sun. The surface temperature is 6360 with its spectral types of G0. The planet WASP-12 b orbits around the star WASP-12 every 1.1 days with its orbital distance of 0.02 AU (3506574.1 km) - ExoKyoto

RA 06:30:32.7966 DEC +29:40:20.266
V mag 11.57, R mag 11.29
Transit depth 17.81 mmag, Transit duration 3.0 hrs – Exoplanet.eu

3.0 ExoClock

This section is for those not familiar with the ExoClock project. There is information on the

Exoplanet's Division website here. The ExoClock website including all targets and observations is here

To get started visit the ExoWorlds Spies website where you will find links to; HOPS software, datasets to analyse and a Transit Scheduler which will enable you to find suitable targets for your location and equipment. A video of the 2022 November 24 HOPS v3.1 Workshop can be linked to from here.

4.0 MicroObservatory Telescope Network

Until further notice, while you may use HOPS and ExoClock on-line analysis to process MicroObservatory observations, please do not submit your observations to the ExoClock database. The reason for this is that multiple observers may submit results of their analysis of the same set of observations which is causing some confusion. Discussions to seek a resolution are in progress.

WASP-12b, and many other exoplanets, can be observed using the MicroObservatory Telescope Network which is free to use - tutorial here

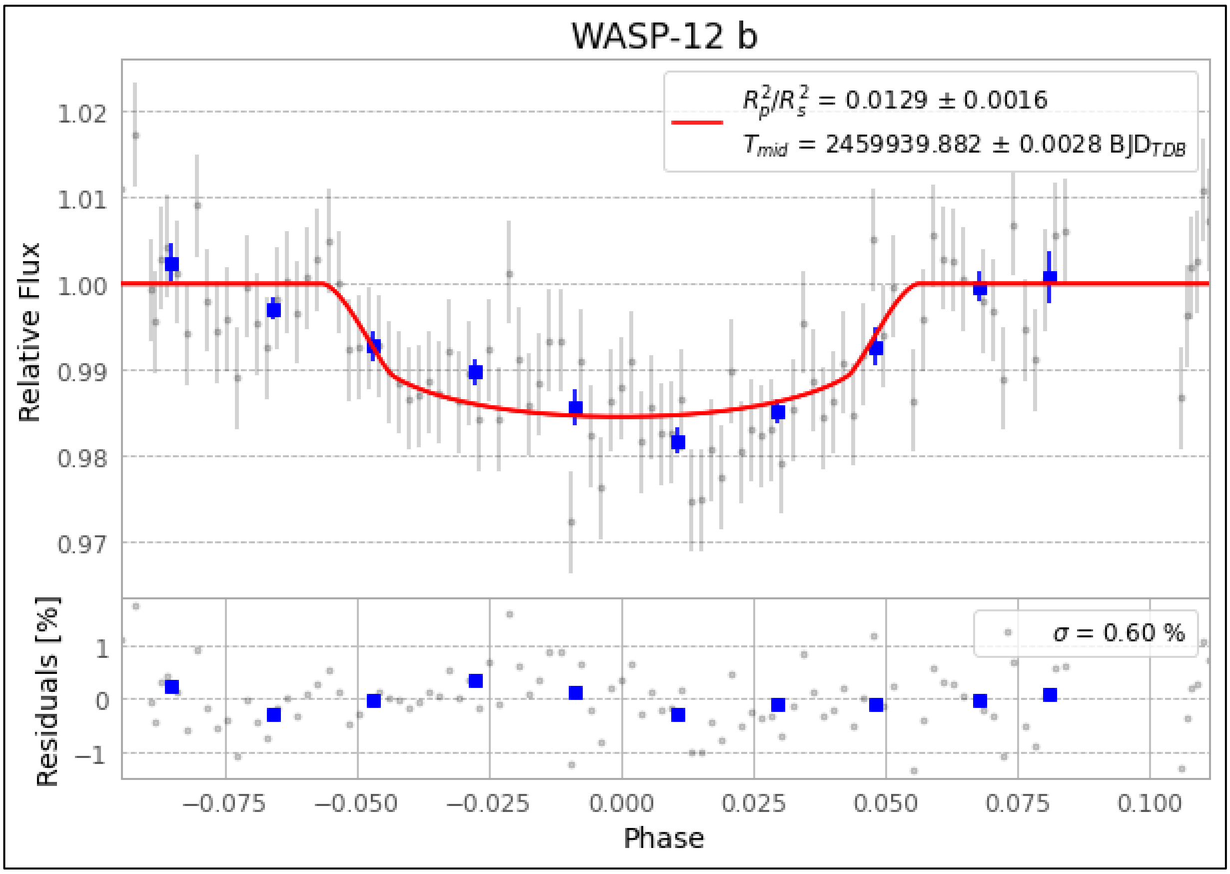


Figure 1 is an example of a transit light curve obtained by Martin Fowler using the MicroObservatory

Martin reports an O-C for the transit of -4.97+/- 4.03 mins which is in line with the ExoClock observations shown in Figure 2.

5.0 Orbital decay

5.1 ExoClock observations

WASP-12b's orbit is decaying as shown by the observations from the ExoClock website – Figure 2

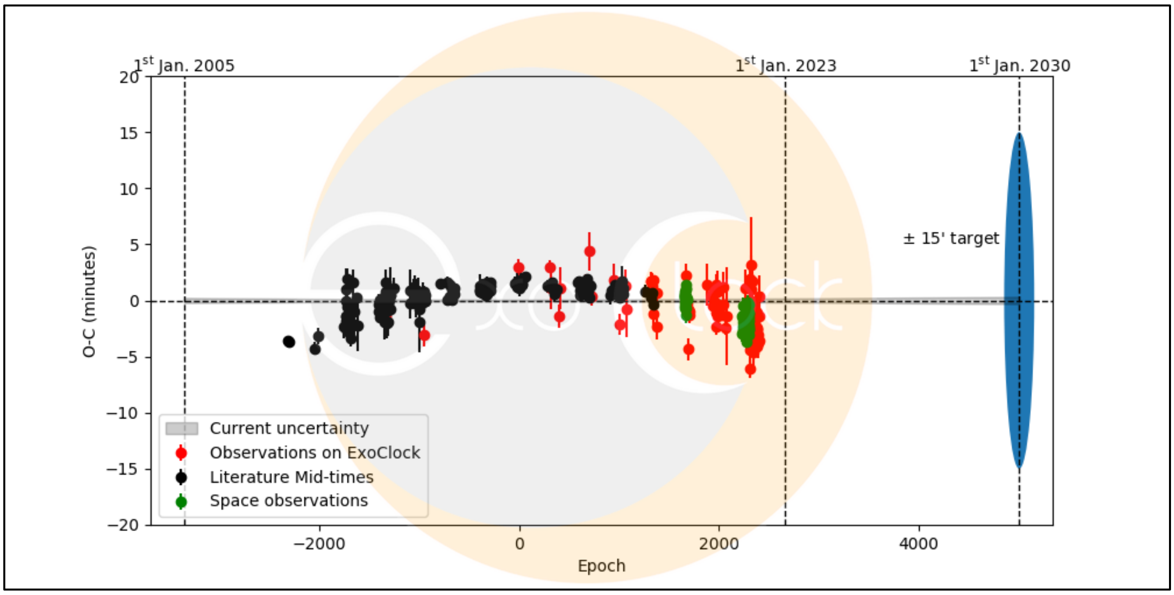


Figure 2, Observations from the ExoClock website

5.2 Obliquity tides

Tidal interactions between hot-Jupiter exoplanets and the host star should be causing their orbits to decay, such that the planet gradually spirals inwards. For most systems the change would be too small to detect in the decade or so that we've been observing them. However, WASP-12b is an exception, showing a clear change in its orbital period. In a new paper on arXiv, Gracjan Maciejewski et al present the latest data for WASP-12b.

The paper states that the WASP-12 system is the best candidate for possessing an in-falling giant exoplanet.

If the host star rotates faster than the planet, the planet's orbital period, and semi-major axis, will increase (as is the case for the Earth-Moon system). On the other hand, if the host star rotation is slower than that of the planet, the planet will spiral inwards towards its host star.

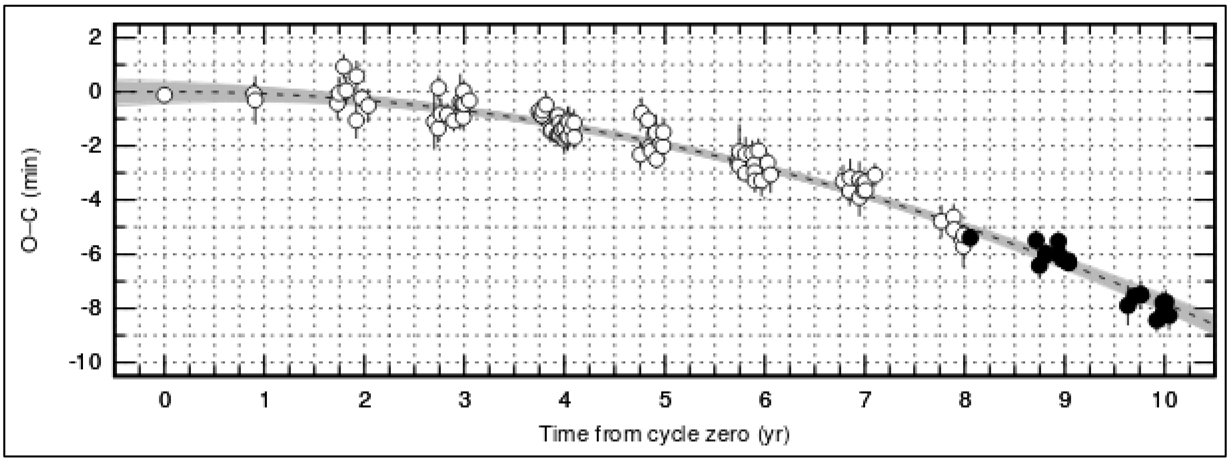


Figure 3. Changes in transit times

Figure 3, taken from WASP Planets, shows the change in transit time ("observed minus calculated" times, or O–C), indicating that the transits are now occurring eight minutes early owing to a decreasing orbital period. Such a rate is far faster than observed in other systems, and too large to be explained by the standard theory of tidal interactions. However, a new paper led by Sarah Millholland suggests an answer. She suggests that the planet is tilted over, so that the axis around which it spins is tilted with respect to the plane of the planet's orbit – Figure 4.

6.0 Additional planet?

In the paper mentioned above Sarah Millholland suggests that a second planet in an outer orbit might be perturbing WASP-12b, keeping it in the high-obliquity state. Planet b's obliquity maintains a large value as it is forced by a

spin-orbit resonance with an exterior, small-mass planet. This scenario requires some fine tuning, but if WASP-12 is the only system known to show this behaviour then the explanation is plausible.

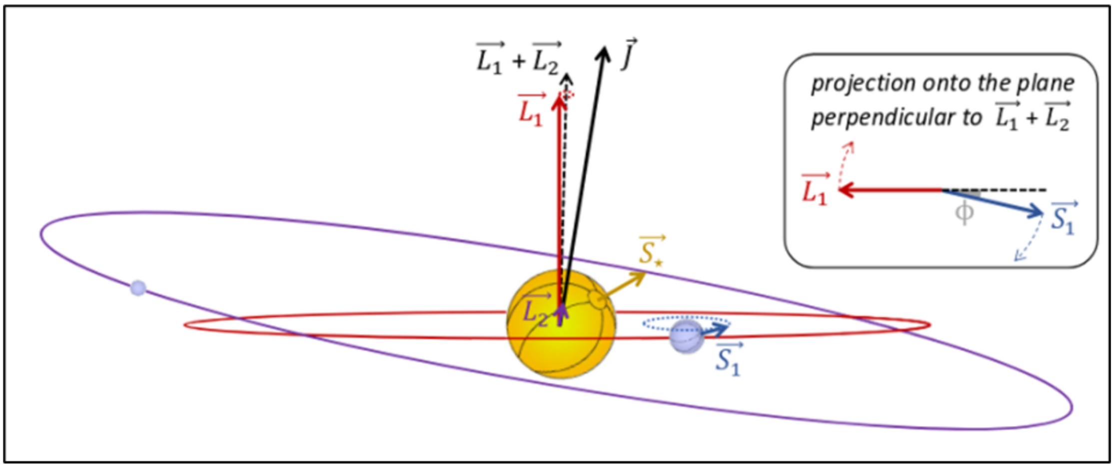


Figure 4. Proposed Wasp-12. Credit Millholland and Laughlin

7.0 Definition of exploit

In keeping with the EXPLORE theme. A bold and daring feat that makes full use of and derives benefit from a resource.

<u>News</u>

Today's (2023 January 2) score from the NASA Exoplanet Archive, Exoplanet and Candidate Statistics

Total conformed exoplanets;	5235
Kepler candidates;	2054
K2 candidates	978
TESS candidates;	6137

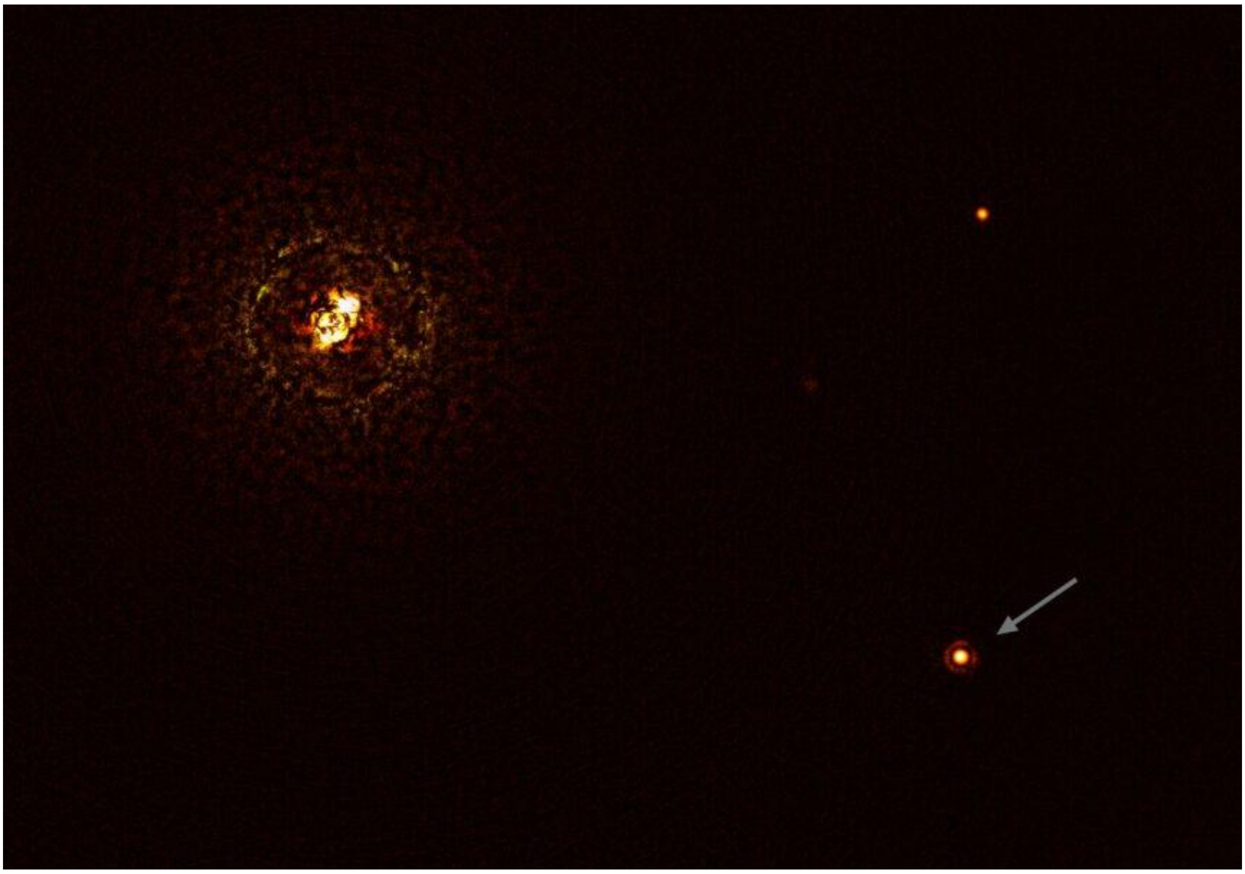
BAA award

Congratulations to, left to right, Adrian Jones, Martin Crow and Simon Dawes who received the award for Pro-Am work on the ExoClock project from BAA President, David Arditti, far left, on 2022 December 10th during the BAA Christmas meeting at the Institute of Physics. The aim of the project is to confirm or otherwise and thus update the timings of exoplanet transits as compared with the literature to support the Ariel space telescope due for launch in 2029. This ensures that the telescope will be pointed at the right target at the right time.

Planets around giant stars

At the BAA Christmas meeting held on 2022 December 10 Tim Parsons gave a talk 'A Massive Star Menagerie: touring through the upper reaches of the H-R Diagram'. A question was asked 'Are there planets around giant stars?' A subsequent trawl of the internet resulted in the following:

https://skyandtelescope.org/astronomy-news/giant-planet-imaged-around-massive-star/ The image below shows the massive binary system known as b Centauri and its giant planet, b Centauri (AB)b. This is the first time astronomers have directly observed a planet orbiting a star pair this massive. The duo, which have a total mass of at least six Suns, is the bright object in the top left corner of the image. The bright and dark rings around it are imaging artifacts. The planet, visible as a bright dot in the lower right of the frame, is a super-Jupiter that orbits the pair at 560 a.u. The other bright dot in the image (top right) is a background star.



Binary system b Centauri Credit ESO / Janson et al.

https://platomission.com/2018/05/01/planets-around-giant-stars/ Several ground-based Doppler planet searches target sub-giant and giant stars instead of main-sequence stars. The number of planets known to orbit giant stars (~60; Niedzielski et al. 2015) is still small compared to those known to orbit main-sequence stars, but their number has dramatically increased in recent years and is expected to do so in the near future thanks to TESS (Campante et al. 2016), CHEOPS, and Gaia.

https://www.ast.cam.ac.uk/talks/archive/3567 Over the past 20 years approximately 1000 exoplanets have been discovered. More than 80% of these exoplanets orbit host stars with masses less than about 1.2 M_sun. The reason for this is that the Doppler method, the most successful detection method, has insufficient precision to detect planets around more massive main sequence stars (this talk was given in 2014, transit photometry is now the most successful method - RD) These stars are hot and thus have few spectral lines that are often broadened by large rotation rates. We thus know little about the process of planet formation as a function of the most fundamental property of a star its mass. Talk slides.

https://www.aanda.org/articles/aa/pdf/2014/06/aa23345-13.pdf More than 50 exoplanets have been found around giant stars, revealing different properties when compared to planets orbiting solar-type stars. In particular, they are super-Jupiters and are not found orbiting interior to ~0.5 AU.#

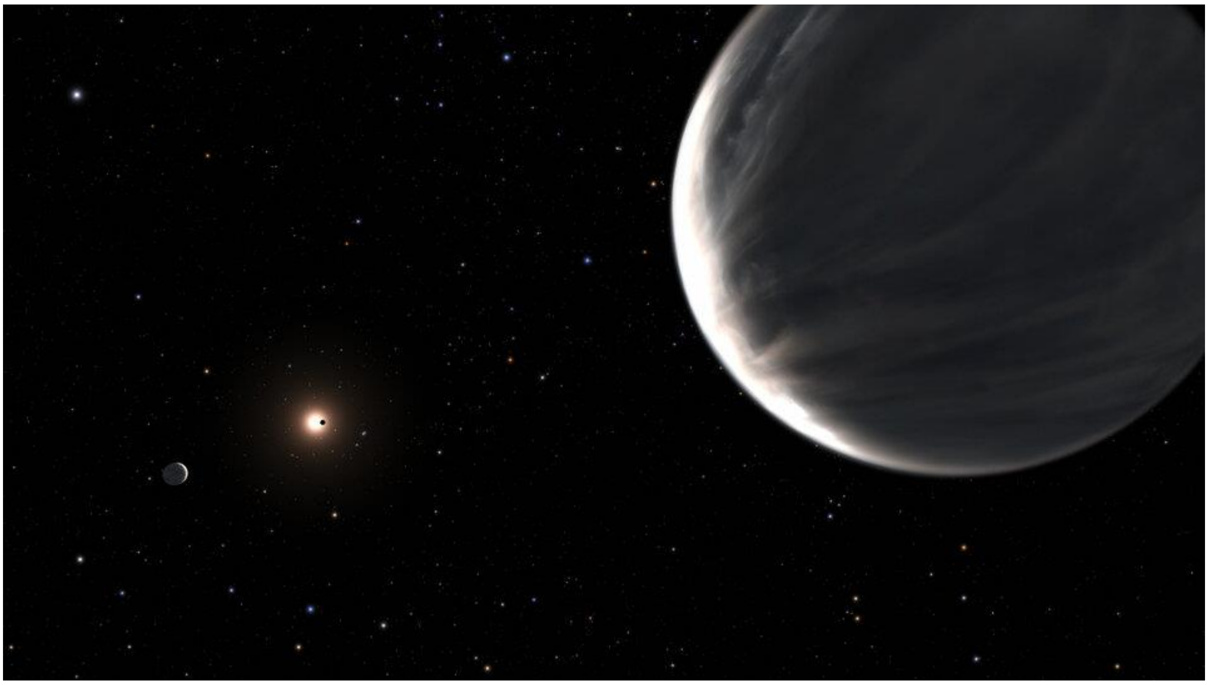
So the answer would appear to be 'Yes there are'.

Webb reveals an exoplanet atmosphere as never seen before

The NASA/ESA/CSA James Webb Space Telescope just scored another first: a molecular and chemical portrait of a distant world's skies. While Webb and other space telescopes, including the NASA/ESA Hubble Space Telescope, have previously revealed isolated ingredients of this heated planet's atmosphere, the new readings provide a full menu of atoms, molecules, and even signs of active chemistry and clouds. The latest data also give a hint of how these clouds might look up close: broken up rather than as a single, uniform blanket over the planet – WASP-39b.

A water world

Researchers have found evidence for the existence of a new type of planet they have called a "water world," where water makes up a large fraction of the entire planet. These worlds, discovered in a planetary system 218 light-years away, are unlike any planets in our Solar System. The team, led by Caroline Piaulet of the Institute for Research on Exoplanets (iREx) at the University of Montreal, published a detailed study of a planetary system known as Kepler-138 in the journal Nature Astronomy on 15 December. Piaulet, who is a member of Björn Benneke's research team at the University of Montreal, observed the exoplanets Kepler-138 c and Kepler-138 d with both the NASA/ESA Hubble Space Telescope and NASA's Spitzer Space Telescope. She found that the planets could be composed largely of water.



Artist’s illustration of the Kepler 138 planetary system

Exoplanet GJ1252-b

GJ 1252 b, a rocky, terrestrial "super-Earth" discovered in 2020, has been given a closer look and astronomers have found that the exoplanet could have a very minimal atmosphere or possibly no atmosphere at all. The planet, which orbits an M-type star, is "the smallest exoplanet yet for which we have such tight constraints on its atmosphere," said lead author Ian Crossfield, an astronomer and assistant professor at the University of Kansas.

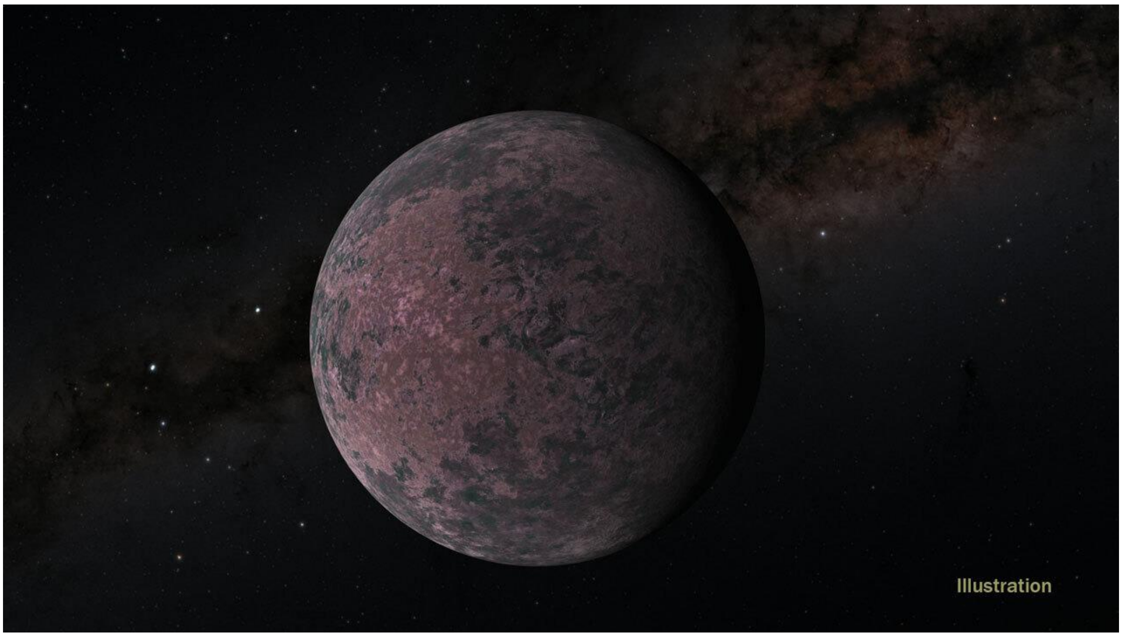


Illustration of the terrestrial super-Earth GJ 1252 b, which lies approximately 65 light-years from Earth. Credit: NASA/JPL-Caltech

Stars and planets grow together

A team of astronomers have found that planet formation in our young Solar System started much earlier than previously thought, with the building blocks of planets growing at the same time as their parent star. A study of some of the oldest stars in the Universe suggests that the building blocks of planets like Jupiter and Saturn begin to form while a young star is growing. It had been thought that planets only form once a star has reached its final size, but new results, published in the journal Nature Astronomy, suggests that stars and planets 'grow up' together.

Planet finding laser

Professor Derryck Reid is head of the Ultrafast Optics Group at Heriot-Watt University. He says the new laser has huge potential to enable astronomers to detect small, Earth-like planets orbiting distant stars. "Using space telescopes, astronomers have already identified thousands of stars that might have exoplanets, but each of these must be confirmed by ground-based telescopes looking for tiny fluctuations in the colour of the star's light that are the signatures of an orbiting planet. "These tiny wavelength shifts confirm the presence of an orbiting planet and provide its mass and orbital period.

Espresso detects barium in the atmosphere of an exoplanet

An international team including researchers from the University of Geneva (UNIGE) and the National Centre of Competence in Research (NCCR) PlanetS has detected the heaviest element ever found in the atmosphere of an exoplanet: barium. This feat was made possible by ESPRESSO, a spectrograph developed largely by the UNIGE and installed on the Very Large Telescope of the European Southern Observatory (ESO VLT). The scientists were surprised to discover such an element at high altitudes in the atmosphere of the ultra-hot gas giants WASP-76 b and WASP-121 b, as their strong gravity should - in theory - pull it down into their deep layers. This study, to be found in the journal Astronomy & Astrophysics, raises questions about the nature of these exotic atmospheres.

Conferences/Meetings/Seminars/Webinars/Videos

NoRCEL's Blue Earth Project 2023 Event (BEP2023)

"Is it time for planet B?"

Stephen Hawking proposed a doomsday scenario in which humanity might have as little as 100 years before leaving Earth, while Elon Musk does not want to wait for that long. Is this how we should confront existential threats to our presence on Earth, or is this a misleading and potentially dangerous or counterproductive direction of thought? Where lies our responsibility for the ecosystem that we depend on? Whatever the answer might be, the future of humanity depends on sound action and must not be left to speculative visions. Join a panel discussion covering a range of perspectives, including existential risk, planetary science, biodiversity, future of humanity, and anthropology.

The Interstellar Research Group (IRG) 8th Interstellar Symposium

IRG's 8th Interstellar Symposium, in collaboration with the International Academy of Astronautics and Breakthrough Initiatives, will take place July 10 – 13, 2023 (with pre-symposium seminars taking place) in Montreal, QC, Canada at McGill University. This symposium will feature many of the leading voices in space exploration, culture, and more.

Towards Other Earths III: The Planet-Star connection, 17-21 July 2023, Porto, Portugal

Planetary systems result from the synergy between the stars and the planets they host. It can be convenient, at first, to consider them in isolation, but the links between them affect all aspects of exoplanetary sciences. Stars can be a hurdle to exoplanetary sciences. The precision and accuracy of our knowledge of stellar parameters is often a major driver for the precision and accuracy of the respective planetary parameters. Stellar activity and its impact on planet detection and characterisation is one of the significant challenges for the next decade. But stars can also be facilitators to exoplanetary sciences. The correlation between stellar metallicity and the frequency of giant planets is well established and the link between stellar and planetary composition is an active topic. In the next few years we also have a lot to learn from the dynamical interactions between stars and planets.

2023 July 24-28 Sagan Summer Hybrid Workshop
Characterising Exoplanet Atmospheres: The Next Twenty Years

Observations of an exoplanet's atmosphere provide the best hope for distinguishing the makeup of its outer layers, and the only hope for understanding the interplay between formation, natal composition, chemical and disequilibrium processes, and dynamics & circulation. The field is entering a revolution in our understanding of exoplanet atmospheres thanks to measurements from the ground, from space, and particularly from the new JWST – the superlative facility for exoplanet studies. In the longer term, such observations will also be essential for seeking signs of biosignature gasses in nearby exoplanets using future, next-generation observatories.

This year's workshop will cover theoretical modelling, interpretation, and observations of exoplanets using a variety of telescopes, techniques, and hands-on exercises, presented by leading experts in the field.

07-13 November 2022 Forming and Exploring Habitable Worlds

Forming and Exploring Habitable Worlds was a multi-discipline four to five day international meeting which took place in Edinburgh, UK.

Publications

Paper - A Catalogue of Habitable Zone Exoplanets

The search for habitable planets has revealed many planets that can vary greatly from an Earth analogue environment. These include highly eccentric orbits, giant planets, different bulk densities, relatively active stars, and evolved stars. This work catalogues all planets found to reside in the HZ and provides HZ boundaries, orbit characterization, and the potential for spectroscopic follow-up observations.

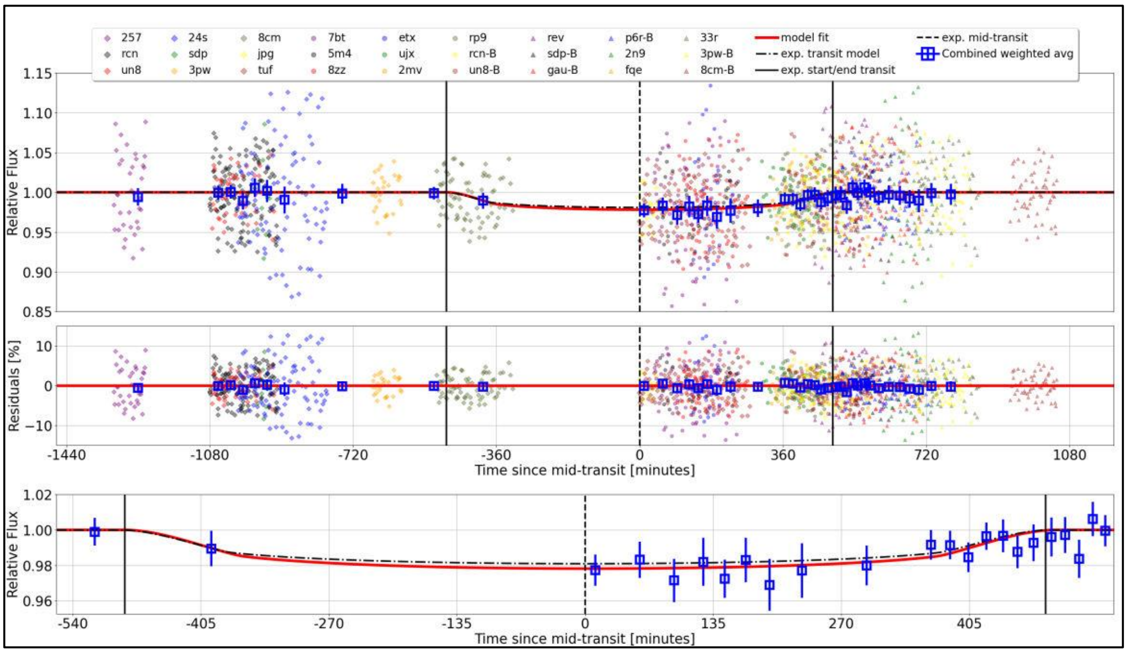
Paper - Large Interferometer For Exoplanets (LIFE): VIII. Where is the phosphine? Observing exoplanetary PH3 with a space based MIR nulling interferometer

Phosphine could be a key molecule in the understanding of exotic chemistry happening in (exo)planetary atmospheres. While it has been detected in the Solar System's giant planets, it has not been observed in exoplanets yet. In the exoplanetary context however it has been theorized as a potential biosignature molecule. The goal of our study is to identify which illustrative science cases for PH3 chemistry are observable with a space-based mid-infrared nulling interferometric observatory like the LIFE (Large Interferometer For Exoplanets) concept. We identified a representative set of scenarios for PH3 detections in exoplanetary atmospheres varying over the whole dynamic range of the LIFE mission.

Note; Ariel is mentioned in the paper as one of 'the first milestones on our roadmap'

Paper - A 16 Hour Transit of Kepler-167 e Observed by the Ground-based Unistellar Telescope Network

More than 5,000 exoplanets have been confirmed and among them almost 4,000 were discovered by the transit method. However, few transiting exoplanets have an orbital period greater than 100 days. Here we report a transit detection of Kepler-167 e, a "Jupiter analog" exoplanet orbiting a K4 star with a period of 1,071 days, using the Unistellar ground-based telescope network. From 2021 November 18 to 20, citizen astronomers located in nine different countries gathered 43 observations, covering the 16 hour long transit. Using a nested sampling approach to combine and fit the observations, we detected the mid-transit time to be UTC 2021 November 19 17:20:51 with a 1σ uncertainty of 9.8 minutes, making it the longest-period planet to ever have its transit detected from the ground. This is the fourth transit detection of Kepler-167 e, but the first made from the ground. This timing measurement refines the orbit and keeps the ephemeris up to date without requiring space telescopes. Observations like this demonstrate the capabilities of coordinated networks of small telescopes to identify and characterize planets with long orbital periods.



Transit light curve of Kepler-167 e. Credit Amaury Perrocheau

Paper - Chasing Nomadic Worlds: A New Class of Deep Space Missions

Nomadic worlds are objects not bound to any star(s). They have garnered attention recently on account of their detection in microlensing surveys and also from the recent discovery of interstellar planetesimals. Our results suggest that tens to hundreds of planet-sized nomadic worlds may populate the spherical volume centred on Earth and circumscribed by Proxima Centauri, and thus may comprise closer interstellar targets than any stellar planetary system. For the first time, we systematically analyse the feasibility of exploring these unbounded celestial bodies via deep space missions.

Astrobiology

Looking for Life? Try Around K Dwarfs

Signs of life in planetary atmospheres are hard to spot! A new study suggests that the best strategy for discovering them may be to look at planets orbiting K-dwarf stars.

The Chemistry of Enceladus' Plumes: Life or Not?

Saturn's moon Enceladus appears to have a global sub-surface water ocean that, based on all observations made thus far, could be habitable to Earth-like life. One such observation is of co-occurring H2 and CO2 in the plumes of ice and gas that vent to space from the south polar region, and are thought to originate in the underlying ocean. On Earth, microorganisms called methanogens can use H2 and CO2 as a source of energy, combining them in a metabolism that generates methane. So their combined presence on Enceladus represents chemical energy that could be used by life in that world's ocean. But could the presence of these gases mean that nobody's home on Enceladus? If life was present in the ocean and using these compounds for energy, would we see them being vented to space at all? Why would there be food left on the table if there's anything there to eat it? Dr. Tori Hoehler, an astrobiologist from NASA Ames Research Center, addresses these questions in a new paper published last month in Nature Astronomy.

Detecting Earth-like Planets with an Alternative Biosignature

NASA-supported researchers have found that the gas methyl bromide (CH3Br) might be useful as a biosignature if it is detected in the atmosphere of Earth-sized planets around M Dwarf stars (also called red dwarf or M-type stars). The Astrophysical Journal article

Launch of UK SETI Post-Detection Hub

The SETI Post-Detection Hub, an initiative of the UK SETI Research Network (UKSRN), and is jointly hosted by the St Andrews Centre for Exoplanet Science and the Centre for Global Law and Governance, was launched in September 2022. The UK SETI Research Network (UKSRN) is a group of UK academics who are active in the field of the Search for Extra-terrestrial Intelligence - SETI. Set up in 2013 with Lord Martin Rees (Astronomer Royal) as patron, its purpose is to provide a forum for discussion, collaboration and promoting academic SETI activity in the UK...and beyond.

Heidelberg Initiative for the Origins of Life – HIFOL

The Heidelberg Initiative for the Origins of Life (HIFOL) seeks to understands one of the most fundamental questions for humanity: how did life emerge on Earth and whether life exists elsewhere in the Universe. HIFOL facilitates a wide range of interdisciplinary theoretical, experimental, and observational research covering the fields of astronomy, physics, geosciences, chemistry, biology and life sciences from a range of research institutes based in Heidelberg. HIFOL brings together researchers from the Max Planck Institute for Astronomy, the Max Planck Institute for Nuclear Physics, the University of Heidelberg,

Heidelberg Institute of Theoretical Studies, and Kirchhoff Institute for Physics, each tackling different aspects of the same problem.

Web sites of interest

Catalogue of Circumstellar Disks

As its name suggests, a catalogue of such objects. Orion 294-606 was imaged by the JWST. That object is also listed in the catalogue here

A circumstellar disc (or circumstellar disk) is a torus, pancake or ring-shaped accretion disk of matter composed of gas, dust, planetesimals, asteroids, or collision fragments in orbit around a star. Around the youngest stars, they are the reservoirs of material out of which planets may form. Around mature stars, they indicate that planetesimal formation has taken place, and around white dwarfs, they indicate that planetary material survived the whole of stellar evolution.

Space missions

PLATO

Update from below mtg

The Ground Observation Program is beginning to take shape and amateur astronomers will be able to participate.

Mauve – Blue Skies Space's new satellite.

Stars, including our own Sun, can release huge amounts of energy during outbursts called flares. The most intense ones pose a danger to modern society through disruption to electricity grids, satellite systems and the Earth's climate. Blue Skies Space's new satellite Mauve is designed to monitor the flaring activity of stars that are hosts to potentially habitable exoplanets. Mauve data will help scientists understand the impact of powerful stellar flares on exoplanet atmospheres and the potential of harbouring life. Construction will commence in November 2022.

Space – stepping stones to other star systems

The Moon

Artemis 1 launched and returned to Earth

At 07:47 CET (06:47 GMT, 01:47 local time), the Artemis I mission started its voyage to the Moon as NASA's new Moon rocket lifted off from the Kennedy Space Center in Florida, USA, and put the Orion spacecraft and its European Service Module into Earth orbit. The capsule splashed down in the Pacific Ocean on 2022 December 11.

Mars

How to build for human life on Mars by Melodie Yasher (TED talk)

11 minute video thanks to Steve Knight, Hampshire Astronomical Group. Using autonomous 3D printers to build habitats.

Wishing you all a Happy New Year

Roger Dymock
ARPS Assistant Director Exoplanets