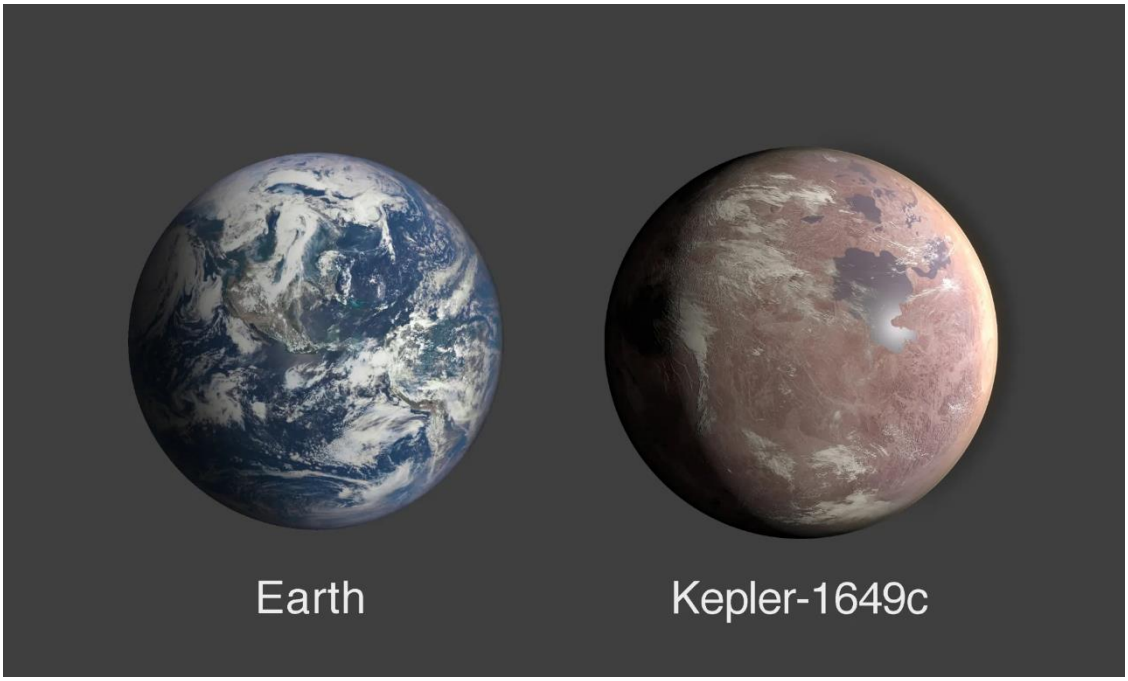
British Astronomical Association
Supporting amateur astronomers since 1890

Infinite Worlds



From a distance, the world looks blue and green and the snow-capped mountains white → 🌀

Who knows what tomorrow brings? → 🌀

Happy New Year to one and all on whichever planet you call home

The e-magazine of the

Exoplanets Division of the Asteroids and Remote Planets Section

Issue 25 2025 January

Contents

Section officers

ARPS Section Director	Dr Richard Miles
Assistant Director (Exoplanets)	Roger Dymock
Assistant Director (Occultations)	Tim Haymes
Assistant Director (Photometry)	Wayne Hawley

Exoplanet Technical Advisory Group (ETAG)

Simon Downs, Steve Futcher, Paul Leyland, David Pulley, Mark Salisbury, Americo Watkins

Exoplanets Division website

Collaboration with the AAVSO Exoplanet Section

This all began when I received an email from Jeremy Shears indicating Dennis Conti, Chair of the AAVSO Exoplanet Section would like a link up with the BAA Exoplanet Division. I then emailed Dennis Conti and received a very encouraging reply. I also discussed this with ARPS Director Richard Miles and we agreed that Cooperating on a specific project or projects would seem to be a good starting point.

An initial plan will be circulated to members shortly (may be even before you read this) and your comments are invited.

Variations on an Exoplanet Theme – Part 2

If at first you don't succeed… We are planning to run this postponed meeting on Saturday 2025 February 22. Fingers crossed.

Provisional agenda

10:30 – 11:00 Introduction to morning session and TTVs - Roger Dymock

11:00 – 12:00 Analysis of TTVs using Exoplanetpie – Peter Vuylsteke

12:00 - 12:30 Exoplanets orbiting non-eclipsing binaries, simulator demo - Paul Dooley

12:30 - 13:30 Lunch break

13:30 - 13:50 Introduction to afternoon session – Rodney Buckland

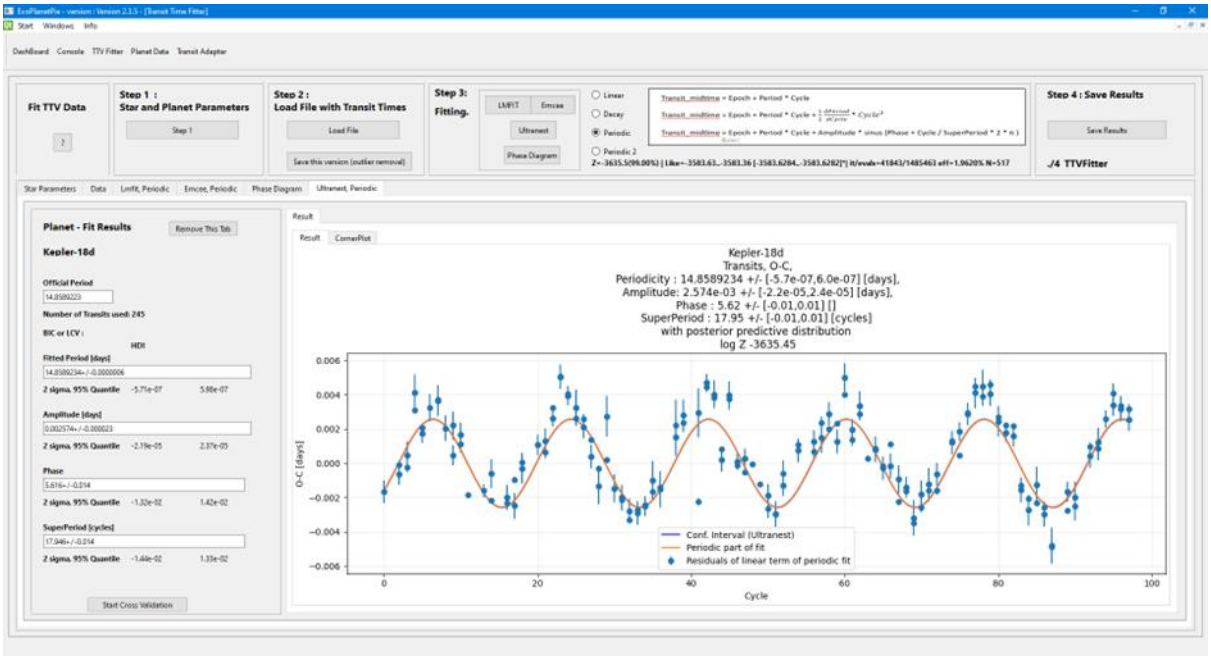
13:50 - 14:20 Stellar variability and the PLATO mission - Karen Burgess

14:20 – 14:30 Break

14:30 – 15:00 Reducing effects of stellar variability using Lombe-Scargle techniques – Daniel Barbos

15:00 – 15:30 The Kepler 88 exoplanetary system – Roger Dymock

15:30 – 16:00 Q and A and close of mtg - Rodney Buckland and Roger Dymock



Exoplanetpie plot showing Transit Timing Variations in the orbital period of Kepler-18d

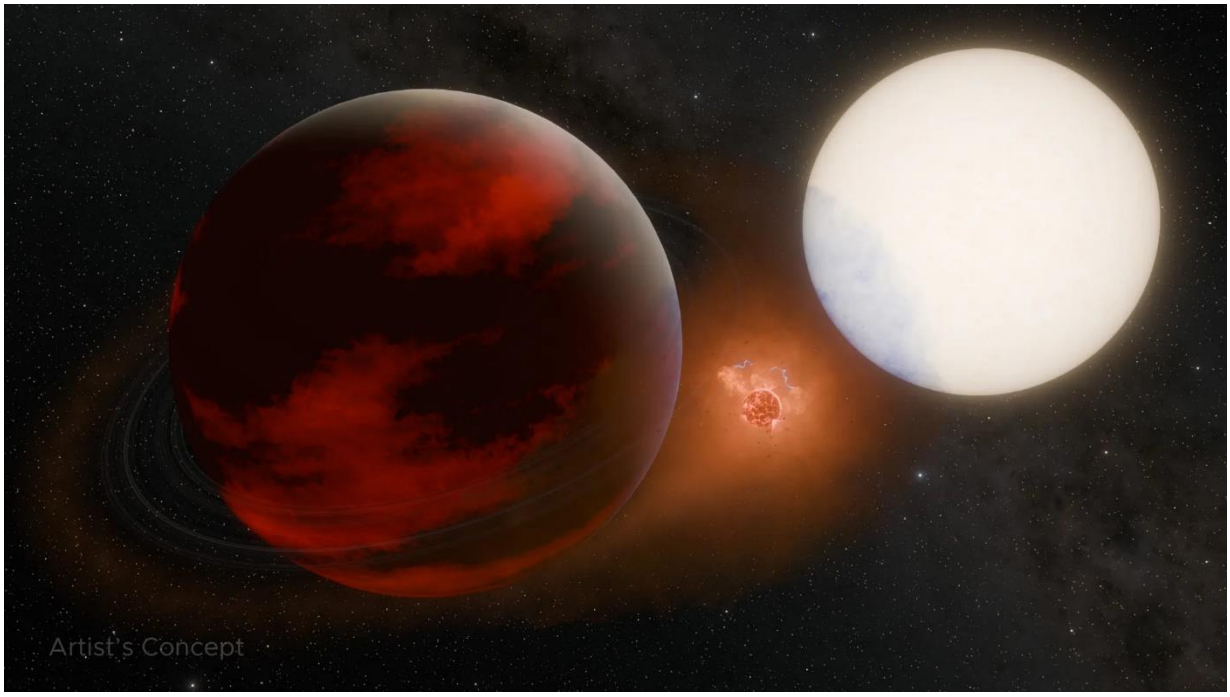
News

Today's score (2024 January 3) from the NASA Exoplanet Archive, Exoplanet and Candidate Statistics

Total confirmed exoplanets;	5811
TESS Confirmed Planets;	591
TESS Project Candidates;	7358

.Does Distant Planet Host Volcanic Moon Like Jupiter's Io?

The existence of a moon located outside our solar system has never been confirmed but a new NASA-led study may provide indirect evidence for one. New research done at NASA's Jet Propulsion Laboratory reveals potential signs of a rocky, volcanic moon orbiting an exoplanet 635 light-years from Earth. The biggest clue is a sodium cloud that the findings suggest is close to but slightly out of sync with the exoplanet, a Saturn-size gas giant named WASP-49 b, although additional research is needed to confirm the cloud's behaviour. Within our solar system, gas emissions from Jupiter's volcanic moon Io create a similar phenomenon.



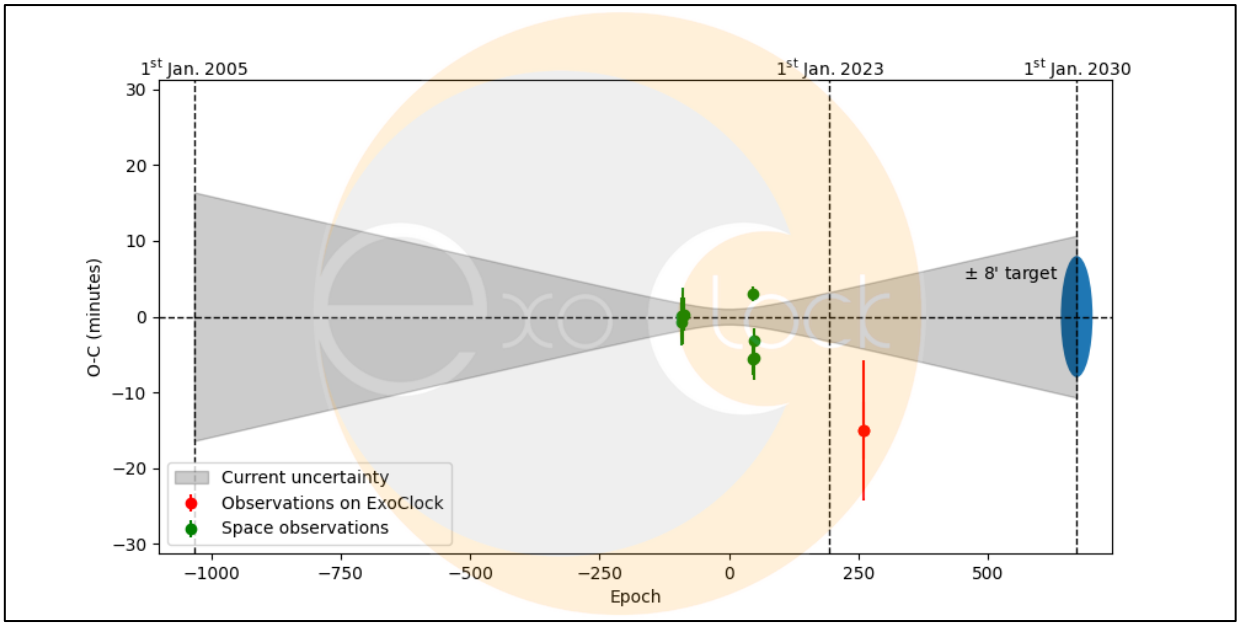
This artist's concept depicts a potential volcanic moon between the exoplanet WASP-49 b, left, and its parent star. Credit NASA

Exoplanet LTT 1445Ab

LTT 1445 is a triple M-dwarf system 22.4 light-years (6.9 parsecs) distant in the constellation Eridanus. The primary LTT 1445 A hosts two exoplanets, Ab and Ac, one discovered in 2019 that transits the star every 5.36 days, and another found in 2021 that transits the star every 3.12 days, close to a 12:7 resonance.

LTT 1445Ac was discovered by ESPRESSO, Echelle Spectrograph for Rocky Exoplanet and Stable Spectroscopic Observations, operating at the Very Large Telescope (VLT) in Chile which also discovered a 3rd non-transiting planet in the system – LTT 1445 Ad. Paper here.

As can be seen in the diagram below from the ExoClock database Ab's transit time is varying considerably.



NASA Exoplanet Archive link here describing the stars and planets in the system

Twinkle is an upcoming space-based telescope with a 0.45 m primary aperture and a broad visible to infrared wavelength coverage (0.5 – 4.5 μm). The Twinkle space mission will conduct two simultaneous surveys during its first three years of operation, which is scheduled to begin in 2025. While one of these will focus on studying objects within our own solar system, the other will be dedicated to the study of extrasolar targets. A large portion of the latter survey will be used to study exoplanet atmospheres. This paper explores the prospects for Twinkle to determine the atmospheric composition of the nearby terrestrial-like planet LTT 1445 Ab, including the possibility of detecting the potential biosignature ammonia (NH3).

Meetings

Know thy star, know thy planet 2 conference, 2025 February 3-7, Caltech Campus, Pasadena, California, USA

n 2017, the "Know Thy Star, Know Thy Planet" conference held in Pasadena, CA focused on understanding how stars affected our ability to discover and do initial characterization of exoplanets. Over the past seven years since that conference, the limits of exoplanet discovery and the field of exoplanet characterization have changed dramatically, with great strides made in the community to understand and account for, at any even more precise and complex levels, the characteristics and effects of the stellar hosts. Know Thy Star 2 focuses on the effects that stars have in

limiting our ability to determine planetary masses, orbits, bulk compositions, and atmospheric abundances - and the state-of-the-art knowledge and techniques that have been developed to mitigate the stellar effects. By Knowing thy Star, we can better Know Thy Planet!

Exoclimes VII Montreal (Canada) from July 7 to 11, 2025.

Exoclimes VII conference will be organized by the Trottier Institute for Research in Exoplanets (https://exoplanetes.umontreal.ca/en/) and held in Montreal (Canada) from July 7 to 11, 2025. To maintain the collaborative spirit of Exoclimes, the number of participants will be limited to 200 Exoclimes is a conference series devoted to the atmosphere, climate, and evolution of sub-stellar bodies from solar system worlds to exoplanets and brown dwarfs.

Detection and Dynamics of Exoplanets (DDE): Interplay between theory and observations University of Coimbra, Portugal, 7 to 11 July 2025

Detecting and characterizing planets in multiple systems is not an easy task, because the traces of each body overlap, and the observations can be reproduced by different orbital configurations. Additionally, in many systems, planets are involved in mean motion resonances or resonant chains, making it even more difficult to disentangle the individual contributions. In the DDE meeting, we aim to bring together communities of observers and theoreticians working on exoplanets. Through the exchange of knowledge and difficulties, we hope that it will be possible to develop common strategies to extract the maximum constraints from observational data and theoretical models.

Astrobiology and the search for life elsewhere

Mars may have been habitable much more recently than thought

Evidence suggests Mars could very well have been teeming with life billions of years ago. Now cold, dry, and stripped of what was once a potentially protective magnetic field, the Red Planet is a kind of forensic scene for scientists investigating whether Mars was indeed once habitable and, if so, when. The “when” question in particular has driven researchers in Harvard’s Paleomagnetics Lab in the Department of Earth and Planetary Sciences. A new paper in Nature Communications makes their most compelling case to date that Mars’ life-enabling magnetic field could have survived until about 3.9 billion years ago.

Publications

Books

‘Life as no one knows it’ by Sara Imari Walker, published by The Bridge Street Press.

What is life? This is among the most difficult open problems in science, right up there with the nature of consciousness and the existence of matter. All the definitions we have fall short. Physicist and astrobiologist Sara Imari Walker argues that solving the origin of life requires radical new thinking and an experimentally testable theory for what life is. She proposes a new paradigm for understanding what physics encompasses and what we recognize as life, inviting us into a world of maverick scientists working without a map, seeking not just answers but better ways to formulate the biggest questions we have about the universe. Rigorous, accessible, and vital, Life As No-One Knows It celebrates the mystery of life and the explanatory power of physics.

Alien Earths, Planet Hunting in the Cosmos, by Lisa Kaltenegger, published by Allen Lane.

For thousands of years, humans have wondered whether we're alone in the cosmos.

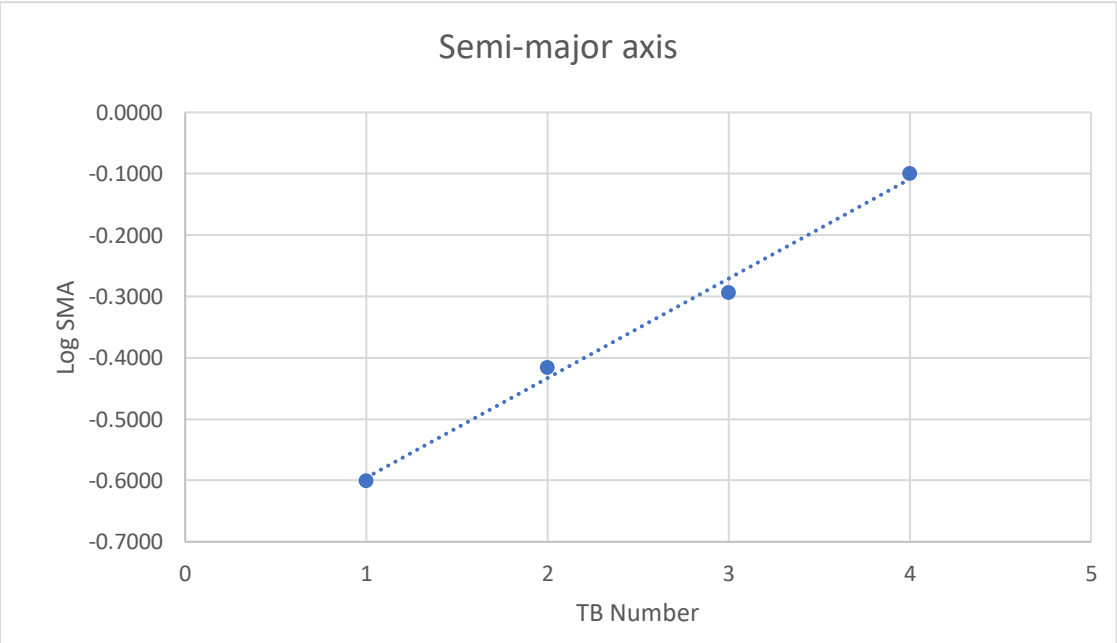
The question should have an obvious answer: yes or no. But once you try to find life elsewhere, you realize it is not so simple. How do you find it over cosmic distances? What actually is life? Astronomer Lisa Kaltenegger works from Carl Sagan’s former office at Cornell University, where she built a team of tenacious scientists from many disciplines to find life on faraway worlds, using Earth’s diverse biosphere and its history as a Rosetta Stone. With infectious enthusiasm, she provides an eye-opening insider’s guide to the most unusual exoplanets that have shaken our worldview – planets covered in oceans of lava, lonely wanderers lost in space, and others with more than one sun in their sky – as well as the best contenders for Alien Earths. She also shows how close imagined sci-fi worlds come to reality.

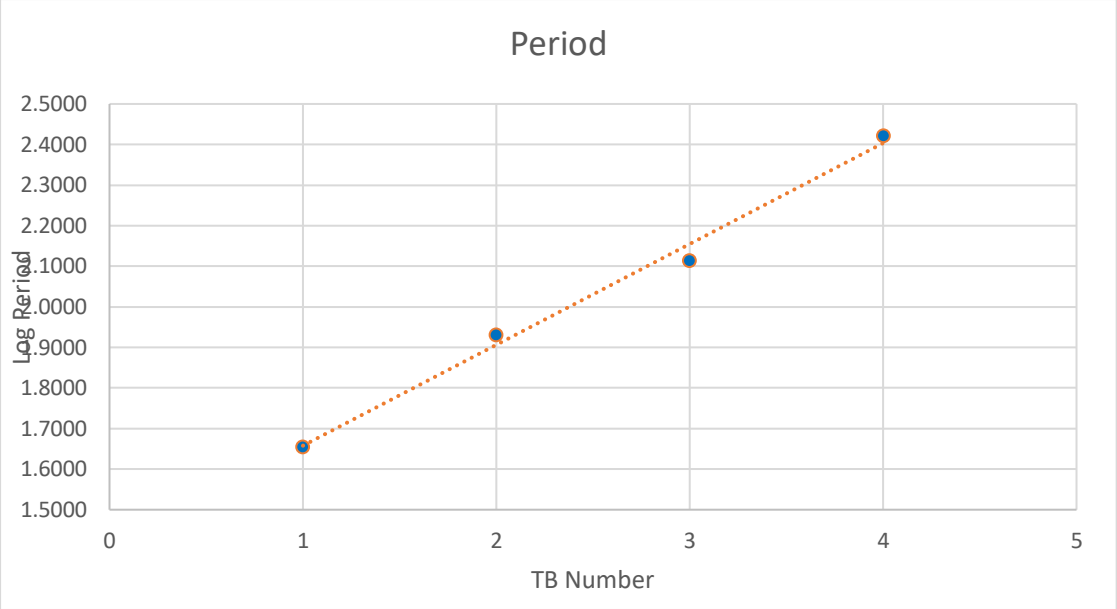
Papers

A Fourth Planet in the Kepler-51 System Revealed by Transit Timing Variations

Kepler-51 is a ≲ 1 Gyr-old Sun-like star hosting three transiting planets with radii ≈ 6–9 R⊕ and orbital periods ≈ 45–130 days. Transit timing variations (TTVs) measured with past Kepler and Hubble Space Telescope (HST) observations have been successfully modelled by considering gravitational interactions between the three transiting planets, yielding low masses and low mean densities (≲ 0.1 g/cm3for all three planets. However, the transit time of the outermost transiting planet Kepler-51d recently measured by the James Webb Space Telescope (JWST) 10 years after the Kepler observations is significantly discrepant from the prediction made by the three-planet TTV model, which we confirmed with ground-based and follow-up HST observations. We show that the departure from the three-planet model is explained by including a fourth outer planet, Kepler-51e, in the TTV model.

A version of the Titius-Bode law plots logs of the semi-major axis and period against the Titius-Bode number (numerical sequence of planets starting with the one that is nearest to its host star. My calculations for the Kepler-51 system and the resulting plots are shown below. It can be seen that the planets lie close to a straight line as the law predicts supporting the findings in the above-mentioned paper.





Some are sceptical of this method but it appears to work for many multi-planet systems including our own Solar System

Exocomets, exoasteroids and exomoons

Comets, asteroids and moons that orbit stars and planets exterior to our solar system are prefixed with ”exo”. While the existence of these objects is certain, our understanding of their physical properties, composition, and diversity is still in its infancy, especially when compared to similar objects within our own solar system. This chapter introduces the topics of exocomets, exoasteroids, and exomoons, putting in context three emerging subfields in astronomy that, despite being relatively small, have experienced rapid growth over the past decade.

The Search for the Inbetweeners: How packed are TESS planetary systems?

This work examines seven systems discovered by TESS, to see whether there is any room in those systems for an additional planet (or several) to lurk unseen between the two planets already confirmed therein. In five of those systems (namely HD 15337; HD 21749; HD 63433; HD 73583 and LTT 3780) there is ample room for an undiscovered planet to move between those that have already been discovered. In other words, as they currently stand, those systems are not tightly packed. In stark contrast, the perturbative influence of the two known TOI-1670 planets is such that additional planets in between are ruled out. The final system, TOI 421, is more challenging. In the vast majority of cases, adding an Earth-mass planet to that system between the orbits of the known planets caused catastrophic instability. Just

~1.1% of our simulations of the modified system proved dynamically stable on a timescale of one million years. As a result, it seems that there is very little room between the two known planets in the TOI 421 system for an addition unseen world to exist, but the existence of such a planet cannot be definitely ruled out on dynamical grounds alone.

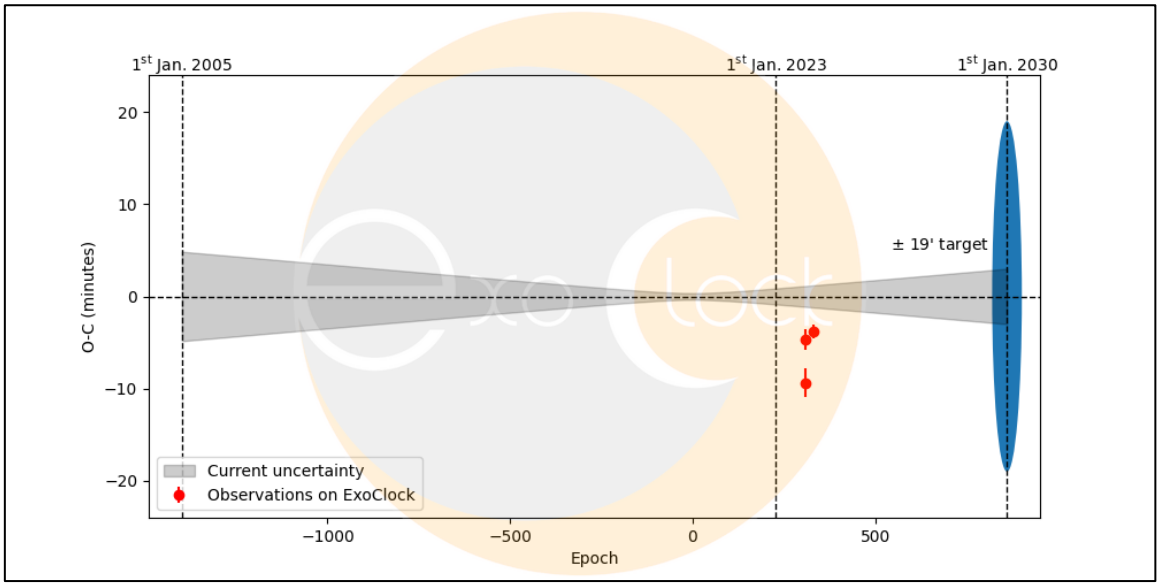
Our Solar System Neighbourhood: Three Diverging Tales of Planetary Habitability and Windows to Earth's Past and Future

Understanding planetary habitability is one of the major challenges of the current scientific era, particularly given the discovery of a large and diverse terrestrial exoplanet population. Discerning the primary factors that contribute to planetary habitability may be extracted through a detailed examination of the terrestrial planets within the Solar System, most particularly Venus, Earth, and Mars, and the evolution of their interiors and atmospheres through time. This paper provides a detailed description of the fundamental properties of these three planets, the effects of solar evolution, and the potential contributions of these various aspects toward driving their evolutionary pathways.

A Planet Candidate Orbiting near the Hot Jupiter TOI-2818 b Inferred through Transit Timing

TOI-2818 b is a hot Jupiter orbiting a slightly evolved G-type star on a 4.04-day orbit that shows transit timing variations (TTVs) suggestive of a decreasing orbital period. In the most recent year of TESS observations, transits were observed ~8 minutes earlier than expected for a constant period. The implied orbital decay rate is 1.35 ± 0.25 s yr−1, too fast to be explained by tidal dissipation even considering the evolved nature of the host star. Radial velocity monitoring rules out the possibility that the apparent change in period is due to a steady acceleration of the star by a long-period companion. Apsidal precession due to the tidal distortion of the planet is also physically implausible. The most plausible explanation for the TTVs appears to be gravitational perturbations from a hitherto undetected planet with mass $\lesssim$10 M$\oplus$ that is in (or near) a mean-motion resonance with the hot Jupiter. Such a planet could be responsible for the observed TTVs while avoiding detection with the available radial velocity and transit data.

ExoClock data, diagram below, supports the variation in TTVs mentioned above. Indicated transits are between 3 and 10 minutes earlier than predicted.



The Exoplanet Edge: Planets Don't Induce Observable TTVs Faster than Half their Orbital Period

Transit timing variations (TTVs) are observed for exoplanets at a range of amplitudes and periods, yielding an ostensibly degenerate forest of possible explanations. This paper offers some clarity in this forest, showing that systems with a distant perturbing planet preferentially show TTVs with a dominant period equal to either the perturbing planet's period or half the perturbing planet's period.

Space missions

Database of Candidate Targets for the LIFE Mission

This paper presents the database of potential targets for the Large Interferometer For Exoplanets (LIFE), a space-based mid-infrared nulling interferometer mission proposed for the Voyage 2050 science program of the European Space Agency. The database features stars, their planets and disks, main astrophysical parameters, and ancillary observations.

Space – stepping stones to other star systems

The Moon

Artemis

The Artemis Moon missions are being delayed. Artemis II — a crewed flight around the Moon and back to Earth — has been pushed from September 2025 to April 2026 at the earliest. Artemis III — a crewed lunar landing — will not take place until 2027 at the earliest. These delays are due to hardware issues, including problems with the Orion capsule's heat shield

Mars

The first Martians

Video (10 mins) – What will the First Martians Face? – Becoming Martian. Thanks to Steve Knight for this. In the not-so-distant future, humans will venture beyond Earth to colonize Mars, but how will life on another planet change us? As we adapt to Mars' harsh environment, unexpected transformations may take place, reshaping how we live and survive in this alien world. What surprising changes lie ahead for humanity as we embark on this monumental journey?

NASA Outlines Latest Moon to Mars Plans

As NASA develops a blueprint for space exploration throughout the solar system for the benefit of humanity, the agency released several new documents Friday updating its Moon to Mars architecture. The roadmap sets NASA on course for long-term lunar exploration under the Artemis campaign in preparation for future crewed missions to Mars.

Roger Dymock
ARPS Assistant Director Exoplanets

If you have any comments, articles, etc which you would like included please let me know.