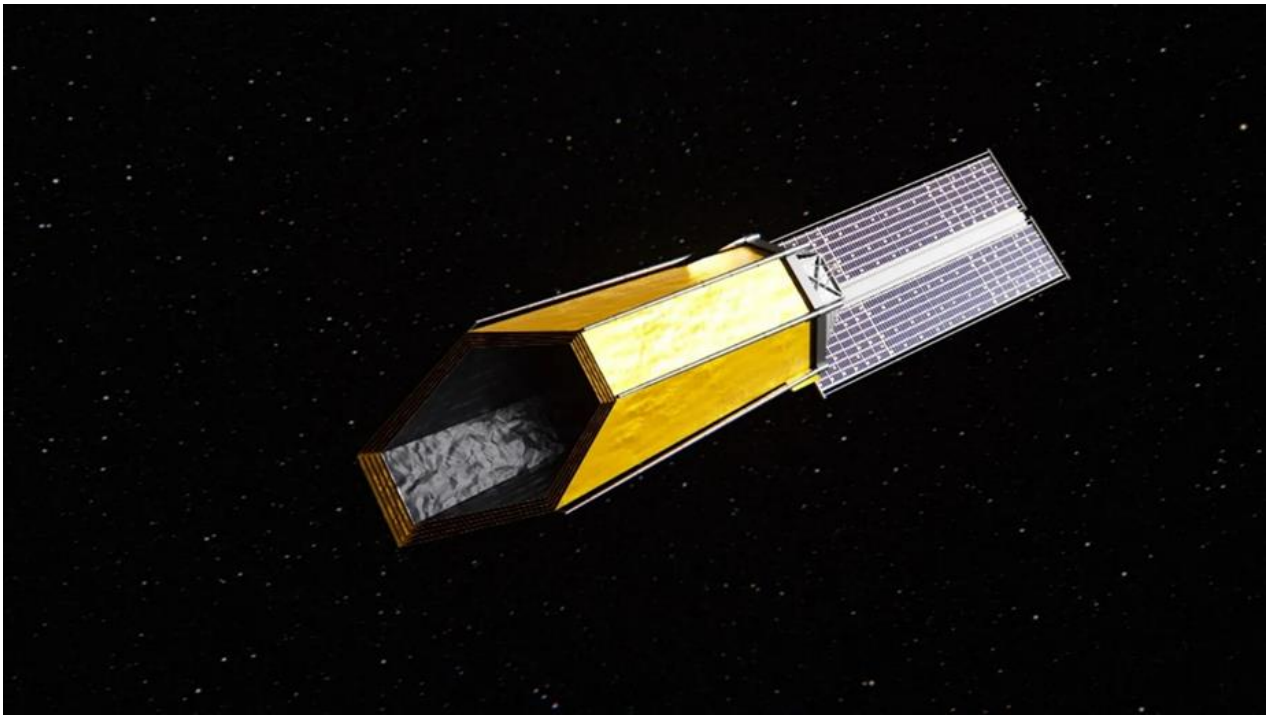
British Astronomical Association
Supporting amateur astronomers since 1890

Infinite Worlds



Artist's concept of a design option for NASA's Habitable Worlds Observatory.
Credits: NASA's Goddard Space Flight Center Conceptual Image Lab

The e-magazine of the

Exoplanets Division
of the
Asteroids and Remote Planets Section

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Contents

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Exoplanets Division website

Exoplanet observation and analysis – the way forward, 2024 **October 5th**

Provisional agenda

- Analysis of transits using HOPS. How to get the best from your observations,
  Martin Crow
- Exoplanetpie, Pieter Vulysteke

Exoplanet pie is a software package in development which allows data to be downloaded from multiple sources and transit timing variations to be analysed to detect for example; decaying orbits, cyclical changes suggesting additional planets. Etc. This will considerably advance our ability to contribute to exoplanet science. A tutorial will be a key part of the meeting mentioned below. More to come in the next issue.

- The Habitable Zone. On-line and off-line analysis, Speaker(s) to be confirmed

News

Today's score from the NASA Exoplanet Archive, Exoplanet and Candidate Statistics

Total confirmed exoplanets;	5678
Kepler candidates yet to be confirmed;	1982
K2 candidates yet to be confirmed;	976
TESS candidates yet to be confirmed;	4655

Smart telescopes

Websites e.g. First Light Optics Rother Valley Optics The Widescreen Centre Unistellar Exoplanet Transits: Missions

Exoplanet Observing with the Unistellar eVscope

Background

Over the last few years, a number of "Smart Telescopes" have been developed for amateur use.

These typically consist of a relative narrow optical train attached to an automated mount. They have software to provide plate solving, tracking and image stacking. They are easy to setup and use.

They have relatively narrow fields and due to their short focal lengths (as well as small apertures) and are best suited to imaging small deep-sky objects.

Unistellar – a French Company setup in 2016 with £2m+ Kickstarter funding – first delivered its scope commercially in 2021. Unlike their competitors they foresaw the possibility of using them for science as well as taking pretty pictures. They partnered with SETI in Mountainview California to produce a program which included exoplanet transit observations.

At 4.5” aperture the scopes are considered too small to take part in the ExoClock *program.*

Exoplanet Observation

SETI produces a list of favoured targets for study. This is based mostly on the NASA requested targets for the TESS satellite. There are about 12,000 eVscope located all around the world but principally in Europe, the USA and Japan. These were the regions where the scopes were first marketed. About 1500 of these have been registered to the “Science” program and of those my impression is about 100 have been actively used for exoplanet observation. The figures for the week commencing 5/5/24 were 48 observations by 38 observers of 13 targets.

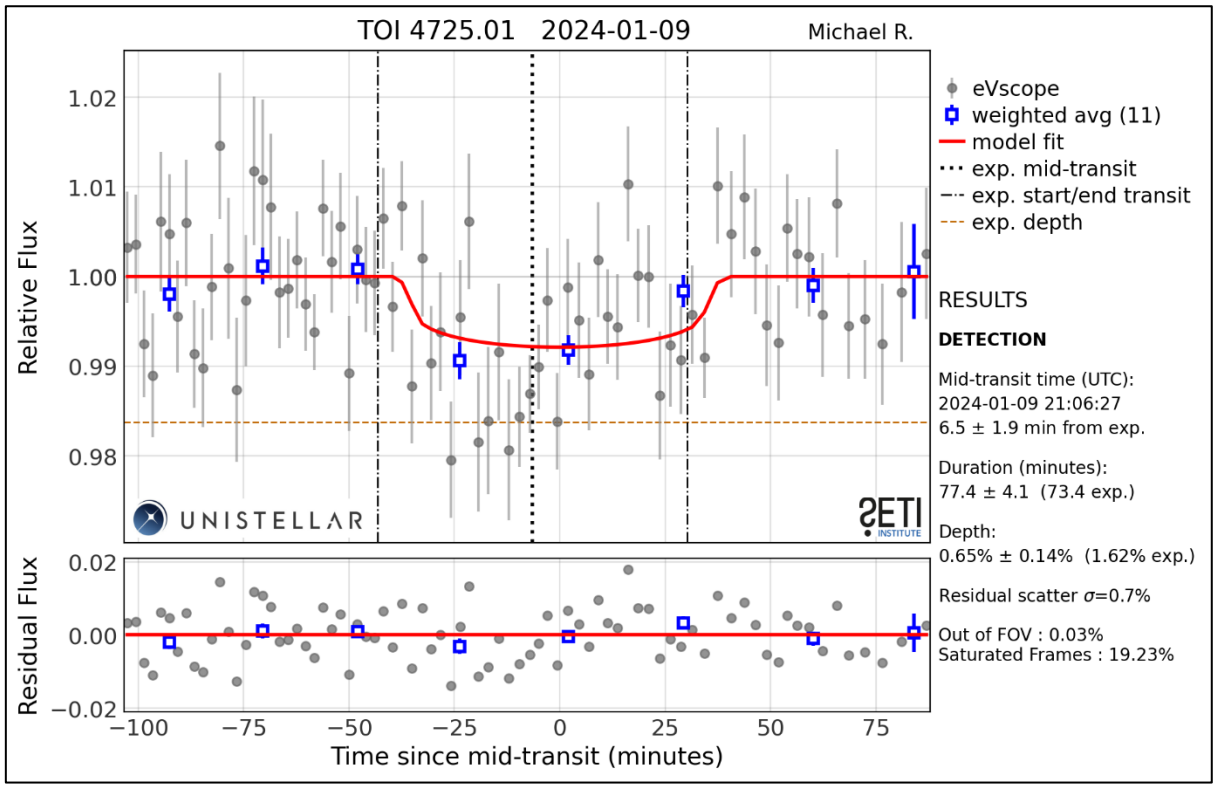
Although there are now several different models of eVscope they are all based around the same optical configuration. This is important as it makes combining data from different scopes relatively easy. SETI have set up a data reduction pipeline that takes uploaded raw frames from participating scopes and produces graphical and numerical output which is returned to participants via a Slack channel. When appropriate, the data from telescopes in different time zones can be combined to allow observations which are impossible from a single site.

This enables long transits to be observed and also long observations of poorly known timings to be tackled. Recently, the program has included candidates whose transits have only been captured 2 or 3 times. The aim is to see if there are any intermediate transits that would suggest a shorter period than originally calculated.

The latest combined observation attempt involved HIP 41378f which has a period of 542 days and transits lasting 19 hours. The ingress was timed to be first visible in S America and then egress in Western Europe. Individual observers were requested to make 2-4 hour observations during the time the star was at least 25 deg above the horizon. The plan was to have the star under continuous observation for 35 hours!

(Most people were going to see no transit!). This therefore also included observers in Japan and Australia. 26 telescopes provided data. The results are awaited.

It is possible for single observers to choose their own targets (Usually from the Swarthmore database -astro.swarthmore.edu) and then do their own analysis. Until recently that involved requesting the data from the SETI servers to which it had been sent directly by the telescope's internal software. This was slow and tedious, involving downloading about 10GB of data which had previously been sent to them. After lobbying from the users, it is now possible to download the data straight from the telescope to a local laptop.



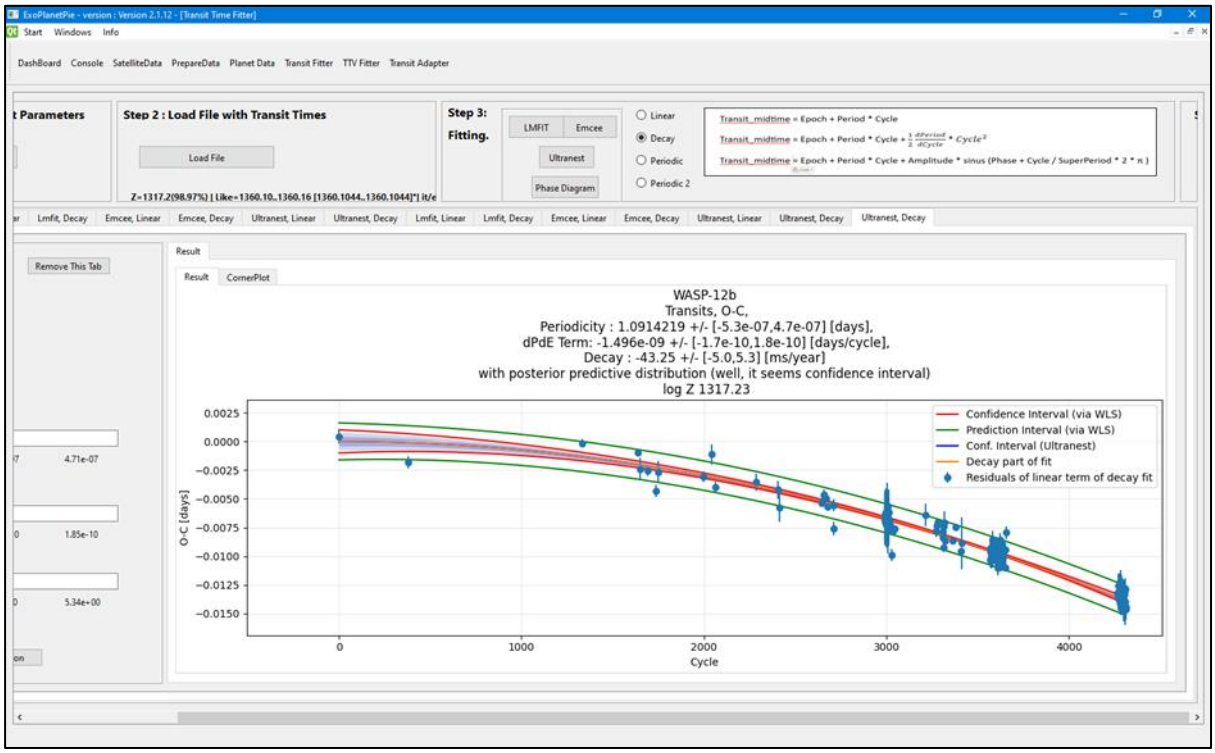
Transit of TOI 4725.01 Credit Mike Rushton

My personal impression is that these scopes will never substitute for results from 8"+ aperture scopes but their uniformity and world-wide distribution plus consistent data reduction means that they have a place in Exoplanet observation.

Mike Rushton

To decay or not to decay?

The paper Doomed Worlds I: No new evidence for orbital decay in a long-term survey of 43 ultra-hot Jupiters presents results from a long-term project to monitor ultra-hot Jupiters. Some of those planets previously thought to be doomed may live long and prosper after all. One that is doomed is WASP-12b which I examined using TESS and ExoClock data with the Exoplanetpie software mentioned above. The screen shot below clearly shows the potential demise of this planet.



Webb presents best evidence to date for rocky exoplanet atmosphere

Researchers using NASA/ESA/CSA James Webb Space Telescope may have detected an atmosphere surrounding 55 Cancri-e, a rocky exoplanet 41 light-years from Earth. This is the best evidence to date for a rocky planet atmosphere outside our solar system.

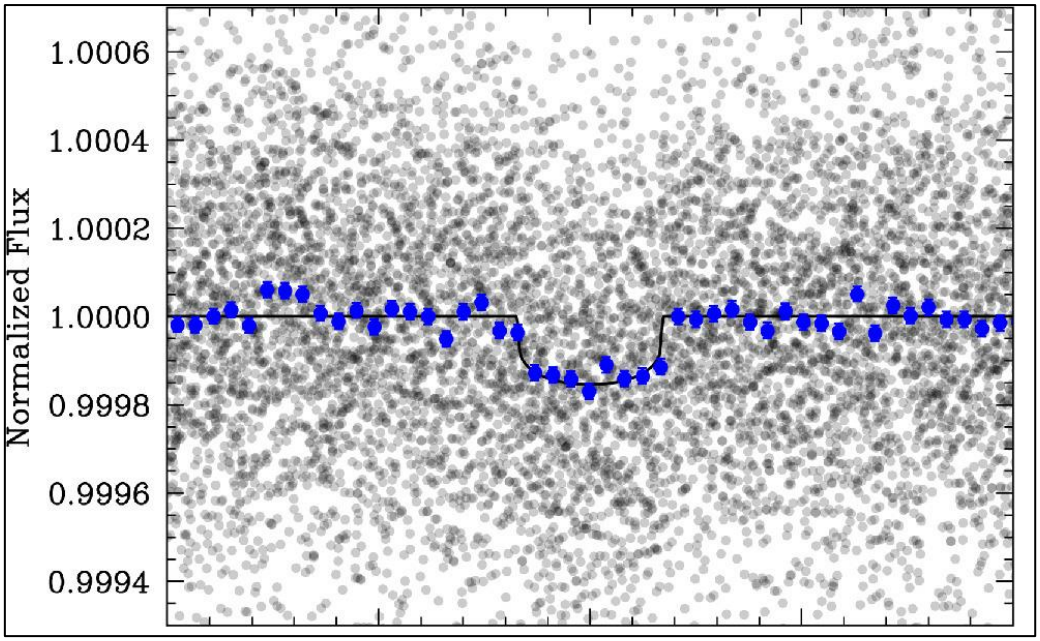
Artist's concept of 55 Cancri-e Credit NASA/ESA/CSA

A new planet candidate discovered in data from NASA's TESS mission could be an extreme lavaworld

An international team of astronomers has just found hints of an extreme exoplanet, TOI-6713.01, that — if it exists — is bursting with so many active volcanoes that its temperature rivals that of some stars. TOI-6713.01 appears to be roughly Earth-size, just 30% larger than our own planet. But it might have more in common with Jupiter's fiery moon Io.

Nasa's Innovative Advanced Concepts Program (NIAC)

This program has selected six visionary concept studies for additional funding and development. Each study has already completed the initial NIAC phase. Three of them relate to exoplanets and manned space flight (to Mars as a stepping stone to the stars? RD)



The TESS mission caught a single transit event, which could be the signal of a close-in planet in the star system HD 104067. If the detection pans out, the extreme gravitational forces experienced by this planet — both from its star and two other planets — could make it a lavaworld. Credit S. Kane et al. / Astronomical Journal

Fluidic Telescope (FLUTE): Enabling the Next Generation of Large Space Observatories

The future of space-based UV/optical/IR astronomy requires ever larger telescopes. The highest priority astrophysics targets, including Earth-like exoplanets, first generation stars, and early galaxies, are all extremely faint, which presents an ongoing challenge for current missions and is the opportunity space for next generation telescopes: larger telescopes are the primary way to address this issue.

The Great Observatory for Long Wavelengths (GO-LoW)

Humankind has never before seen the low frequency radio sky. It is hidden from ground-based telescopes by the Earth's ionosphere and challenging to access from space with traditional missions because the long wavelengths involved (meter- to kilometer-scale) require infeasibly massive telescopes to see clearly. Electromagnetic radiation at these low frequencies carries crucial information about exoplanetary and stellar magnetic fields (a key ingredient to habitability), the interstellar/intergalactic medium, and the earliest stars and galaxies.

Pulsed Plasma Rocket (PPR): Shielded, Fast Transits for Humans to Mars

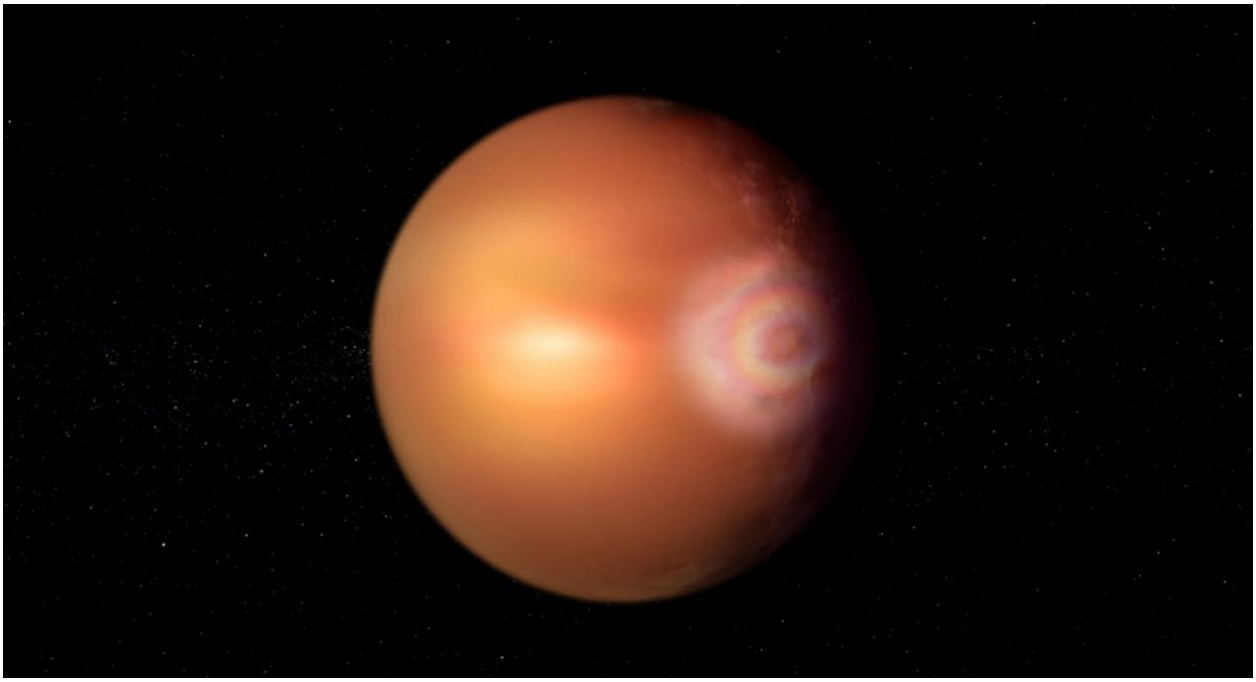
The future of a space-faring civilization will depend on the ability to move both cargo and humans efficiently and rapidly. Due to the extremely large distances that are involved in space travel, the spacecraft must reach high velocities for reasonable mission transit times. Thus, a propulsion system that produces a high thrust with a high specific impulse is essential. However, no such technologies are currently available.

Planet Hunters TESS

Planet Hunters TESS has discovered and published another planetary system. The paper, which has been published here, outlines the discovery of the, to date, brightest known planetary system that contains a transiting habitable zone planet. In our case this planet, TOI 4633c, is about 3 times the size of the Earth (we call this size of planets mini-Neptunes) and it takes the planet about 270 days to orbit around its host star. In addition to this habitable zone planet, there is an additional shorter period (non-transiting) planet on a 34 day orbit. Imaging data going back to the year 1905 shows that there is also a second star This second star orbits around the primary star (and around the two planets) on a highlight elliptical 300-year orbit. You can find out more information about this system with illustrations showing what the system might look like) here.

Artist's impression of TOI 4633c, a Neptune-like planet

Glory on WASP-76b

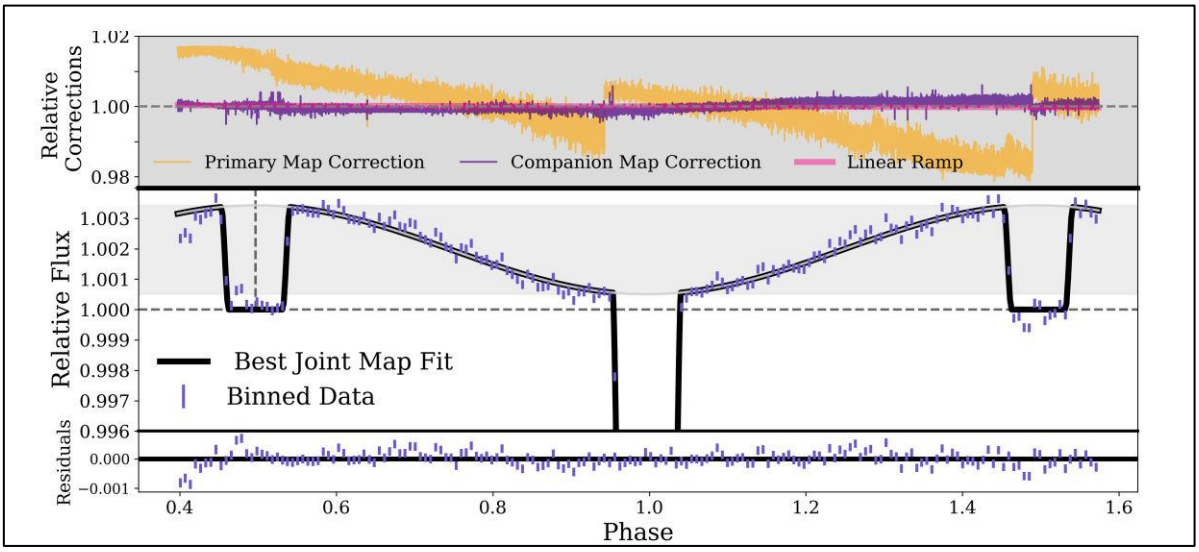


Artist impression of glory on exoplanet WASP-76b Credit ESA

For the first time, potential signs of the rainbow-like 'glory effect' have been detected on a planet outside our Solar System. Glory are colourful concentric rings of light that occur only under peculiar conditions. Data from ESA's sensitive Characterising ExOplanet Satellite, Cheops, along with several other ESA and NASA missions, suggest this delicate phenomenon is beaming

straight at Earth from the hellish atmosphere of ultra-hot gas giant WASP-76b, 637 light-years away.

A paper Spitzer phase curve observations and circulation models of the inflated ultra-hot Jupiter WASP-76b includes a phase curve (below) showing primary (centre) and secondary transits (left and right) and the expected brightening due to reflected starlight before and after the planet passes behind the star. However, note that this particular effect is not due to a glory (RD)



Meetings

2024 Sagan Summer Workshop. 2024 July 22-26, CalTech, Pasadena, California, USA

Direct imaging and spectroscopy have become a standard tool for studying the atmospheres and orbits of young, self-luminous giant planets in wide orbits. Advances in starlight suppression and spectroscopy technologies and techniques have gradually improved sensitivity to lower-mass and closer-in young planets.

This workshop will cover the scientific questions in exoplanets motivating direct imaging. Sessions will explore basic optical principles of high-contrast imaging and the fundamentals of coronagraph and wavefront sensing technologies and high-contrast instrument design. Presentations and group exercises will cover approaches to starlight/PSF subtraction and to planet and disk recovery, determination of orbits

from imaging observations, and other topics. The workshop will conclude with a look toward future facilities.

The 2024 workshop will be hybrid with both in-person and on-line attendance. The Sagan Summer Workshops are aimed at advanced undergraduates, grad students, and postdocs, however all are welcome to attend. There is no registration fee for these workshops.

COSPAR-2024-B1.2: Unveiling planet formation and how it connects small bodies, planets, circumstellar disks, and stars. 2024 July 13-21, Busan, Republic of Korea

The path of planet formation starts from the interstellar medium and leads to the great diversity of planetary bodies that we observe in the Solar System and among exoplanets. Stars and their circumstellar disks inherit their composition from the interstellar medium and set the chemical and physical stage for the birth of planetary bodies. The interactions between the different components of forming planetary systems and their surrounding environment shape the direction of planet formation. Dust grains grow within the disks and their interaction with the disk gas allows planetesimals to form. Planets are born from planetesimals and dust and their interactions with the gas shape their orbital evolution and their growth into giant planets. Interactions between the planets and the planetesimals create the interstellar objects like those that in recent years crossed our Solar System. The composition of the bodies populating the planetary systems, including the host stars, preserves a record of all these processes and their genetic link to the interstellar gas and dust from which they started.

Are We a Unique Species on a Unique Planet or are we just the ordinary Galactic standard? 2024 July 30 – August 2, Copenhagen, Denmark

Homo sapiens may be the only species in the entire Galaxy with an intelligence advanced enough to understand how it all arose and evolved. But we may also be so dumb that we just don’t understand that the universe is already teaming with life everywhere, similar or very different from ourselves. Each of the scenarios would be equally fascinating, and the sign of a road towards a meaningful answer has never been closer than it is today. We are lucky to have convinced world-leading experts to

come to Copenhagen to discuss the issue with us during four intense conference days.

Europlanet Science Congress, 2024 September 8-13, Henry Ford Building, Freie Universität Berlin, Germany

The intention of the Europlanet Science Congress 2024 is to cover a broad area of science topics related to planetary science and planetary missions.
Included as part of the “Missions, Instrumentation, Techniques, Modelling (MITM)” and “Exoplanets, Origins of Planetary Systems and Astrobiology” programmes: “Future and current instruments to detect and characterise extrasolar planets and their environment, EPSC 2024, MITM8”. Exoplanets are being discovered in large numbers thanks to recent and ongoing surveys using state-of-the-art instrumentation from the ground and from space. In the next years, new astronomical instruments will scout ever more distant regions of our Galaxy and they will validate new technology for the ultimate direct characterisation of temperate exoplanets.

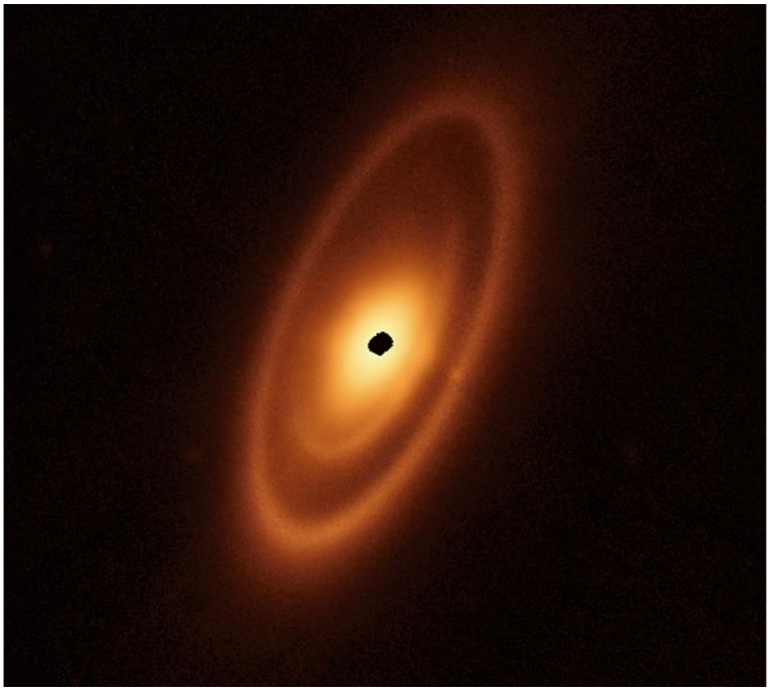
First European Interstellar Symposium 2024 December 2-5, European Convention Center, Luxembourg

The University of Luxembourg’s First European Interstellar Symposium will take place in December 2024, with the IRG’s input and guidance. The Symposium and an Interstellar Art Show will be held at the European Convention Center in Luxembourg City, Luxembourg. This symposium will feature many of the leading voices in space exploration, culture, and more. The theme for the event is Building Our Home Among the Stars

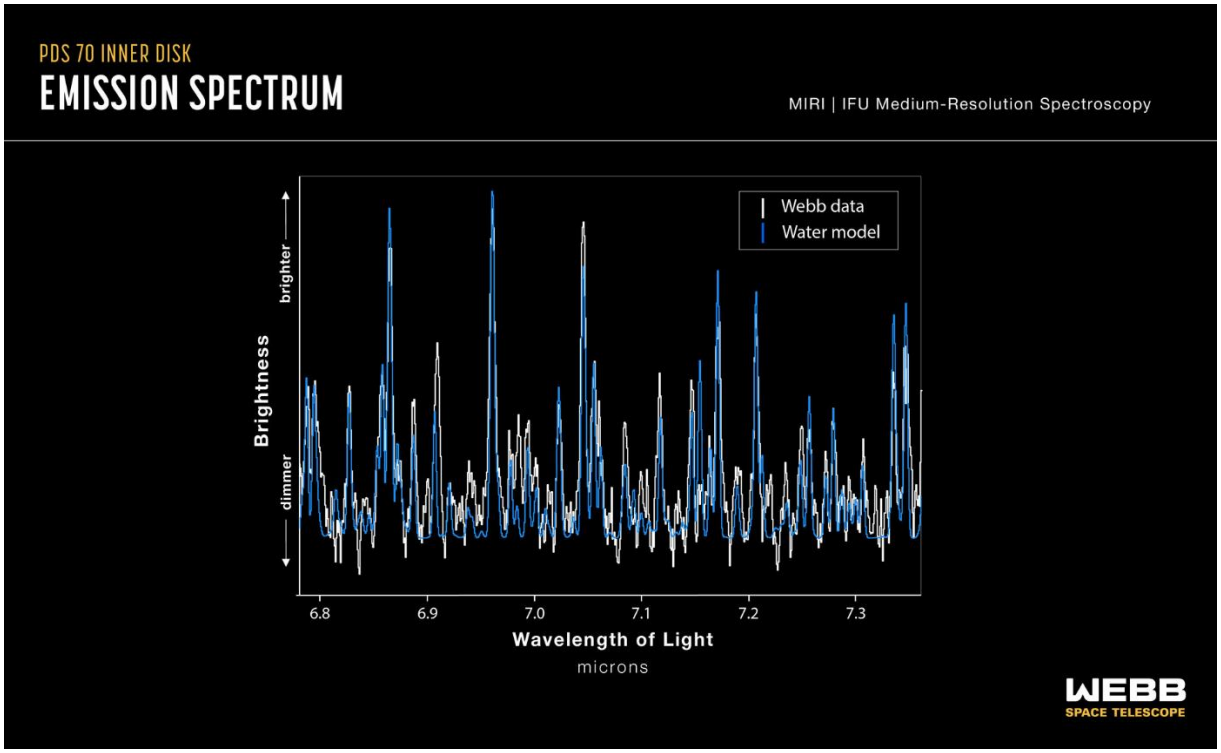
Astrobiology and the search for life elsewhere

JWST MIRI

A talk by Gillian Wright, European principal investigator for the Mid-Infrared instrument (MIRI) on the James Webb Space Telescope at this year’s BAA Winchester Weekend pointed me in the direction of some aspects of that instrument as outlined below.



This image of the dusty debris disk surrounding the young star Fomalhaut is from Webb's Mid-Infrared Instrument (MIRI). It reveals three nested belts extending out to 14 billion miles (23 billion kilometers) from the star. The inner belts – which had never been seen before – were revealed by Webb for the first time.



New measurements from the NASA/ESA/CSA James Webb Space Telescope's Mid-InfraRed Instrument (MIRI) have indicated the presence of water vapour in the inner disc of the system PDS 70, located 370 light-years away. This is the first detection of

water in the terrestrial region of a disc already known to host two or more protoplanets. This is spectrum of the protoplanetary disk of PDS 70, obtained with Webb's MIRI instrument, displays a number of emission lines from water vapour.

ETHzurich Exoplanets and Habitability Group

Mission statement. To enable the detection and characterization of terrestrial exoplanets and assess their habitability we carry out astronomical observations on state-of-the-art telescopes, contribute to the development of key technologies and instruments for world-leading facilities and design powerful data processing algorithms and statistical frameworks to interpret the data. Cycle 3 JWST observation time awarded to study some of the coolest gas giant planets beyond our solar system. The Exoplanets and Habitability Group will be involved in four projects that have been awarded with observation time in the third cycle of proposal calls using the Mid InfraRed Instrument (MIRI) onboard the James Webb Space Telescope (JWST), three of them as Principal Investigator. The projects will result in an improved understanding of the characteristics and formation of cold companions.

Project Hephaistos

The scientific search for intelligent life in outer space represents one of the most compelling quests that humanity has ever undertaken. With SETI, astronomers have scanned the skies for any hints of extraterrestrial life. Unfortunately, this has been largely unsuccessful. Alternative strategies should be considered, and that is where Project Hephaistos comes in. The project is explained in three papers. The first outlines the search for extraterrestrial supercivilizations and interesting outlier galaxies. The second discusses Dyson spheres - a hypothetical megastructure that encompasses a star and captures a large percentage of its solar power output - and dysonian technology, noting potential signs of their existence. The final paper explores how Dyson spheres could be detected by the project and explores the likelihood of success compared to SETI. All the papers and more information can be found here: https://www.astro.uu.se/~ez/hephaistos/hephaistos.html#home.

Zooniverse project – Are we alone in the universe?

The mission of UCLA SETI is to find evidence of other civilizations in the Galaxy. We conduct searches for radio technosignatures with the largest fully steerable

telescope on Earth, the 100-meter Green Bank Telescope in West Virginia. Our searches are sensitive to signals emitted thousands of light years away, enabling contact from a large fraction of the Milky Way Galaxy. We have sampled over 55,000 stars and detected over 82 million candidate signals to date, with more observations planned in the near future. The truth is out there, if you know what you're looking for...

The best places to search for life in our Solar System Kate Howells, The Planetary Society

The search for life beyond Earth has been one of the driving forces in space science since its very earliest days. As humans have learned more about the planets and moons of our Solar System, we've identified several that could have the potential to hold life. But space is vast and exploration is challenging, so humanity has to focus our search on the worlds that we think are most likely to be home to life.

Publications

Books

A traveller's guide to the stars, By Les Johnson, published by Princeton University Press

With known exoplanets now numbering in the thousands and initiatives like 100 Year Starship and Breakthrough Starshot advancing the idea of interstellar travel, the age-old dream of venturing forth into the cosmos and perhaps even colonizing distant worlds may one day become a reality. A Traveler's Guide to the Stars reveals how.

Contact with Extraterrestrial Intelligence and Human Law by Michael Bohlander, published by Brill. It is statistically unlikely that humans are the only intelligent species in the universe. Nothing about the others will be known until contact is made beyond a radio signal from space that merely tells us they existed when it was sent. That contact may occur tomorrow, in a hundred years, or never. If it does it will be a high-risk scenario for humanity. It may be peaceful or hostile. Relying on alien altruism and benign intentions is wishful thinking. We need to begin identifying as a planetary species, and develop a global consensus on how to respond in either scenario.

Papers

Enhancing Exoplanet Ephemerides by Leveraging Professional and Citizen Science Data

This paper presented an updated ephemeris, and physical parameters, for the exoplanet WASP-77 A b. 64 ground- and space-based transit observations, 6 space-based eclipse observations, and 32 radial velocity observations to produce this target's most precise orbital solution to date. A vast array of citizen science data from ExoClock, Exoplanet Transit Database (ETD) and Exoplanet Watch was included (one observation by the Assistant Director also got a mention).

A Test Case with WASP-77A b

Planet Hunters NGTS: New Planet Candidates from a Citizen Science Search of the Next Generation Transit Survey Public Data

We present the results from the first two years of the Planet Hunters Next Generation Transit Survey (NGTS) citizen science project, which searches for transiting planet candidates in data from the NGTS by enlisting the help of members of the general public. Over 8000 registered volunteers reviewed 138,198 light curves from the NGTS Public Data Releases 1 and 2.

Searching for Free-Floating Planets with TESS: I. Discovery of a First Terrestrial-Mass Candidate Describes the detection, using gravitational microlensing, by the Transiting Exoplanet Survey Satellite (TESS) of a Free-Floating-Planet – one not orbiting a host star.

An Overview of Exoplanet Biosignatures

In the last three decades, knowledge of planetary systems other than our own has increased rapidly with the discovery of over 5,000 exoplanets (Christiansen 2022). These worlds vary greatly in mass, composition, and insolation, encompassing planets ranging in size from smaller than Mercury (Barclay et al. 2013) to more than twice the radius of Jupiter (Crouzet et al. 2017). Most recently, exoplanetary science has entered a new era of planetary characterization with the launch of the James Webb Space Telescope (JWST), which has already unveiled the composition and chemical processes of exoplanet atmospheres in unprecedented detail.

Is artificial intelligence the great filter that makes advanced technical civilisations rare in the universe? By Michael A. Garrett

This study examines the hypothesis that the rapid development of Artificial Intelligence (AI), culminating in the emergence of Artificial Superintelligence (ASI), could act as a "Great Filter" that is responsible for the scarcity of advanced technological civilisations in the universe. It is proposed that such a filter emerges before these civilisations can develop a stable, multiplanetary existence, suggesting the typical longevity (L) of a technical civilization is less than 200 years.

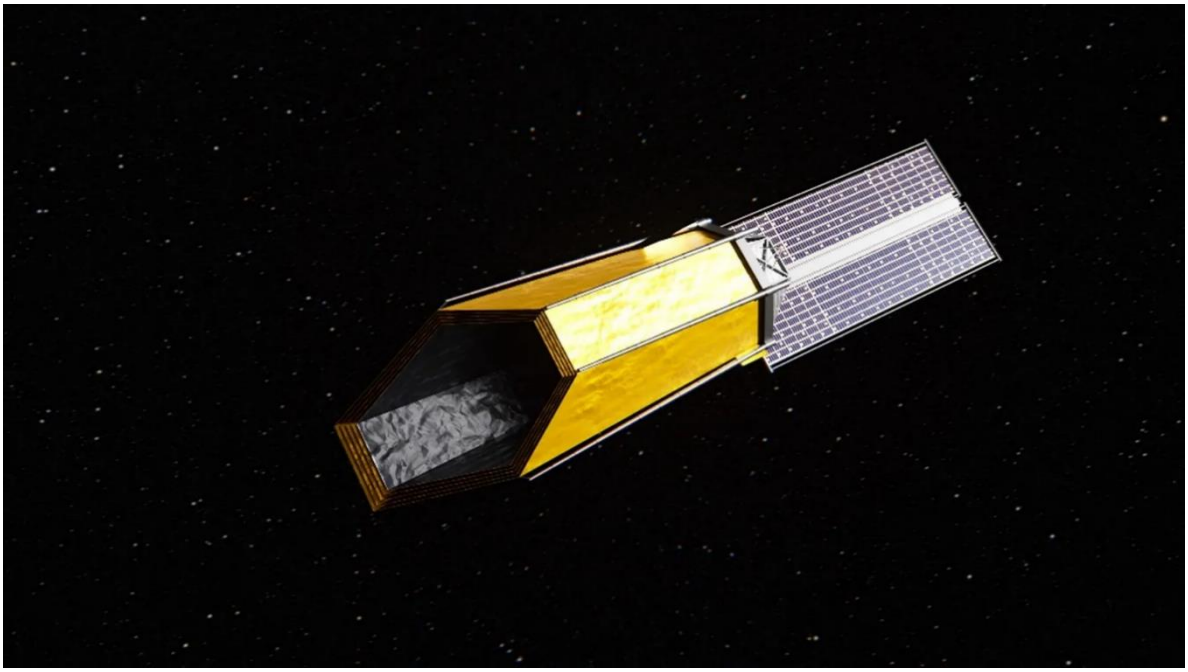
Strategies for Interstellar Exploration

On 16 April 2024, Elsevier's journal Advances in Space Research published an article by Johannes Lebert, Andreas M. Hein, and Martin Dziura titled "Optimal strategies for the exploration of nearby stars." This article presents optimal strategies for the exploration of a large number of nearby stars. After extensively discussing and defining variables and parameters, the paper uses computer simulations to determine the optimal route. The full paper can be found here: https://www.sciencedirect.com/science/article/pii/S0273117724003351

Space missions

Habitable Worlds Observatory

NASA announced Friday it selected three industry proposals to help develop technologies for future large space telescopes and plan for the agency's Habitable Worlds Observatory mission concept, which could be the first space telescope designed to search for life outside our solar system. The mission would directly image Earth-like planets around stars like our Sun and study their atmospheres for the chemical signatures of life, as well as enable other investigations about our solar system and universe



This artist's concept features a design option for NASA's Habitable Worlds Observatory. Credits: NASA's Goddard Space Flight Center Conceptual Image Lab

Space – stepping stones to other star systems

The Moon

I wonder if the French will argue as to who should set the standard? (RD) The adoption of a Prime Meridian and the International Meridian Conference of 1884

NASA directed to establish 'Moon Standard Time'

This memorandum outlines the Biden-Harris Administration's policy to establish time standards at and around celestial bodies other than Earth to advance the National Cislunar S&T Strategy. The lower gravity on the Moon means that time runs a little quicker there – Gravitational Time Dilation

Mars

Can we make Mars Earth-like through terraforming?

Mars was once an Earth-like world. When life emerged on our watery planet sometime between 3.5 to 4 billion years ago, Mars was also home to lakes of liquid water and possibly flowing rivers. Combined with a thick atmosphere, a magnetic field to shield against radiation, and a variety of organic molecules, Mars had favourable conditions to form and support life as we know it. Mars probably didn't remain habitable for very long, though. The Red Planet lost its magnetic field

sometime between 3 to 4 billion years ago, which allowed the solar wind—an incessant stream of energetic particles coming from the Sun—to strike and strip away most of the planet's atmosphere and surface water, turning Mars into the chilly desert we see today. Can we reverse nature's effects and terraform Mars into a habitable planet again? Here's what it could take.

Outer Solar System – Planet X/9

Why include this? An outer Solar system planet such as this might act as a way-station on the way to more distant exoplanets (RD). Although they may sound like science fiction worlds, Planet X and Planet Nine are both hypothetical planets that have been thought to exist in our Solar System. Since the early 1900s, astronomers have been searching for a planet that could be responsible for perturbations in the orbits of other objects in the outer Solar System. In the early years of the search, the mystery world was known as Planet X. In the new millennium, the hunt for a ninth planet was renewed, this time under the name Planet Nine. To this day, a hypothetical ninth planet remains possible, yet elusive.

Roger Dymock
ARPS Assistant Director Exoplanets

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