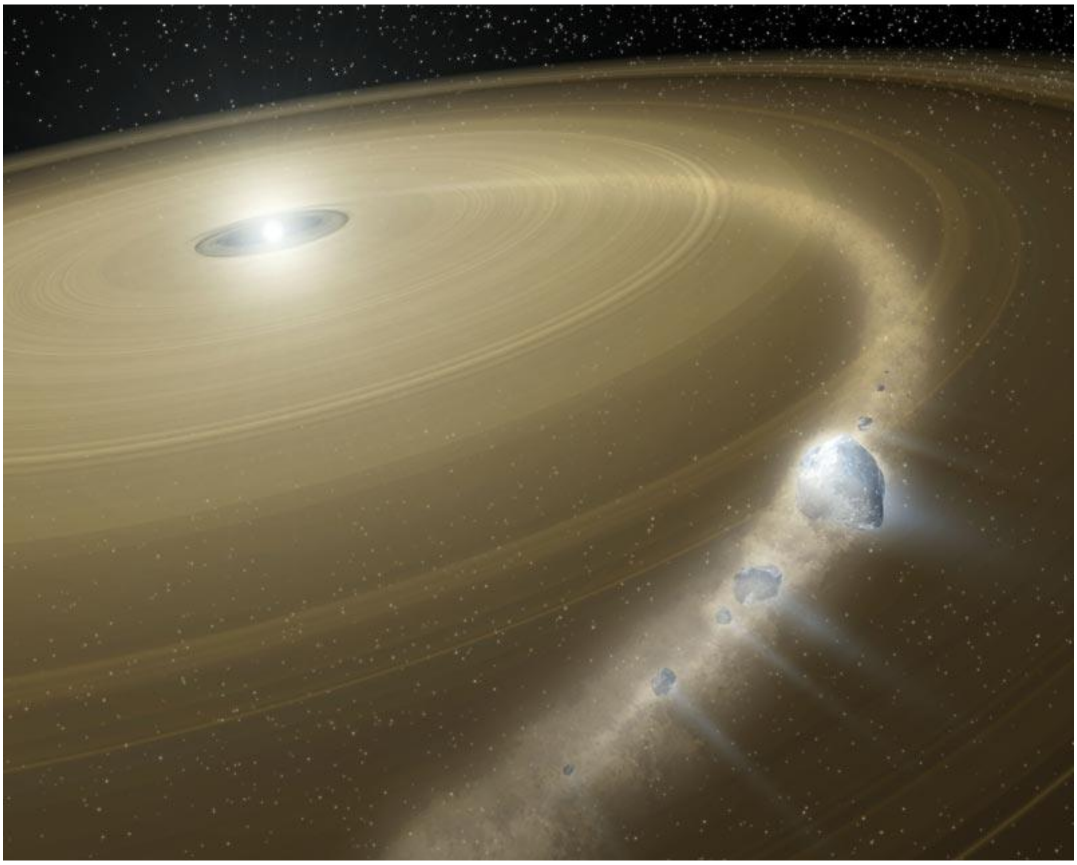
Infinite Worlds



Exoasteroids orbiting a White Dwarf Credit NASA/HST

The e-magazine of the

Exoplanets Division

of the

Asteroids and Remote Planets Section

Issue 24 2024 October

Contents

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Exoplanets Division website

Unistellar UNITE

Giant exoplanets resembling Jupiter that have been recently discovered by TESS, NASA's current exoplanet hunting mission, need your help. Astronomers don't have enough information to fully understand the orbits of these planets, which take months or years to circle their star once. This is usually because TESS and other telescopes haven't had many chances to catch the temporary dimming of the exoplanet's star as the planet passes, or transits, in front it. This is where you and UNITE come in! Only a network of people around the world, cooperating to observe the same target, will be able to catch more transits by these exoplanets. This can be because these planets take many hours to transit their star (much longer than a single night on Earth) or because the dates of future transits cannot yet be accurately predicted. With your observations, scientists can understand the orbits and conditions of these foreign worlds like never before.

Variations on an Exoplanet Theme – Part 2

If at first you don't succeed… We are hoping 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 Lamb-Scargle techniques – Daniel Bardos

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

News

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

Total confirmed exoplanets;	5780
TESS Confirmed Planets;	564
TESS Project Candidates;	7241

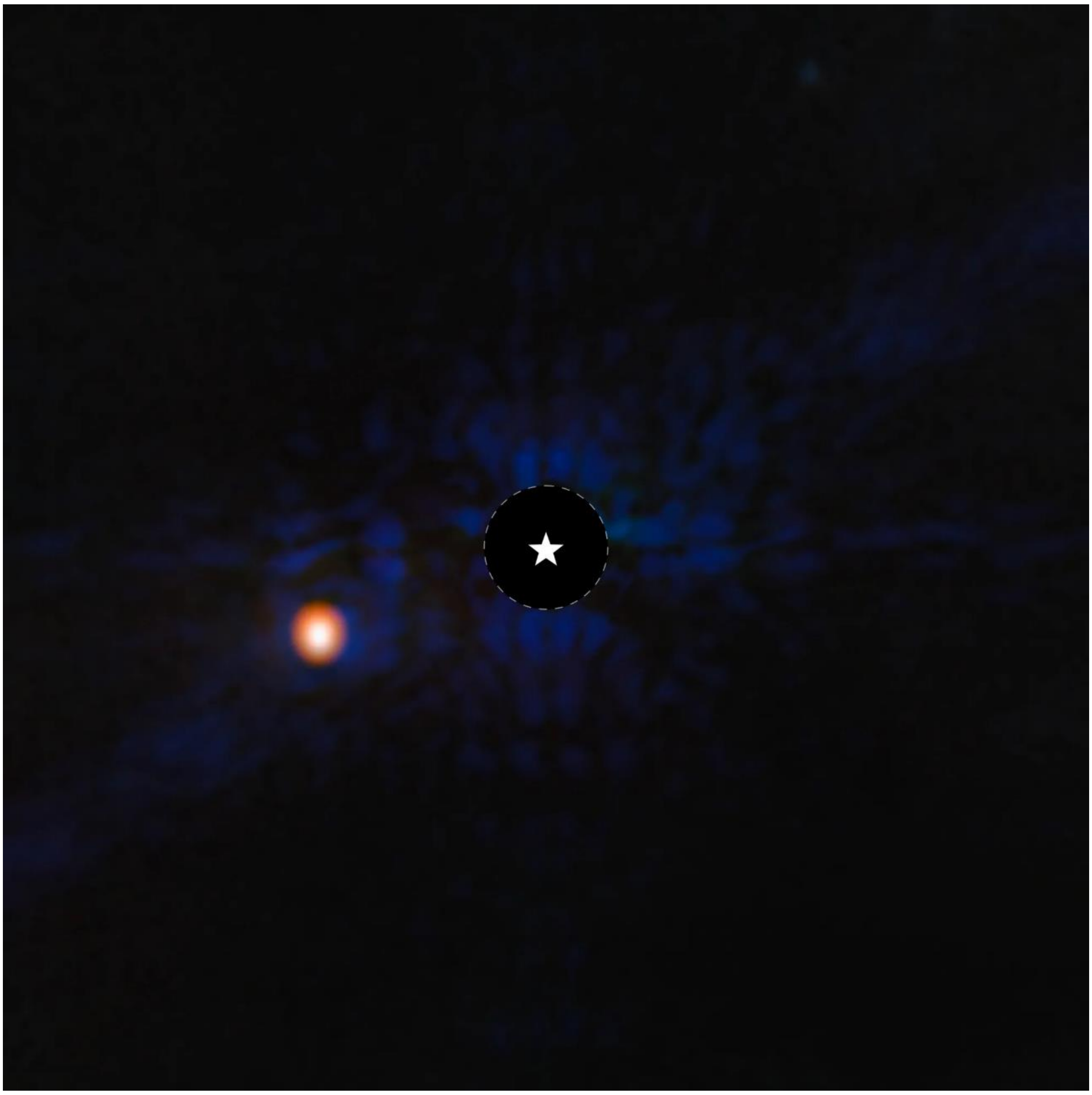
Astronomers find surprising ice world in the habitable zone with JWST data

A team that includes a University of Michigan astronomer has identified a temperate exoplanet as a promising super-Earth ice or water world. The findings, led by Université de Montréal, show that the habitable zone exoplanet, LHS 1140 b, is not likely a mini-Neptune, a small so-called gas giant—large planets composed mostly of gas—with a thick hydrogen-rich atmosphere. The planet, located about 48 light-years away in the constellation Cetus, emerges as one of the most promising habitable zone exoplanet candidates known, potentially harbouring an atmosphere and even a liquid water ocean.

JWST images exoplanet Epsilon Ab

An international team of astronomers using NASA's James Webb Space Telescope has directly imaged an exoplanet roughly 12 light-years from Earth. The planet, Epsilon Indi Ab, is one of the coldest exoplanets observed to date.

The planet is several times the mass of Jupiter and orbits the K-type star Epsilon Indi A (Eps Ind A), which is around the age of our Sun, but slightly cooler. The team observed Epsilon Indi Ab using the coronagraph on Webb's MIRI (Mid-Infrared Instrument).



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Credit; NASA, ESA, CSA, STScI, E. Matthews (Max Planck Institute for Astronomy)

The above image of the gas-giant exoplanet Epsilon Indi Ab was taken with the coronagraph on NASA's James Webb Space Telescope's MIRI (Mid-Infrared Instrument). A star symbol marks the location of the host star Epsilon Indi A, whose light has been blocked by the coronagraph, resulting in the dark circle marked with a dashed white line. Epsilon Indi Ab is one of the coldest exoplanets ever directly imaged. Light at 10.6 microns was assigned the colour blue, while light at 15.5 microns was assigned the colour orange. MIRI did not resolve the planet, which is a point source.

[Scientists discover planet orbiting closest single star to our Sun]

Using the European Southern Observatory's Very Large Telescope (ESO's VLT), astronomers have discovered an exoplanet orbiting [Barnard's star], the closest single star to our Sun. On this newly discovered exoplanet, which has at least half the mass of Venus, a year lasts just over three Earth days. The team's observations also hint at the existence of three more exoplanet candidates, in various orbits around the star.

Located just six light-years away, Barnard's star is the second-closest stellar system — after Alpha Centauri's three-star group — and the closest individual star to us. Owing to its proximity, it is a primary target in the search for Earth-like exoplanets. Despite a promising detection back in 2018, no planet orbiting Barnard's star had been confirmed until now.

Artist's impression of a sub-Earth mass planet orbiting Barnard's star. Credit ESO

[An Earth-mass planet and a brown dwarf in orbit around a white dwarf]

It has been theorized that terrestrial planet born beyond 1–3 au could avoid being engulfed during the red-giant phases of their host stars. Nevertheless, only a few gas-giant planets have been observed around white dwarfs (WDs), the end product left behind by a red giant. This report contains evidence that the lens system that produced the microlensing event KMT-2020-BLG-0414 is composed of a WD orbited by an Earth-mass planet and a brown dwarf companion, as shown by the non-detection of the lens flux using Keck adaptive optics. From microlensing orbital motion constraints, we determine the planet to be a 1.9±0.2 Earth-mass ($M_\oplus$) planet at a physical separation of 2.1±0.2 au from the WD during the event.

Meetings

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

Rogue Worlds 2024: Uniting Theory and Observation

Rogue Worlds 2024 is the first international workshop dedicated to advancing the understanding of free-floating planets. With new probes of this population launching in the coming years, now is the time to bridge the gap between theoretical predictions and observational prospects. This workshop will bring together leading researchers from both theory and observation to foster collaboration and new insight on these exciting, little-understood worlds.

A paper on this topic - The origin of free-floating objects in the Galaxy.

Artists impression of a Jupiter size 'rogue planet'. Credit NASA

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!

Astrobiology and the search for life elsewhere

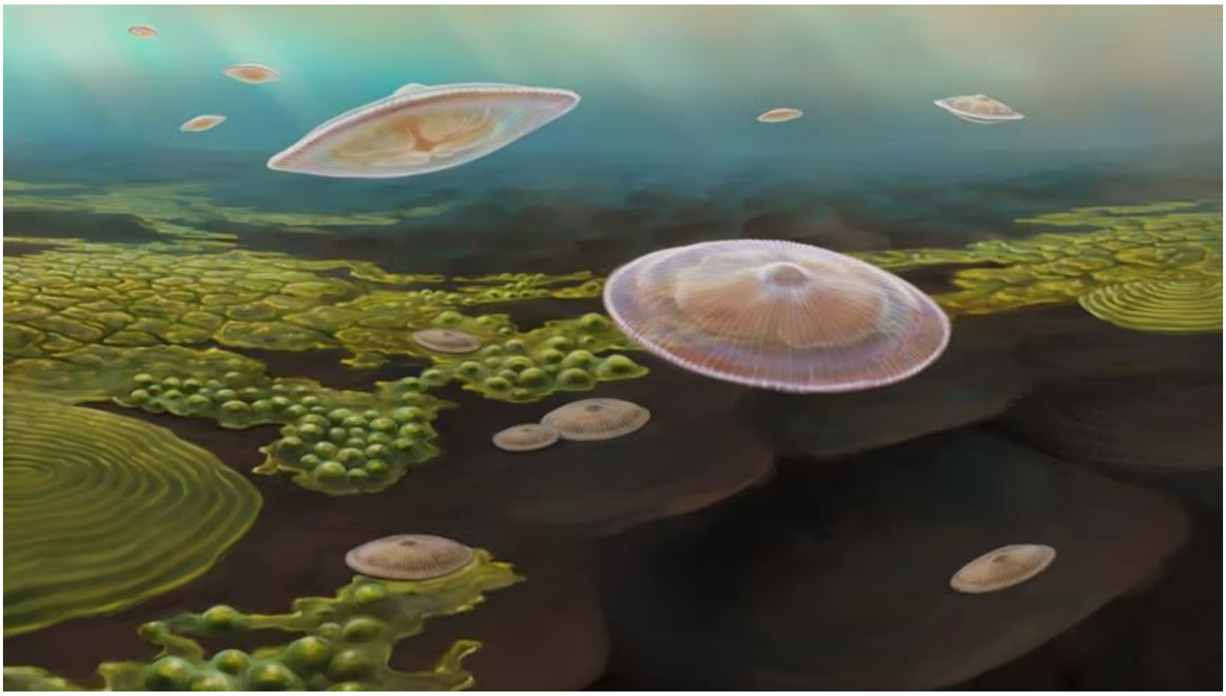
Europa Clipper

NASA's Europa Clipper will conduct detailed reconnaissance of Jupiter's moon Europa and investigate whether the icy moon could harbour conditions suitable for life.

Is life possible on rogue planets and moons ?

Scientists think planets that don't orbit any star, called free-floating planets or rogue planets, can harbour life too. These planets originally form around stars like any other but get kicked out of their system at some point due to gravitational effects of giant planets within. Planets may have been ejected out of our solar system too over 4 billion years ago, and now orbit our galaxy as dark worlds. Without a star, how can these dark worlds conceivably host life as we know it? Our exploration of the solar system combined with two decades of exoplanet research tells us there are several possibilities.

One of the four questions Astrobiology seeks to answer is ‘How did life originate and diversify?’ We don’t know the answer to that but it may have happened on Earth much earlier than previously thought. Environmental evidence of the very first experiments in the evolution of complex life on Earth, has been uncovered by an international team of scientists.



Artist’s impression of the lobate macrofossils living 2.1 billion years ago in a shallow marine inland sea created by the collision of two continents. Credit Professor Abderrazzak El Albani of the University of Poitiers, France.

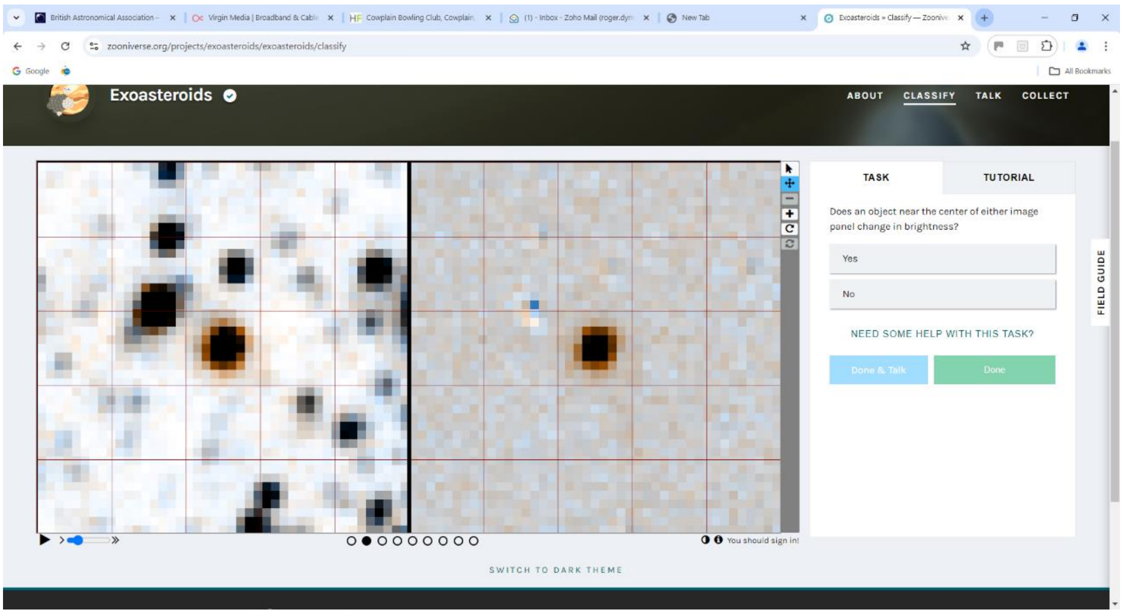
A question not asked is ‘How can we prevent life on Earth ending?’ One idea is supported by Mary Hagedorn, a research fellow at the Smithsonian Institution, she has successfully used cryopreservation to preserve coral and now proposes to build a lunar “Noah’s Ark” to store animal DNA. The Moon is an ideal location because of its distance from man-made disasters and low natural temperatures, making it easy to freeze.

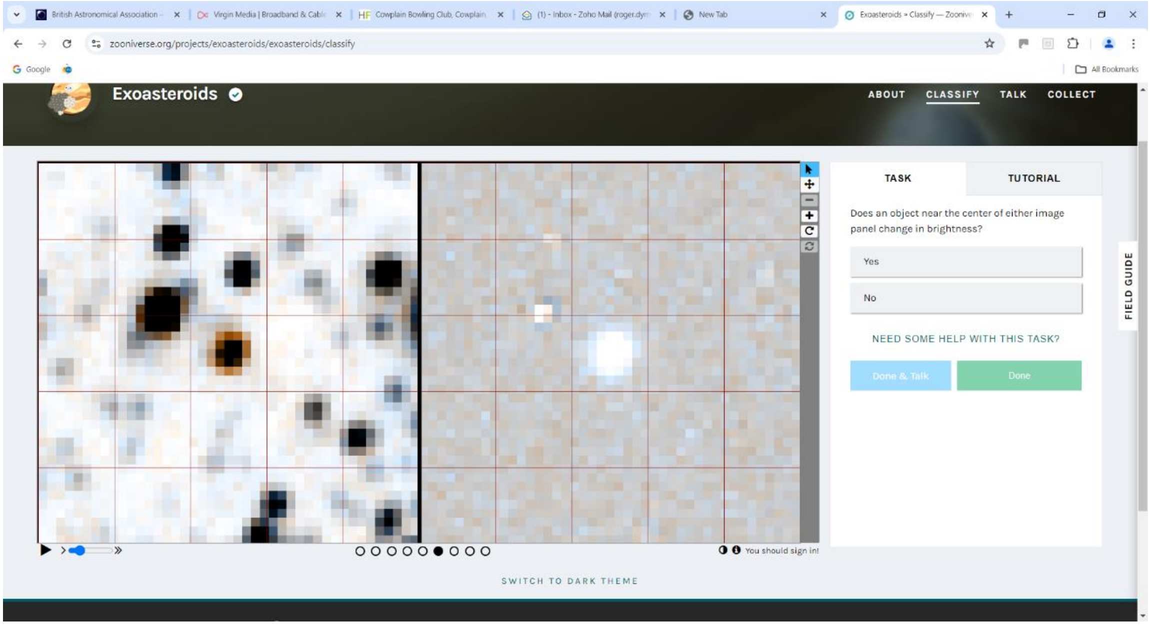
[Zooniverse - Exoasteroids]

Well, we are part of the Asteroids and Remote Planets section so why not include this. We call asteroids that orbit stars other than the Sun "oxosteroids". Join our search for oxosteroids around white dwarfs, planet-sized objects that represent the final evolutionary stage of Sun-like stars. When a Sun-like star dies it becomes a white dwarf. Many white dwarfs are surrounded by dusty disks, thought to be remnants of planetary systems. These disks may harbour orbiting bodies such as asteroids and comet. (See the artist's rendition below). Dusty disks around white dwarfs are excellent laboratories for studying the end stage of planetary systems, providing unique information about the formation and death of planets.

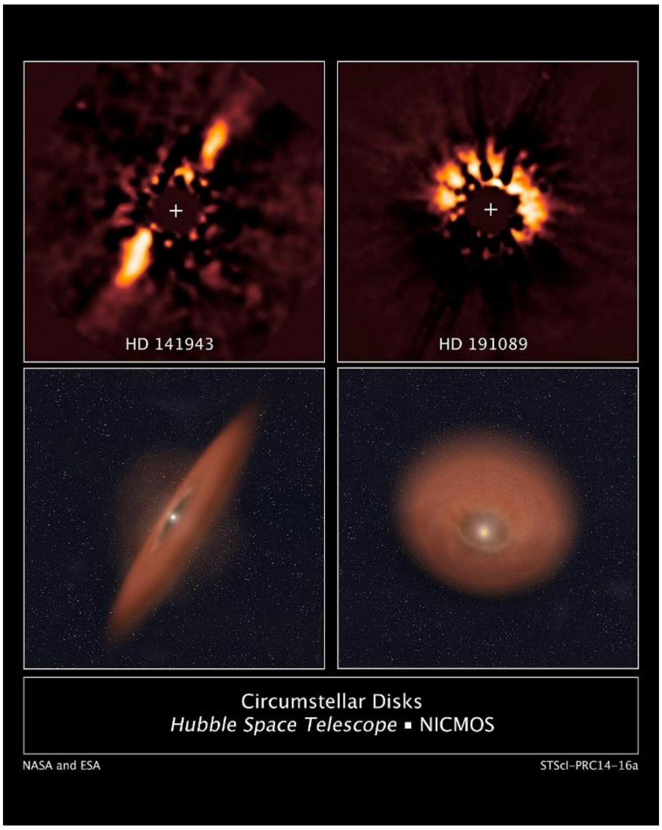
Here at the Exoasteroids project, you will use time-lapse movies of the sky to identify white dwarfs that have changed in brightness over the past decade. These brightness changes can occur when objects similar to asteroids break in pieces, releasing vast quantities of dust. In other words, when a white dwarf that changes in brightness over time, it's a sign that oxosteroids may be orbiting it. So, through your hard work in this project, you can help reveal the evolution of planetary systems, chemistry, and maybe even life in the Universe!

Screen shots below showing variation in brightness. Click on the arrowhead at bottom left of the screen to cycle through the image sequence.





The image below shows pictures of a white dwarf with a circumstellar disk taken from the Hubble Space Telescope at top and computer-rendered images at bottom representing what astronomers believe to be the disk's true three-dimensional form. This image shows the general shape of the disk around a white dwarf.



See also this NASA [webpage]

Publications

Papers

Probing the Possible Causes of the Transit Timing Variation for TrES-2b in TESS Era

Nowadays, transit timing variations (TTVs) are proving to be a very valuable tool in exoplanetary science to detect exoplanets by observing variations in transit times. To study the transit timing variation of the hot Jupiter, TrES-2b, we have combined high-quality transit light curves from all seven sectors of NASA's Transiting Exoplanet Survey Satellite (TESS) along with 60 best-quality light curves from the ground-based facility Exoplanet Transit Database (ETD) and 106 mid-transit times from the previous works. From the precise transit timing analysis, we have observed a significant improvement in the orbital ephemerides, but we did not detect any short period TTVs that might result from an additional body. Orbital decay appeared to be a better explanation for the observed TTV with $\triangle BIC = 4.32$. The orbital period of the hot Jupiter TrES-2b appears to be shrinking at a rate of $\sim -5.58 \pm 1.81$ ms yr^{-1} .

Likelihood and appearance of life beyond the Earth: An astronomical perspective
As of 2023, over 5500 planets are known to orbit stars other than our Sun.

We can measure their sizes and orbital periods, infer their masses and temperatures, and constrain their compositions. Based on these data, about 1% of extrasolar planets are potentially habitable for life as we know it, implying that of the billions of planets in our Galaxy, some may actually be inhabited, at least by microbes. However, recognizing signs of alien life forms is a major challenge for current technology, because of the wide range of conditions on extrasolar planets, and because of the wide range of forms that life may take. This chapter reviews observations of exoplanets and discusses astrobiological definitions of habitability and the likelihood of finding life beyond the Earth, both within and outside the Solar system.

Space missions

[CHEOPS in-flight performance. A comprehensive look at the first 3.5 years of operations]

Since the discovery of the first exoplanet almost three decades ago, the number of known exoplanets has increased dramatically. By beginning of the 2000s it was clear that dedicated facilities to advance our studies in this field were needed. The CHaracterising ExOPlanet Satellite (CHEOPS) is a space telescope specifically designed to monitor transiting exoplanets orbiting bright stars. In September 2023, CHEOPS completed its nominal mission duration of 3.5 years and remains in excellent operational conditions. As a testament to this, the mission has been extended until the end of 2026.

[Ariel stellar characterisation II. Chemical abundances of carbon, nitrogen, and oxygen for 181 planet-host FGK dwarf stars]

One of the ultimate goals of the ESA Ariel space mission is to shed light on the formation pathways and evolution of planetary systems in the Solar neighbourhood. Such an endeavour is only possible by performing a large chemical survey of not only the planets, but also their host stars, inasmuch as stellar elemental abundances are the cipher key to decode the planetary compositional signatures. This work aims at providing homogeneous abundances of C, N, and O of a sample of 181 stars belonging to the Tier 1 of the Ariel Mission Candidate Sample. We applied the spectral synthesis and the equivalent width methods to a variety of atomic and molecular indicators (C I lines at 5052 and 5380.3 A, [O I] forbidden line at 6300.3 A, C_2 bands at 5128 and 5165 A, and CN band at 4215 A) using high-resolution and high S/N spectra collected with several spectrographs. We provide carbon abundances for 180 stars, nitrogen abundances for 105 stars, and oxygen abundances for 89 stars. We analyse the results in the light of the Galactic chemical evolution, and in terms of the planetary companions' properties. Our sample basically follows the typical trends with metallicity expected for the [C/Fe], [N/Fe], and [O/Fe] abundance ratios. The fraction between C and O abundances, both yields of primary production, is consistent with a constant ratio as [O/H] increases, whereas the abundance of N tends to increase with the increasing of the O abundance, supporting the theoretical assumption of a secondary production of nitrogen. The [C/N], [C/O], and [N/O] ratios are also correlated with [Fe/H], which might introduce biases in the interpretation of the planetary compositions and formation histories if host stars of different metallicity are compared. We provide relations that can be used to qualitatively estimate whether the atmospheric composition of planets is enriched or not with respect to the host stars.

Chinese Exoplanet Mission

China plans to launch an exoplanet observatory in 2028 with the aim of making a breakthrough detection of a potential second Earth. Around 5,000 exoplanets have been found since 1995, but no Earth-sized planets in the habitable zones of sun-like stars have been spotted. Earth 2.0, or ET, proposed by the Shanghai Astronomical Observatory under the Chinese Academy of Sciences (CAS), intends to use six 28-centimetre-aperture wide-field optical telescopes to observe about 2 million stars in the Kepler mission star field and other, larger nearby regions, continuously monitoring for transits of so-called exo-Earths over four years. The mission is now targeting launch in 2028, according to a new paper authored by the mission principal investigator and others and published in the Chinese Journal of Space Science.

See also The Tianlin Space Telescope

S In terms of getting off the ground and into space, Tianlin could launch on a Long March 5 — currently China's largest rocket. Its maker is already working on an expanded payload fairing with a 6.4-meter (21-foot) diameter, meaning it may be able to encapsulate Tianlin. Another option would be the larger Long March 9 super heavy-lift rocket, currently in development.

Long March 5's first launch China's first Long March 5 rocket lifted off from the Wenchang Spacecraft Launch Center on November 3, 2016 at 20:43 local time (12:43 UTC). Image: Xinhua news

Space – stepping stones to other star systems

The Moon

EXPLORE 2040 – The European Exploration Strategy

I should have copyrighted the term EXPLORE (EXoPLanet Orbit REsearch for the uninitiated)

Space exploration is accelerating faster than ever across the globe, as both traditional and new actors pursue far-reaching plans driven by political agendas. In this context I am delighted to introduce ESA's Explore 2040, which is a refined European exploration strategy for which ESA Member States take ownership in response to the Seville 2023 Space Summit Resolution. At the core of the strategy is a bold vision to establish continuous, sustainable, and responsible human and robotic exploration of the Solar System by providing unique contributions and benefiting society. terrestrial applications and science…..

Daniel Neuenschwander, Director Human and Robotic Exploration Programmes European Space Agency

Mars

Challenges facing the human exploration of Mars

Sending people to Mars has long been on humanity's to-do list. But it's no secret the obstacles are daunting. The fact that no person has travelled beyond low-Earth orbit since the Apollo program ended in 1972 highlights the reality that long-duration, long-distance missions with fragile humans on board are fraught with intimidating challenges. What are some of the biggest concerns?

See also

- SpaceX – Mars and beyond
- NASA's Human Path to Mars

Roger Dymock
ARPS Assistant Director Exoplanets

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