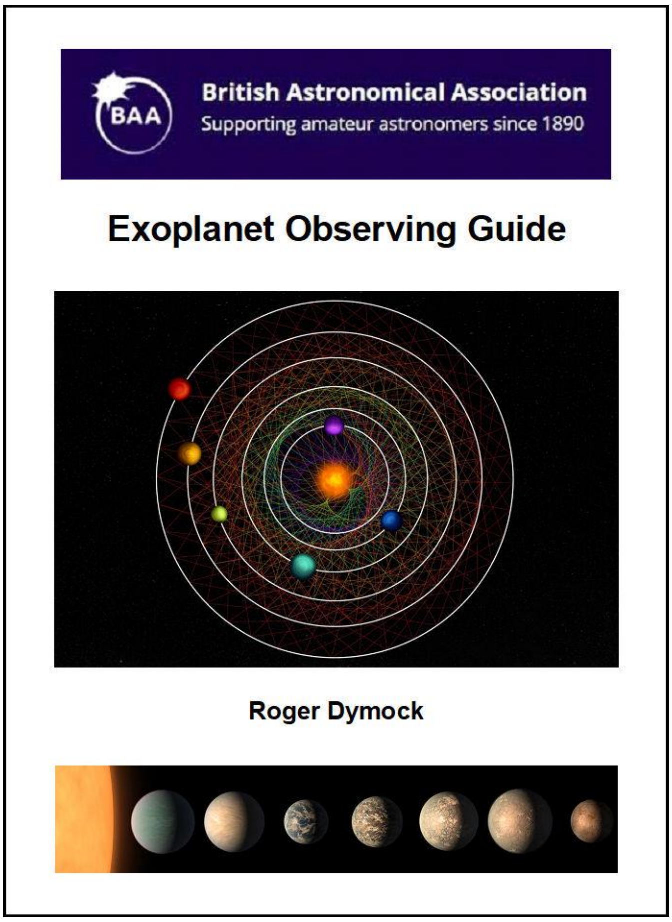
British Astronomical Association
Supporting amateur astronomers since 1890

Infinite Worlds



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

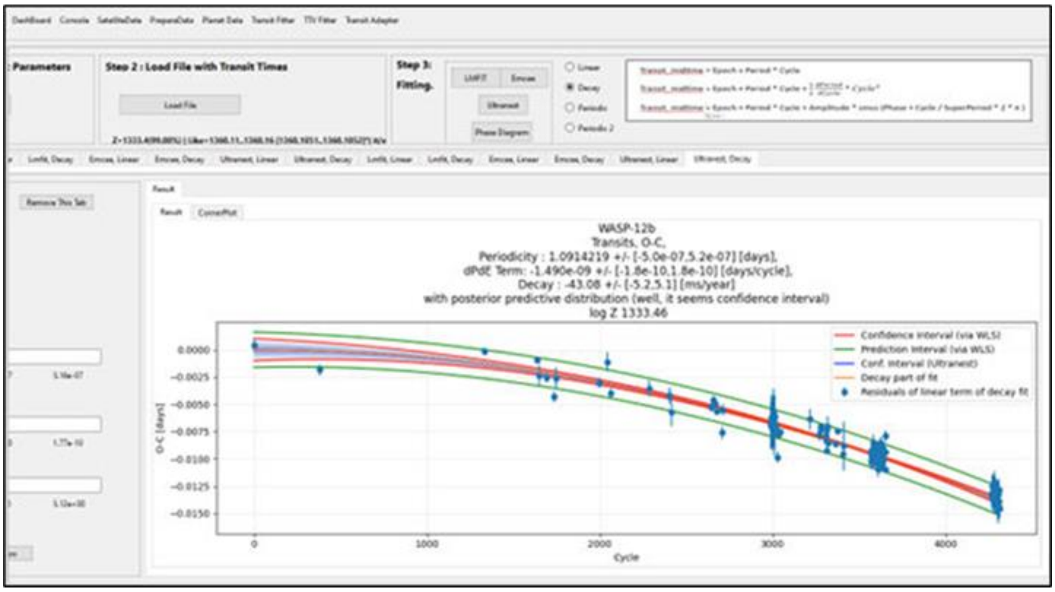
Exoplanet observing guide

As shown on the front cover this guide can now be purchased through the BAA shop and will also be available at the Winchester Weekend.

Contents

Exoplanetpie – Transit Timing Variation analysis software

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. The chart below was constructed from merging TESS and ExoClock data using Exoplanetpie and indicates that the orbit of WASP-12b is likely decaying. A tutorial will be a key part of the meeting mentioned below.



Exoplanet observation and analysis – time and place, 2024 October 5th

Making accurate transit observations and their subsequent analysis is a key part of understanding exoplanet characteristics. These together with a knowledge of the host star lead to a definition of the habitable zone and thus the possibility of the existence of life.

Martin Crow will explain the best way to construct a transit light curve using HOPS. Peter Vuylsteke then takes us through his Exoplanetpie software which will indicate whether an exoplanet's orbit is stable or varying in some way.

A stable orbit is a necessity if that planet is to remain within the host star's habitable zone and such zones will be explained in the final presentation of the day.

Provisional agenda

Morning

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

Afternoon

- The Habitable Zone. On-line and off-line analysis, Speaker to be confirmed
- Conclusion, Rodney Buckland, Roger Dymock

News

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

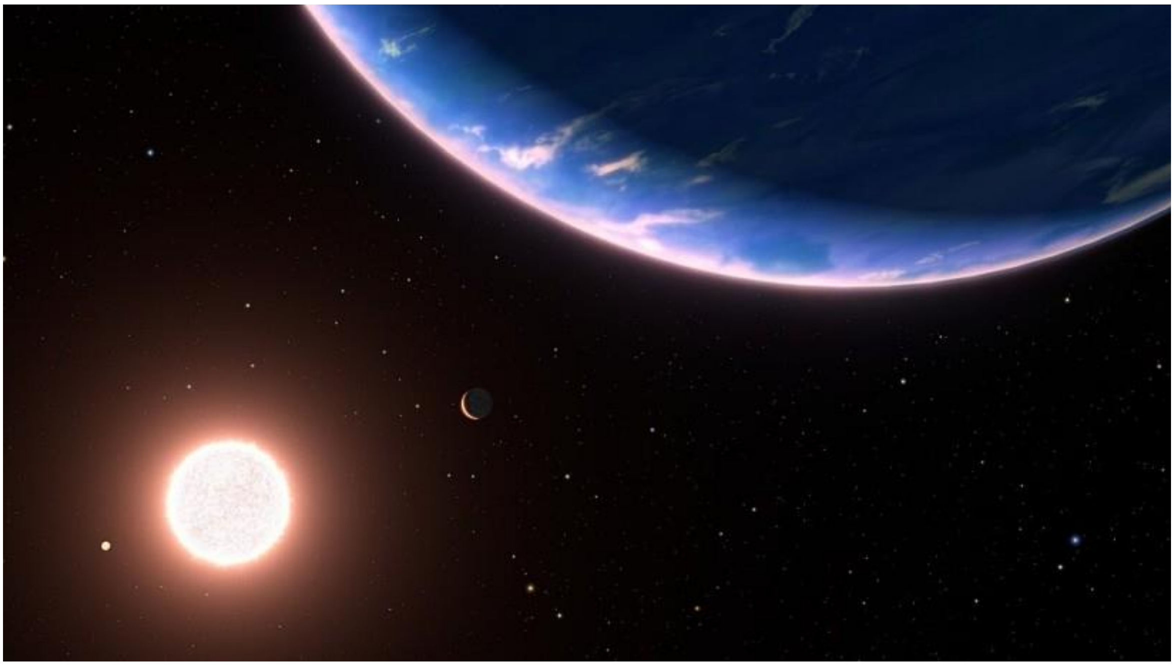
Total confirmed exoplanets;	5602
Kepler candidates yet to be confirmed;	1983
K2 candidates yet to be confirmed;	977
TESS candidates yet to be confirmed;	4613

Hubble observes a changing exoplanet atmosphere

An international team of astronomers has assembled and reprocessed observations of the exoplanet WASP-121 b that were collected with the NASA/ESA Hubble Space Telescope in the years 2016, 2018 and 2019. This provided them with a unique dataset that allowed them not only to analyse the atmosphere of WASP-121 b, but also to compare the state of the exoplanet's atmosphere across several years.

The team found clear evidence that the observations of WASP-121 b were varying in time. And demonstrated that these temporal variations could be explained by weather patterns in the exoplanet's atmosphere.

Hubble detects water vapour in atmosphere of Gliese 9827 d



Artists impression of Gliese 9827 d Credit NASA, ESA, Leah Hustak and Ralf Crawford (STScI))

Gliese 9827 dis a sub-Neptune planet that belongs to the planetary system around the star GJ 9827, a bright K-type red dwarf located in the constellation of Pisces. This small exoplanet is the outermost planet of a trio of transiting massive exoplanets discovered by NASA's Kepler/ K2 mission. This planet is only 97 light years away from us and completes its revolution around its star in just 6.2 days. It was discovered in 2017 by the defunct Kepler space telescope. Its radius is only twice that of the Earth but smaller than Neptune, even though its mass would be more significant. It is also believed to be overheated due to its average temperature of 430 degrees Celsius.

JWST Photographs Possible Giant Planets Around White Dwarfs

Paper - JWST Directly Images Giant Planet Candidates Around Two Metal-Polluted White Dwarf Stars

We report the discovery of two directly imaged, giant planet candidates orbiting the metal-rich DAZ white dwarfs WD 1202−232 and WD 2105−82. JWST’s Mid-Infrared Instrument (MIRI) data on these two stars show a nearby resolved source at a projected separation of 11.47 and 34.62 au, respectively. Assuming the planets formed at the same time as their host stars, with total ages of 5.3 and 1.6 Gyr, the MIRI photometry is consistent with giant planets with masses ≈1–7 MJup. The probability of both candidates being false positives due to red background sources is approximately 1 in 3000. If confirmed, these would be the first directly imaged planets that are similar in both age and separation to the giant planets in our own solar system, and they would demonstrate that widely separated giant planets like Jupiter survive stellar evolution. Giant planet perturbers are widely used to explain the tidal disruption of asteroids around metal-polluted white dwarfs. Confirmation of these two planet candidates with future MIRI imaging would provide evidence that directly links giant planets to metal pollution in white dwarf stars.

Meetings

PLATO Planetary systems – formation to observe architectures, 2023 May 14-16, Catana, Sicily, Italy

PLATO is the 3rd mission of class M in the ESA Cosmic Vision program. Its main goal is detecting terrestrial planets in the habitable zone of solar type stars. With its huge FOV, most of the PLATO targets are bright stars that will be monitored with high cadence (25 s) for at least 2-3 years during the long duration observing program, while contemporary a number of very bright stars in the sample will be observed with 2.5 s cadence. The collected data, photometry from space and high-resolution spectroscopy from the ground, will provide accurate planetary structures as well as architectures and evolutionary stage - via asteroseismic analysis - of a large number of planetary systems. PLATO is planned for a launch in Dec 2026.

With PLATO Mission due for launch soon this would seem a good time to review the present state of knowledge of exoplanet systems and the objectives of the mission. PLATO is optimized for the detection and characterization of small planets in the habitable zones of Sun-like stars.

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.

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.

Astrobiology and the search for life elsewhere

The possibility of panspermia in the deep cosmos by means of the planetary dust grains

Paper by Zaza N. Osmanov. By obtaining the assumption that planetary dust particles can escape from the gravitational attraction of a planet, we consider the possibility for the dust grains to leave the star's system by means of the radiation pressure. It has been shown that, during 5 billion years, the dust grains will reach 105 stellar systems, and by taking the Drake equation into account, it has been shown that the whole galaxy will be full of planetary dust particles.

Could we colonise Europa, Callisto and Titan?

39-minute-long video thanks to Steve Night, Hampshire Astronomical Group.
Two missions are mentioned in this video; ESA's Jupiter Icy Moons Explorer (JUICE) launched on 2023 April 14 and due to arrive at Jupiter 2031 July and NASA's Europa Clipper which is scheduled to launch 2024 October and arrive at Jupiter in 2030.

In my various talks I use the term 'settle' rather than 'colonise' as the latter carries rather a lot of baggage on this Earth – Roger Dymock

The Habitable Worlds Observatory

NASA is further prioritizing its long-running search for life in the universe and laying the groundwork for its next flagship astrophysics mission after the Nancy Grace Roman Space Telescope (slated to launch by May 2027). This observatory would simultaneously provide powerful capabilities for transformational astrophysics discoveries, from our cosmic backyard of the solar system to the distant universe and everything in between.

Currently referred to as the Habitable Worlds Observatory (HWO), this is a concept for a mission that would search for and characterize habitable planets beyond our solar system. Building upon studies conducted for two earlier mission concepts called the Large Ultraviolet Optical Infrared Surveyor (LUVOIR) and Habitable Exoplanets Observatory (HabEx), HWO would be designed specifically to identify potentially habitable planets around other stars, closely examining their atmospheres to determine if life could possibly exist.

SETI COSMIC

The primary goal of the search for extraterrestrial intelligence (SETI) is to gain an understanding of the prevalence of technologically advanced beings (organic or inorganic) in the Galaxy. One way to approach this is to look for technosignatures: remotely detectable indicators of technology, such as temporal or spectral electromagnetic emissions consistent with an artificial source. With the new Commensal Open-Source Multimode Interferometer Cluster (COSMIC) digital backend on the Karl G. Jansky Very Large Array (VLA), SETI aim to conduct a search for technosignatures that is significantly more comprehensive, more sensitive, and more efficient than previously attempted. The COSMIC system is currently operational on the VLA, recording data, and designed with the flexibility to provide user-requested modes. This paper describes the hardware system design, the current software pipeline, and plans for future development.

SETI Institute Post-Doctoral Researchers, Dr Savin Varghese and Dr Chenoa Tremblay, in front of one of the 82-foot diameter dishes that makes up the Very Large Array.

Intelligent Life on Other Planets

15 min long video thanks to Steve Knight, Hampshire Astronomical Group.

Europa Clipper mission mentioned in video.

Publications

Books

Thriving in Space: Ensuring the Future of Biological and Physical Sciences Research: A Decadal Survey for 2023-2032

Research in biological and physical sciences in space provides the critical scientific and technological foundations that make space exploration possible. As humanity looks towards the Moon and Mars for future missions, this work is needed to help astronauts adapt and live in the harsh environments of space. Thriving in Space provides a roadmap for increasing national investment in biological and physical science research, from experiments to infrastructure to education.

Papers

This link to IOP Astronomy and astrophysics might be of interest. The tutorial An Introduction to High Contrast Differential Imaging of Exoplanets and Disks is a little above my pay grade but worth a look.

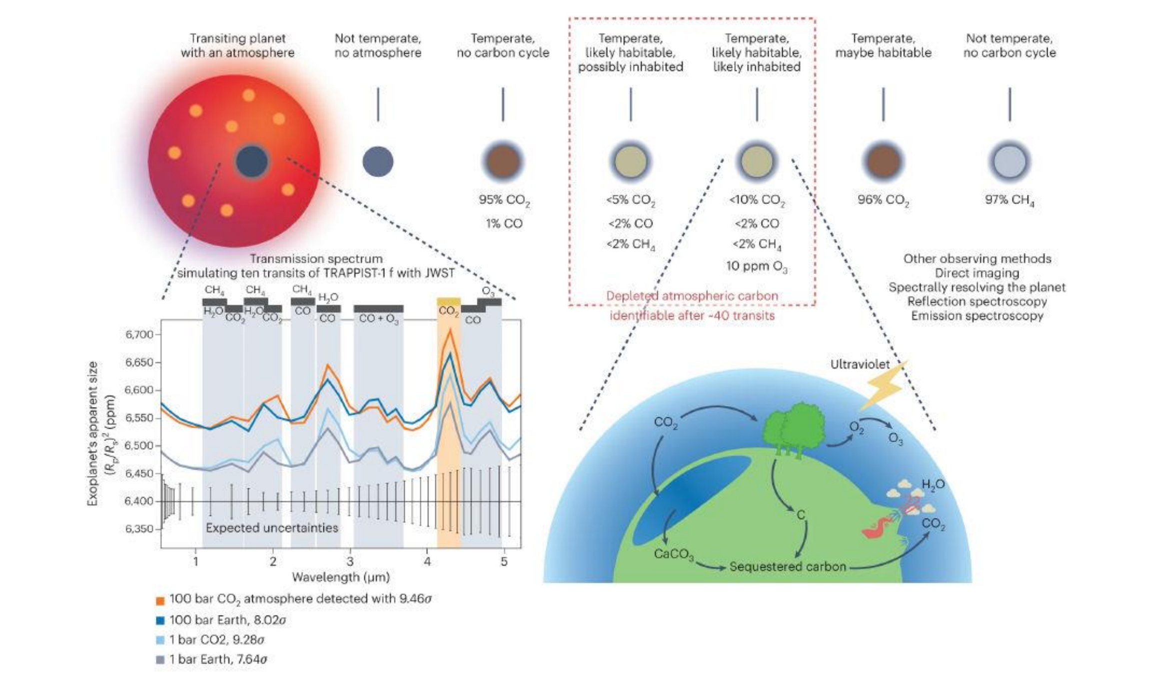
Variable Star Section papers in the Journal of the British Astronomical Association are often worth a read particularly where the use of software such as Peranso is used to analyse periodic changes.

TESS Duotransit Candidates from the Southern Ecliptic Hemisphere
Discovering transiting exoplanets with long orbital periods allows us to study warm and cool planetary systems with temperatures similar to the planets in our own Solar system. The TESS mission has photometrically surveyed the entire Southern Ecliptic Hemisphere We use the observations to search for exoplanet systems that show a single transit event in each year - which we call duotransits. The periods of these planet candidates are typically in excess of 20 days, with the lower limit determined by the duration of individual TESS observations. We find 85 duotransit candidates, which span a range of host star brightnesses between $8 < Tmag < 14$, transit depths between 0.1 per cent and 1.8 per cent, and transit durations between 2 and 10 hours. Of these candidates, 25 are already known, and 60 are new.

Atmospheric carbon depletion as a tracer of water oceans and biomass on temperate terrestrial exoplanets
The conventional observables to identify a habitable or inhabited environment in exoplanets, such as an ocean glint or abundant atmospheric O2, will be challenging to detect with present or upcoming observatories. Here we suggest a new signature. A low carbon abundance in the atmosphere of a temperate rocky planet, relative to other planets of the same system, traces the presence of a substantial amount of

liquid water, plate tectonics and/or biomass. Here we show that JWST can already perform such a search in some selected systems such as TRAPPIST-1

The main concept of a habitability signature illustrated below. Each planet to the right-hand side of the star describes a different scenario discussed in the paper



(along with illustrative atmospheric concentrations). The bottom left panel depicts a simulation of the transmission spectrum of the temperate terrestrial planet TRAPPIST-1f. We explore the detectability of an atmosphere with about ten JWST/NIRSpec Prism transit observations–the minimum needed to produce a reliable diagnostic. Note that the deviation from a flat signal (no atmosphere) is primarily supported by the strong absorption features of CO2, notably at 4.3 µm (highlighted). On the bottom right, we illustrate a simplified view of a carbon cycle involving surface liquid water and a biology sequestering cycle, producing a depletion in atmospheric carbon. Atmospheric concentrations given near the planets are illustrative.

Space – stepping stones to other star systems

The Moon

Updates to the Artemis missions

With Artemis missions, NASA will land the first woman and first person of color on the Moon, using innovative technologies to explore more of the lunar surface than ever before. We will collaborate with commercial and international partners and establish the first long-term presence on the Moon. Then, we will use what we learn on and around the Moon to take the next giant leap: sending the first astronauts to Mars.

Moon to Mars

On Tuesday, January 23, NASA released the outcomes of its 2023 Moon to Mars Architecture Concept Review, the agency's process to build a roadmap for exploration of the solar system for the benefit of humanity.

Destination Mars Credit NASA

Mars

Can we make Mars Earth-like through terraforming?

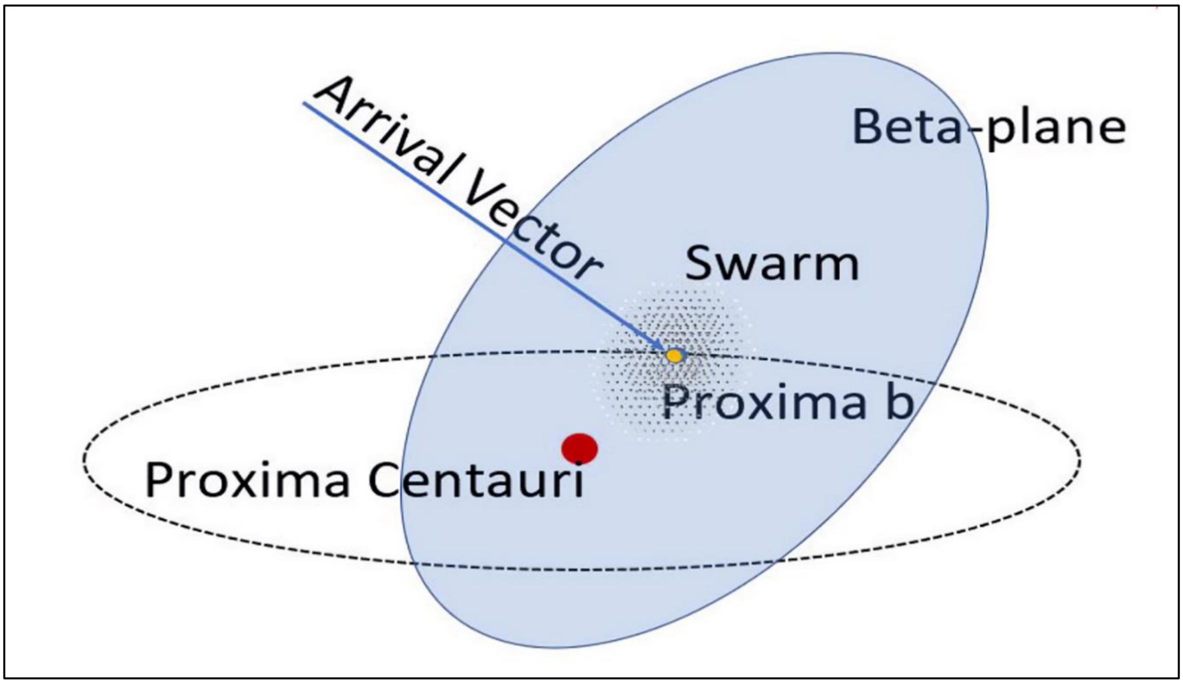
Mars was once an Earth-like world. When life emerged on our watery planet sometime between 3.5 to 4 billion years ago, Mars was also home to lakes of liquid water and possibly flowing rivers. Combined with a thick atmosphere, a magnetic field to shield against radiation, and a variety of organic molecules, 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?

Video – How SpaceX will land on Mars
It's all about delta V and being very careful with your fuel.

Video - The Mars mission that could change everything. Both thanks to Steve Knight, Hampshire Astronomical Group

Interstellar
Swarming Proxima Centauri: Coherent Picospacecraft Swarms Over Interstellar Distances

Tiny gram-scale interstellar probes pushed by laser light are likely to be the only technology capable of reaching another star this century. Florida-based Space Initiatives presuppose availability by mid-century of a laser beamer powerful enough (~100-GW) to boost a few grams to relativistic speed, lasersails robust enough to survive launch, and terrestrial light buckets (~1-sq.km) big enough to catch their optical signals. Their proposed representative mission, around the third quarter of this century, is to fly by our nearest neighbour, the potentially habitable world Proxima b, with a large autonomous swarm of 1000s of tiny probes. Given extreme constraints on launch mass (grams), onboard power (milliwatts), and coms aperture (centimeters to meters), it was determined over the last 3 years that only a large swarm of many probes acting in unison can generate an optical signal strong enough to cross the immense distance back to Earth.



Graphic depiction of Swarming Proxima Centauri: Coherent Picospacecraft Swarms Over Interstellar Distances. Credit Thomas Eubanks

Roger Dymock

ARPS Assistant Director Exoplanets