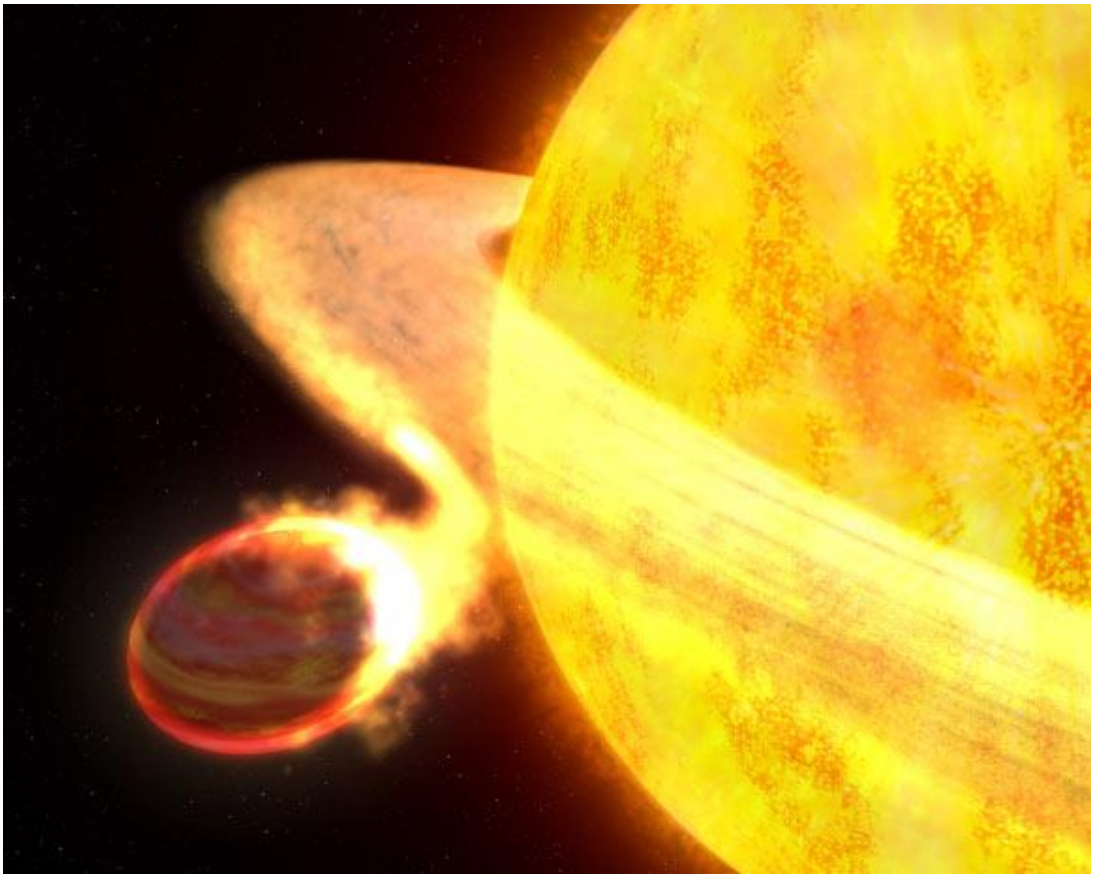
British Astronomical Association
Supporting amateur astronomers since 1890

Infinite Worlds



An artist's concept of the hot-Jupiter exoplanet WASP-12b.

Image credit: NASA / ESA / G. Bacon, STScI / C. Haswell, Open University.

The e-magazine of the

Exoplanets Division
of the
Asteroids and Remote Planets Section

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Section officers

ARPS Section Director	Dr Richard Miles
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Simon Downs, Steve Futcher, Paul Leyland, David Pulley, Mark Salisbury, Americo Watkins

Exoplanets Division website

Please note that I have changed the default font from Times New Roman to Arial and the line spacing from 1.0 to 1.5 as this will make it easier for visually impaired people to read. These changes will make this publication somewhat longer than previous issues.

Projects

EXoPLanet Orbit REsearch - EXPLORE

Rodney Buckland, Peter Little and myself are exploring two projects. The immediate plan is to develop flowcharts to tie all the various aspects together (in the right order as someone, almost, famously said)

- Transit Timing Variations
- Detecting exoplanets in variable star data

At the moment, we have more questions than answers so, if either of these are of interest, please contact me and we will then see how we can best work together to further these projects

Transit Timing Variations

The ExoClock project is supporting this by flagging exoplanets exhibiting TTVs in their database. For specific TTV discussion it is possible that an ExoClock Slack channel will be implemented whereas more general exoplanet topics will continue to be explored on the BAA forum.

TTVs may indicate;

- the presence of additional planets (do exoplanets in known multi-planet systems exhibit TTVs?)
- a decaying orbit (a relevant paper is The Orbit of WASP-12b is Decaying. Since the planet's discovery in 2008, the time interval between transits has been decreasing by 29 ± 2 ms yr−1. This is a possible sign of orbital decay, although the previously available data left open the possibility that the planet's orbit is slightly eccentric and is undergoing apsidal precession. See also NASA WASP-12b 3D Model
- an eccentric orbit (although the orbits of close-in exoplanets are most likely to be circular)

Exoplanets in variable star data

- what has been done to date?
- which host stars are known to be variable and does the data indicate the presence of exoplanets?
- do observations of binary stars indicate the presence of exoplanets?

- how can existing variable star databases be best analysed? Python programs possibly so expertise in this field would prove useful.

News

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

Total conformed exoplanets; 5338

Kepler candidates; 2053

K2 candidates; 978

TESS candidates; 4201

New Research Suggests Solar System May Have Once Harbored Super-Earths

Long before Mercury, Venus, Earth, and Mars formed, it seems that the inner solar system may have harbored a number of super-Earths—planets larger than Earth but smaller than Neptune. If so, those planets are long gone—broken up and fallen into the sun billions of years ago largely due to a great inward-and-then-outward journey that Jupiter made early in the solar system's history.

Giant exoplanet has astronomers puzzled

A team of astronomers led by Olga Zakhozhay from the MPIA discovered a giant exoplanet around the Sun-like star HD 114082. With an age of only 15 million years, this super-Jupiter is the youngest exoplanet of its kind for which astronomers managed to determine its radius and mass. While its size matches Jupiter's diameter, the mass of HD 114082 b amounts to eight times Jupiter's value. Combining these quantities is hard to reconcile with the widely accepted models of planet formation. A possible solution to this riddle may require an update of the formation models to allow for an unusually large solid planetary core.

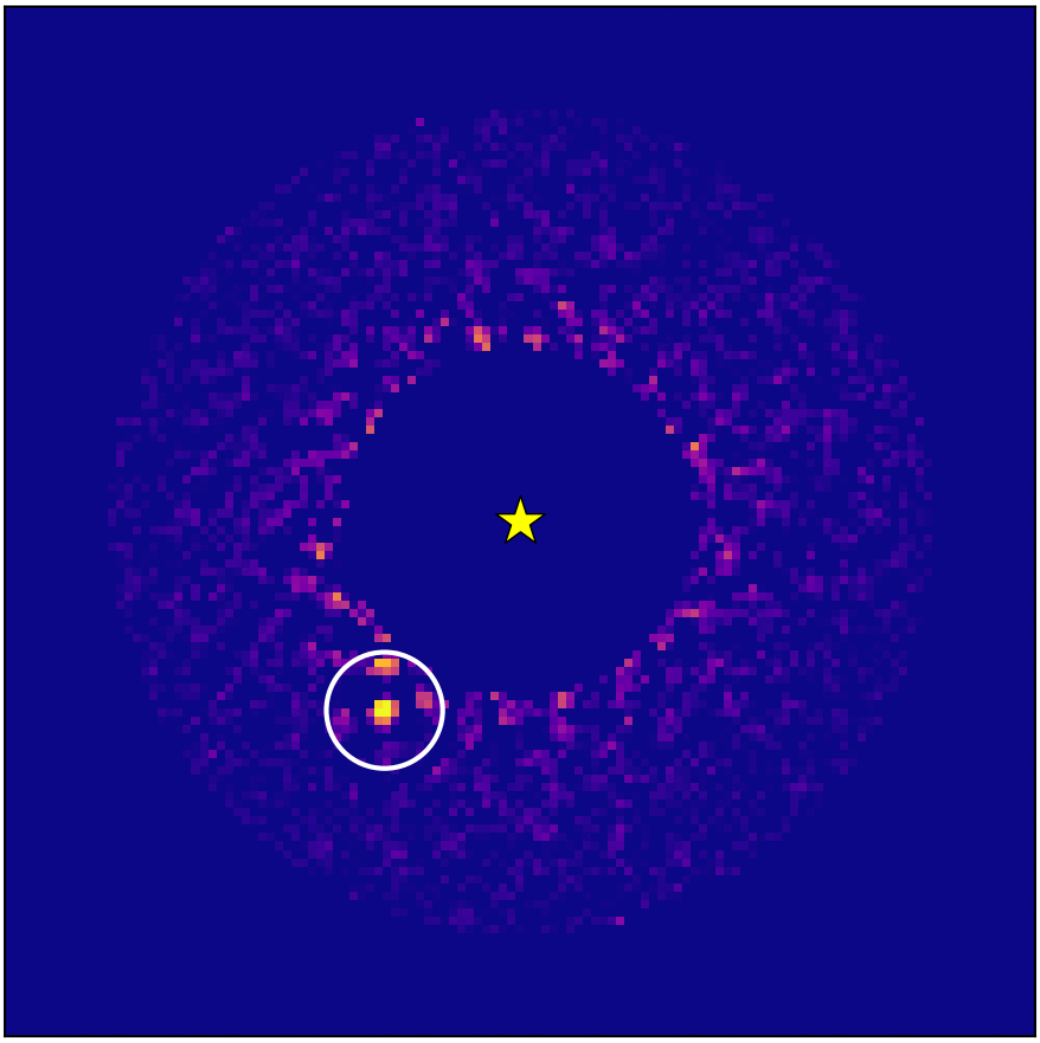
Planetary systems Around White Dwarfs

White dwarf planetary science is a rapidly growing field of research featuring a diverse set of observations and theoretical explorations. Giant planets, minor planets, and debris discs have all been detected orbiting white dwarfs. The innards of broken-up minor planets are measured on an element-by-element basis, providing a unique probe of exoplanetary chemistry. Numerical simulations and analytical investigations trace the violent physical and dynamical history of these

systems from au-scale distances to the immediate vicinity of the white dwarf, where minor planets are broken down into dust and gas and are accreted onto the white dwarf photosphere.

Astrometry of star found in Gaia-Hipparcos data confirms presence of an exoplanet

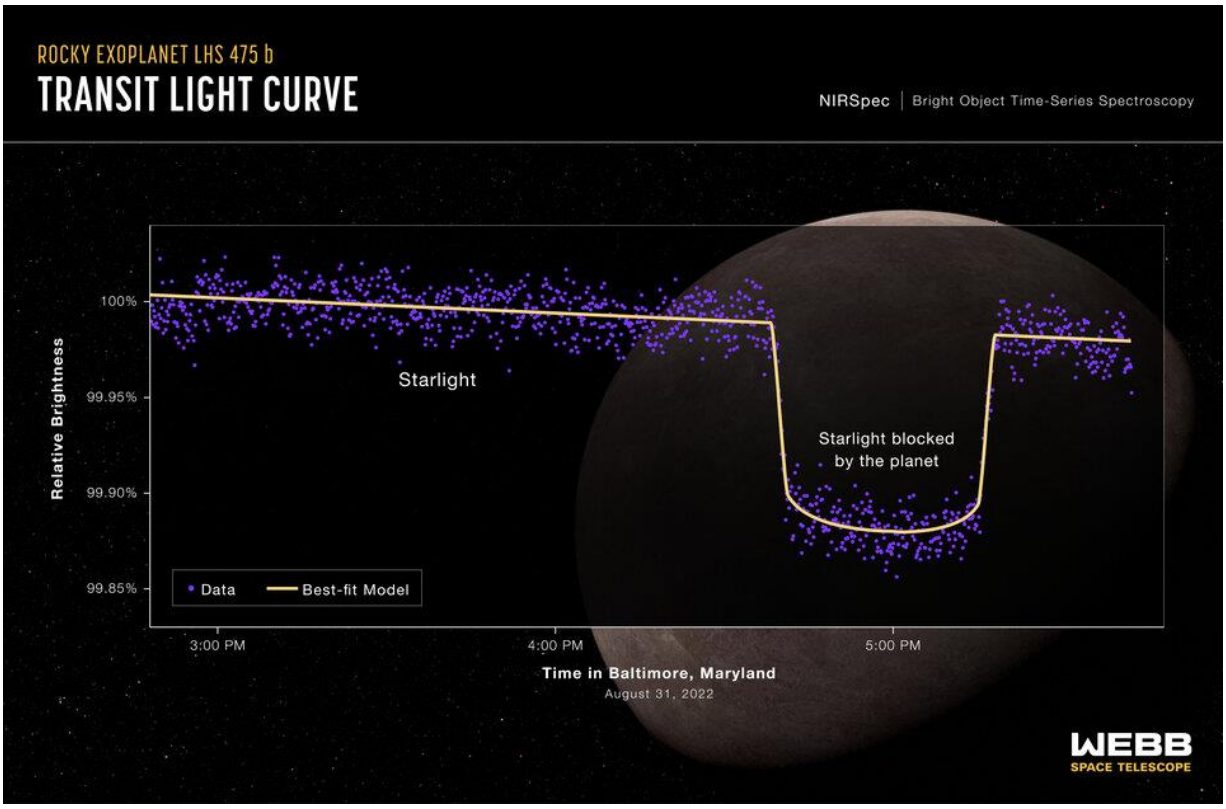
Data from ESA's star-mapping Gaia spacecraft has allowed astronomers to image a gigantic exoplanet using Japan's Subaru Telescope. This world is the first confirmed exoplanet found by Gaia's ability to sense the gravitational tug or 'wobble' a planet induces on its star. And the technique points the way to the future of direct exoplanet imaging



HIP99770 b Credit ESA

[JWST confirms its first exoplanet]

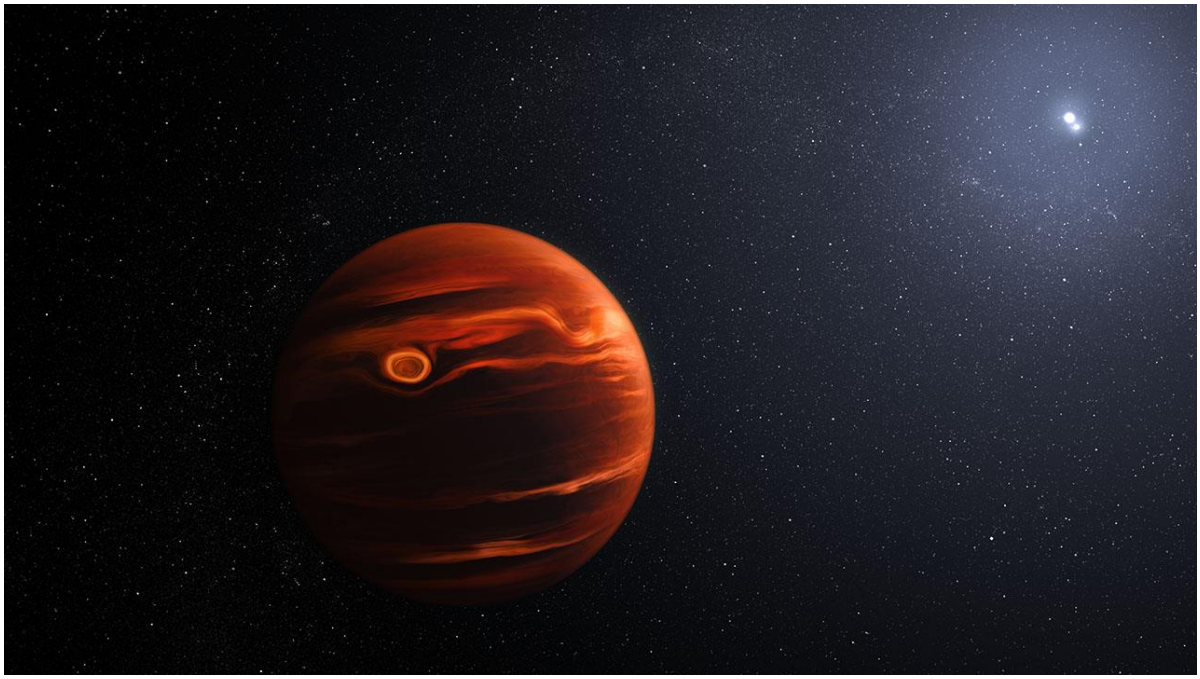
Researchers have confirmed the presence of an exoplanet using the NASA/ESA/CSA James Webb Space Telescope for the first time. Formally classified as LHS 475 b, the planet is almost exactly the same size as our own, clocking in at 99% of Earth's diameter.



An Earth-sized exoplanet 72 light-years away has been found

The planet, named K2-415b, orbits one of the coolest stars known to have exoplanets. The discovery was made using data from NASA's now-defunct Kepler space telescope and the Transiting Exoplanet Survey Satellite.

JWST spots swirling, gritty clouds on exoplanet VHS 1256 b



Exoplanet VHS 1256 b Credit Webb Space Telescope

This illustration conceptualizes the swirling clouds identified by the James Webb Space Telescope in the atmosphere of exoplanet VHS 1256 b. The planet is about 40 light-years away and orbits two stars that are locked in their own tight rotation.

Its clouds are constantly rising, mixing, and moving during its 22-hour day. Plus, they're filled with silicate dust. Some clouds contain silicate grains as tiny as smoke particles. Other contain slightly larger flecks that are similar to small grains of sand. Researchers detected both brighter and darker cloud patches, indicating some clouds are lower and hotter or higher and cooler than others, respectively.

More from JWST

Conferences/Meetings/Seminars/Webinars/Videos

The 2023 Humans to Mars Summit, 2023 May 16-18

"It is time for the space community to inject a sense of urgency into our common goal of sending humans to Mars," stated Explore Mars CEO Chris Carberry. "H2M 2023 will not only highlight the steps that need to be taken to assure that NASA, industry, Congress and the Administration, and international partners will do what is necessary in order to achieve this goal by the mid-2030s, but also how we can inspire and harness non-traditional business and other players to become our partners in this effort."

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.

European Astronomical Society Annual Meeting, 202 July 10-14, Krakow, Poland. Special Session SS12, Planets not orbiting main sequence stars

Extrasolar planetary science does not end when host stars leave the main sequence! Studies of planetary systems found within off-main sequence stellar environments represent an under-explored yet essential area of research within exoplanet science, which provides chemical and dynamical information not attainable in main-sequence planetary systems.

Special Session SS6 10 July 2023, Formation of planetary systems: connecting theory and observations

The new observations of young stars with their surrounding disks and the raising number of known exoplanets bring new constraints on the planet formation process. Thus, in recent years the planet formation theory is undergoing major changes. The goal of this special session is to facilitate discussion between observers and theorists working on planet formation.

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.

Publications

Eclipse timing variations in post-common envelope binaries: Are they a reliable indicator of circumbinary companions?

A paper by four BAA members; D. Pulley, I. D. Sharp, J. Mallett, S. von Harrach Post-common envelope binary systems evolve when matter is transferred from the primary star at a rate that cannot be accommodated by its secondary companion. A common envelope forms which is subsequently ejected resulting in a system with a binary period frequently between 2 and 3 hours. Where circumbinary companions are predicted, it remains unclear whether they form before or after the common envelope ejection. From observations of eclipse time variations (ETVs), exoplanet databases e.g. NASA Exoplanet Archive, list typically a dozen systems with confirmed circumbinary planets. Here we examine seven of these systems, discuss other possible causes and consider whether, for these dynamic systems, the ETV methodology is a reliable indicator of planetary companions

A framework for the architecture of exoplanetary systems. I. Four classes of planetary system architecture - Lokesh Mishra, Yann Alibert, Stéphane Udry, Christoph Mordasini

A framework for the architecture of exoplanetary systems. II. Nature versus nurture: Emergent formation pathways of architecture classes
L. Mishra1,2, Y. Alibert1, S. Udry2, C. Mordasini1

The first paper of this series proposed a model-independent framework for characterising the architecture of planetary systems at the system level. There are four classes of planetary system architecture: similar, mixed, anti-ordered, and ordered. The second paper
investigates the formation pathways leading to these four architecture classes.

Astrobiology and the search for life elsewhere

Jupiter's moon Europa

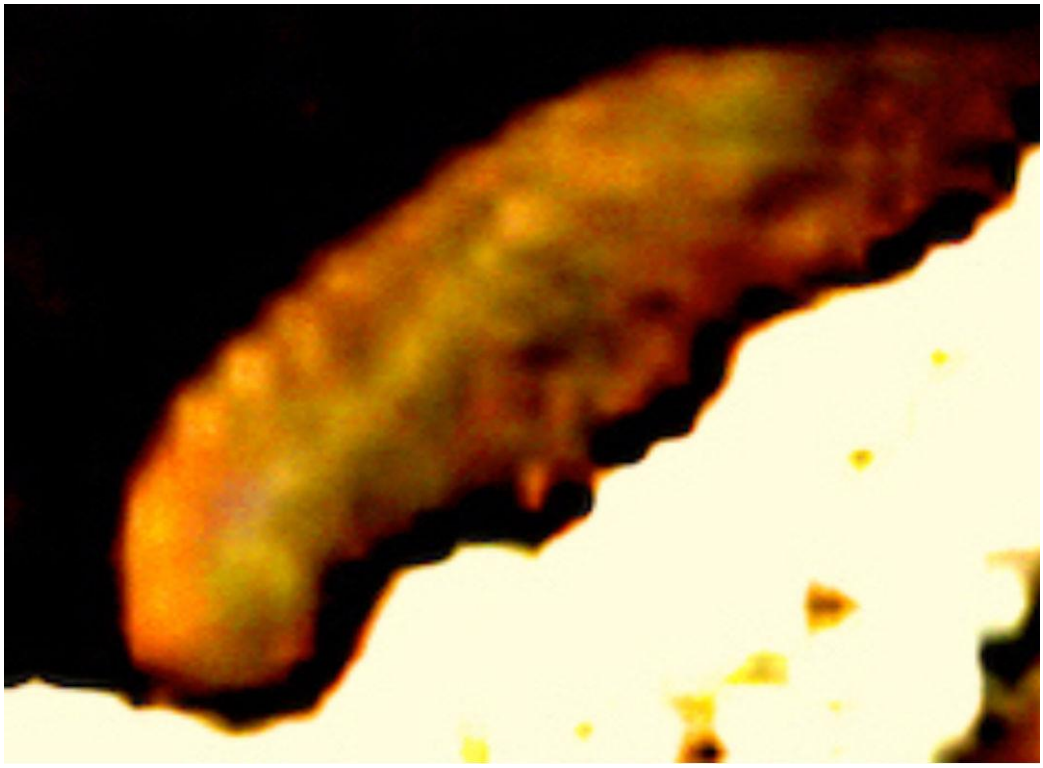
13 minute Video - NASA Claims That Jupiter's Moon Europa Is Home To Otherworldly Life. Thanks to Steve Knight, Hampshire Astronomical Group. As

mentioned in this video, Professor Monica Grady has stated that ‘It's 'almost a racing certainty' there's alien life on Jupiter's moon Europa—and Mars could be hiding primitive microorganisms, too’.

How did Earth get its water?

A breakthrough study from researchers at Carnegie Science and UCLA suggests that the origins of Earth’s water may be linked to the interactions between hydrogen-rich atmospheres and magma oceans of the planetary embryos during Earth’s formative years. The research, published in the journal *Nature*, offers new insights into the development of Earth’s signature features and has significant implications for our understanding of the planet’s evolution.

Arthropods on Mars: Evidence of Life



A semi-translucent millipede-like organism photographed in Gale Crater on Sol 0553 Image from referenced paper.

As presented in this report numerous fossils like forms resembling a variety of marine arthropods including crustaceans, sea spiders, scorpions, arachnids, nematodes, annelids, tube worms, sea snakes, Kimberlla, Namacalathus, Lophotrochozoa, armored trilobites and millipedes have been found in Gale Crater

(on Sols 302, 553, 753, 781, 809, 869, 880, 905, 1032), and (annelids, tube worms, crustaceans) in Meridiani Planum both of which have hosted rivers, lakes, and inland seas.

JWST Unveils Dark Side of Pre-stellar Ice Chemistry

If you want to build a habitable planet, ices are a vital ingredient because they are the main source of several key elements — namely carbon, hydrogen, oxygen, nitrogen, and sulphur (referred to here as CHONS). These elements are important ingredients in both planetary atmospheres and molecules like sugars, alcohols, and simple amino acids. An international team of astronomers using NASA's James Webb Space Telescope has obtained an in-depth inventory of the deepest, coldest ices measured to date in a molecular cloud. In addition to simple ices like water, the team was able to identify frozen forms of a wide range of molecules, from carbonyl sulphide, ammonia, and methane, to the simplest complex organic molecule, methanol. This is the most comprehensive census to date of the icy ingredients available to make future generations of stars and planets, before they are heated during the formation of young stars.

A nearby potentially habitable Earth-mass exoplanet

A team of astronomers led by MPIA scientist Diana Kossakowski have discovered an Earth-mass exoplanet orbiting in the habitable zone of the red dwarf star Wolf 1069. Although the rotation of this planet, named Wolf 1069 b, is probably tidally locked to its path around the parent star, the team is optimistic it may provide durable habitable conditions across a wide area of its dayside

Web sites of interest

The Data Analysis Center for Exoplanets (DACE)

The Data Analysis Center for Exoplanets (DACE) is a facility based at the University of Geneva dedicated to extrasolar planets data visualisation, exchange and analysis. DACE is a new project, with more tools and data being implemented regularly. At the moment, DACE provides access to CORALIE, HARPS-S and HARPS-N data to registered users (Geneva planet search group collaborators). Kepler data are available to any visitor of DACE through sophisticated visualising tools as well as a few basic data analysis tools. In the near future, all published radial velocity data will

be made available to the public with dedicated data visualisation and analysis tools. DACE will be further developed, including a wide range of observational and theoretical data with the tools to analyse and compare them.

Are we alone in the universe?

UCLA SETI uses the largest fully steerable telescope on Earth to search for evidence of civilizations in the Galaxy. We observe stars and their planetary systems at radio frequencies with the goal of detecting signals emitted by radio beacons or other powerful radio emitters. So far, we have observed 42,000 stars and detected over 64 million radio signals. Help us identify the most promising signals in our data. You will classify signals by matching them to common classes of radio frequency interference (RFI).

Space – stepping stones to other star systems

European manned space flight

1) Terra Novae 2030+ Strategy Roadmap

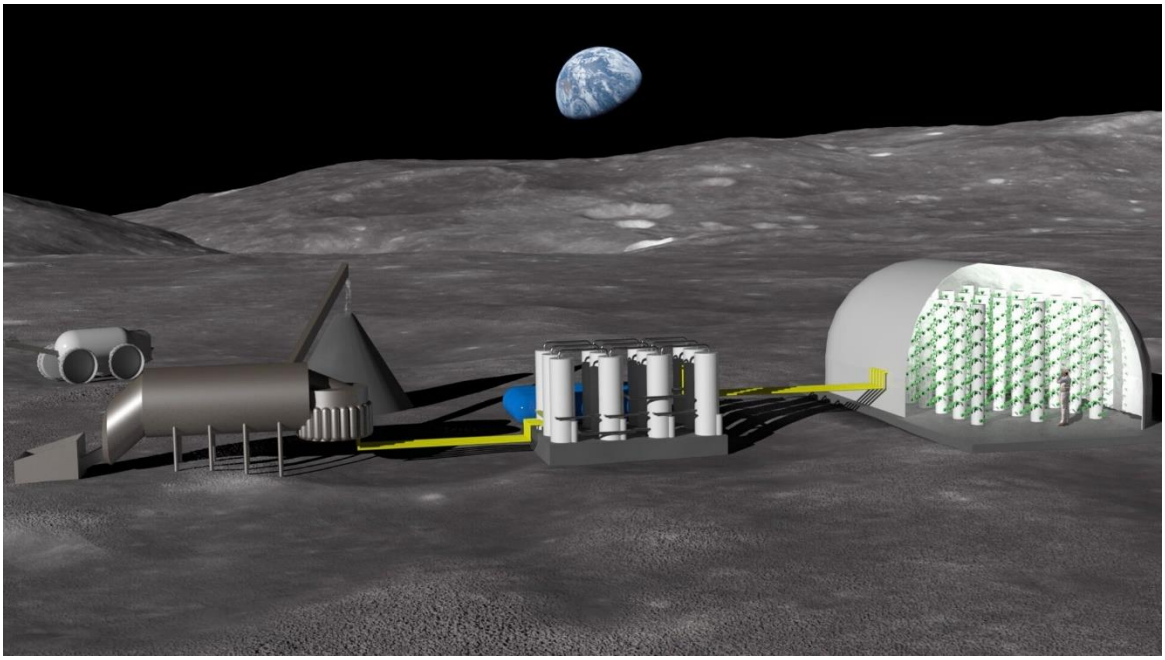
The mission of the Terrae Novae exploration programme is to lead Europe's human journey into the Solar system, using robots as precursors and scouts, and to return the benefits of exploration back to society.

Terrae Novae has the literal meaning of the 'New Worlds' that encompasses the three ESA exploration destinations: Low Earth Orbit (LEO), Moon and Mars. It evokes the spirit of new discoveries, new ambitions, new science, new inspiration, and new challenges. It symbolises the constant quest for technological, process and procurement innovations that result in new and better ways to deliver the programme.

2) Revolution Space

The European Space Agency, which currently partners with NASA and others for its astronaut program, is assessing a report from a high-level advisory group that recommends developing independent capabilities including crewed vehicles, a commercial space station, and a European human landing on the Moon within a decade

The Moon



Artist's impression of a regolith sorting area Credit ESA

Farming on the Moon

Sooner or later, settlers on the Moon will have to become farmers. A new ESA Discovery project led by Norway's Solsys Mining is looking into the treatment of lunar soil to create fertiliser for growing plants. The good news is that analysis of lunar samples returned to Earth in the past by Moonwalkers and robots shows sufficient essential minerals are available for plant growth, apart from nitrogen compounds. The bad news is that lunar soil (or 'regolith') compacts in the presence of water, creating problems for plant germination and root growth. Hydroponic farming therefore offers a practical alternative; this type of agriculture involves feeding plant roots directly with nutrient-rich water, without the need for soil. The potential is still there however to put lunar regolith to work, on the basis of 'in-situ resource utilisation' – or living off the land.

ESA invites space firms to create lunar services

The European Space Agency is inviting private space companies in Europe and Canada to create a shared commercial telecommunication and navigation service for lunar missions by putting a constellation of satellites around the Moon. ESA will either lead or be an international partner in many of these lunar missions – robotic and crewed – including those that envisage a permanent lunar presence.

Telling time on the Moon

A new era of lunar exploration is on the rise, with dozens of Moon missions planned for the coming decade. Europe is in the forefront here, contributing to building the Gateway lunar station and the Orion spacecraft – set to return humans to our natural satellite – as well as developing its large logistic lunar lander, known as Argonaut. As dozens of missions will be operating on and around the Moon and needing to communicate together and fix their positions independently from Earth, this new era will require its own time.

How about timekeeping on Mars? See below

Hidden water source on the Moon

The moon is strewn with minuscule beads of glass that have formed over billions of years as soil ejected during asteroid impacts cools and falls back to the lunar surface. An analysis of lunar samples delivered to Earth by China's Chang'e-5 probe has now revealed that those beads contain a substantial amount of water.

NASA names astronauts for Artemis II mission

NASA and the Canadian Space Agency (CSA) announced the four astronauts, Reid Wiseman, Victor Glover, and Christina Hammock Koch, and CSA astronaut Jeremy Hansen, who will venture around the Moon on Artemis II, the first crewed mission on NASA’s path to establishing a long-term presence at the Moon for science and exploration through Artemis.

Mars

Telling time on Mars

The article linked to was written by Stefan DuBois, volunteer for The Mars Society. Using Earth time to measure events on Mars would have little practical benefit; even if clocks were initially synchronized between the two planets, the 40-minute time differential per day means that Earth time would rapidly diverge to the point where it had no bearing on the local solar time at Mars. Proposed alternatives to Earth time have included adding a 25th partial Earth hour at the end of each sol, an altogether new system based on powers of 10, and stretching terrestrial measurements to preserve the convention of a 24-hour day. The last of these has been the method which Mars missions have employed to date.

Roger Dymock
ARPS Assistant Director Exoplanets