'Habitable Worlds Observatory (HabWorlds)' Abstracts

Talks

The Habitable Worlds Observatory in the UK

Authors

Martin Barstow (1), On behalf of the UK HWO community

(1) University of Leicester

Abstract

The Habitable Worlds Observatory will be the next NASA flagship mission following JWST and Roman Space Telescope. Its headline goal is to search for Earth-like planets orbiting stars in our galaxy and search for evidence of life through characterisation of their atmospheres and surfaces. However, it will be an observatory type mission, with the ability to cover a wide range of science goals addressing the interests of most of the astronomical community. Like past flagships it will be an international endeavour, with key mission components provided by other agencies and countries. The UK is planning to lead the provision of a core focal plane instrument and considering the provision of subsystems for others. We have developed the UK community through a series of open workshops and have recently completed several UKSA-funded instrument studies. This presentation will report on progress regarding UK participation in HWO, including outcomes from the instrument studies and discuss the next steps for the community.

Using galaxy evolution simulations to predict planet habitability beyond Earth

Authors

Rob Yates (1)

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Abstract

In this talk, I will discuss how the latest generation of galaxy evolution simulations can aid the HWO community by providing meaningful predictions for the location and chemical composition of extrasolar planets in the Milky Way, Local Group, and beyond.
I will start by giving a brief overview of recent progress in the study of galactic habitable zones using simulations, followed by signposting some exciting future developments in this field. In particular, I will present the cosmological-scale L-GALAXIES simulation and super-high-resolution EDGE simulation, which are both optimised for galaxy chemical evolution research. The efficiency and size of L-GALAXIES makes it ideal for testing planet formation models on very large samples of galaxies (including Milky Way analogues) evolved over their entire lifetime in a fully cosmological context. The unrivalled resolution of EDGE (down to $\sim$ 20Msun in gas mass and $\sim$ 3 pc in size) allows it to resolve individual massive stars and supernovae (SN), allowing us to embed planet formation models in a realistic galaxy context to assess habitability in SMC- and LMC-like dwarf galaxies. These simulations already model the key building blocks required for habitable planet formation, including chemical elements, dust, sterilisation sources (e.g. SNe, AGN and GRBs), and (soon) complex organic molecules. The natural next step is to provide statistically significant estimates of exoplanet demographics for HWO, by considering much more realistic input parameters and galaxy contexts than previously possible. This will help guide our search for life in the Universe from a rigorous theoretical perspective.
I will also present our plans to combine these two simulations through advanced Bayesian Inference techniques to create a synchronised simulation suite which will coherently map the processes driving star and planet formation at scales of a few pc to the entire Universe. These plans are made possible by our recently awarded UKRI-STFC funding, enabling us to maximise the UK's involvement in this rapidly evolving field alongside HWO's own involvement.

Determining PSF stability requirements for low-mass dark matter subhalo detection with the Habitable Worlds Observatory

Authors

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Abstract

Dark matter comprises 85\% of all matter in the universe, yet its fundamental nature remains unknown. Different theoretical frameworks of dark matter (WDM, CDM, SIDM, etc.) predict vastly different populations and morphologies of small-scale substructure within galactic dark matter halos. While current telescopes can only detect subhalos above $\sim 10^8\,M_\odot$, the upcoming Habitable Worlds Observatory (HWO) may achieve the sensitivity needed to probe the $\sim 10^6$--$10^7\,M_\odot$ regime, where competing theories diverge. This project develops HWO-SLAPS (HWO Strong Lensing Analysis Pipeline for Subhalos), a comprehensive simulation framework to determine the point spread function (PSF) quality and stability requirements necessary for this detection. The pipeline simulates galaxy-galaxy strong lensing systems with embedded subhalos and propagates them through a realistic segmented-mirror PSF model with various aberration modes, including segment-level hexagonal Zernike modes. It then adds detector and instrumental noise to create a mock observation and uses Fisher information matrices to forecast detection significance and parameter uncertainties as a function of subhalo mass and PSF stability. By systematically varying PSF aberrations (Zernike modes Z_4--Z_{50}) and temporal stability parameters at both global and segment-level scales, we map the minimum detectable subhalo mass as a function of PSF wavefront error and drift. These results inform quantitative tolerances on PSF stability and engineering requirements for HWO to robustly detect $\sim 10^6$--$10^7\,M_\odot$ subhalos, while also providing a general framework for connecting optics stability to dark matter science yield.

Feasibility of life-forming planets around K-Dwarf planets (Online)

Authors

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Abstract

With over 5,000 exoplanets discovered to date [1], identifying which host stars are most conducive to life has become a central question. While M-dwarf stars have received considerable attention, K stars remain comparatively understudied. However, compared to M dwarfs, K dwarfs have shorter pre-main-sequence phases (<0.1 Gyr compared to up to 1 Gyr for M dwarfs) [2], and are less active with longer main-sequence lifetime, making them more favorable candidates for the emergence and evolution of life. From an initial pool of 740 K-star exoplanets sourced from the NASA Exoplanet Archive, we identified 26 as HZ (Habitable Zone) candidates using both conservative and optimistic HZ limits from Kopparapu et al. [3]. The majority of them fall within 0.4–4 AU of their host star, with a small number of outliers at larger orbital distances likely corresponding to giant planets. Out of these 26, five planets — Kepler-62 e, Kepler-62 f, TOI-2134 c, TOI-4600 c, and Kepler-1661 b — had sufficient mass and radius data to attempt density-based categorization. Our density analysis of these five planets suggests mostly gaseous compositions, though some showed unusually high densities (as high as 68 gm/cubic cm), possibly due to limitations in the observational data, calling for possible re-examinations of these objects. We also examined UV flux levels at the HZ of K-type stars, which were estimated using a blackbody approximation and found to be lower than current Earth levels, further supporting a more benign radiation environment for life. This is consistent with earlier research [4], which reports that young planets orbiting K dwarfs are subjected to 5–50 times lower UV and X-ray fluxes compared to early M dwarfs, and 50–1000 times lower compared to late M dwarfs. The effects of orbital eccentricity, tidal locking, and binary star dynamics on the habitability of these candidates are also being examined, as several planets in our sample are subject to one or more of these conditions. With K dwarfs comprising 12% of the main sequence population — more than G and F dwarfs combined — and their lower luminosity making their planets easier to detect via direct imaging [5], they represent a large and observationally accessible sample for such investigations.

Reference:
[1] NASA Exoplanet Science Institute, "Exoplanet Exploration", NASA, 2026, science.nasa.gov/exoplanets/how-many-exoplanets-are-there/
[2] Luger & Barnes, Astrobiology, 15(2), 119–143, 2015
[3] Kopparapu et al., ApJL, 787(2), L29, 2014
[4] Richey-Yowell et al., ApJ, 872(1), 17, 2019
[5] Arney, ApJL, 873(1), L7, 2019

Detector developments for HWO and other UV missions

Authors
Jason Gow (1)

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Abstract
To ensure the success of the Habitable Worlds Observatory (HWO) and future space-based observatories, the Centre for Electronic Imaging at The Open University is conducting a comprehensive programme of research, development, and testing aimed at advancing ultraviolet (UV) detector technologies. The space qualification of high-performing, UV-enhanced sensor technologies is essential, because Earth's atmosphere absorbs a large proportion of UV light. Our work includes testing and derisking of UV enhancement technologies down below 100 nm; testing and optimising the next generation of CMOS image sensors, such as the CIS300 series detectors from Teledyne e2v; and developing new photon-counting sensor technologies. Collectively, these activities will position UK academia and industry to make substantial contributions by delivering critical sensor hardware for HWO and other future space science missions.

Science highlights and updates from the HWO-UK meeting in London (Invited)

Authors

Vincent Van Eylen (1), Mat Page (1), Daniel Dicken (2)

(1) MSSL
(2) UKATC

Abstract

Update on science highlights, instrument concept studies and news from the Habitable Worlds Observatory UK Community Workshop, which was held this June in London.

Posters

Direct imaging of cold giant planets with HWO

Authors

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Abstract

Cold gas giant exoplanets, analogous to Jupiter and Saturn in our own solar system, are so far poorly characterized due to current observational limitations. Jupiter and Saturn and their migration played an important role in the formation of our own solar system, and their exoplanet counterparts are likely to have similarly influenced other systems with potentially habitable rocky worlds. Constraining the atmospheric properties of Jupiter and Saturn analogues can help to place the evolution of the solar system in context.
NASA's Habitable Worlds Observatory (HWO), due to launch in the mid-2040s, will boast a coronagraph capable of imaging and spectroscopically characterizing solar system analogue planets orbiting nearby, sunlike stars. Designed to achieve star:planet contrast ratios of 10^{10}, HWO will cover wavelengths from the UV to the near infrared, allowing the reflected starlight from these planets to be measured. Whilst a primary goal of the mission is to discover potentially habitable rocky worlds, it will also provide vital data to help us understand their larger, gaseous siblings. This will bridge the current observational gap between hot transiting exoplanets and the solar system gas giants.
We present our science case developed as part of the HWO START initiative, describing how HWO will determine key atmospheric properties of cold gas giants. These include molecular composition, cloud and haze characteristics, and temperature structure, across planets of varying sizes and orbital separations. Via reflected light spectroscopy and polarimetry, HWO will enable comparative planetology of cool gas giants orbiting both solar-type and M-dwarf stars. We describe the observational requirements, including ideal wavelength ranges, and survey strategies necessary to uncover correlations between atmospheric properties and planetary or stellar parameters. Cold gas giant observations with HWO will establish critical constraints on planetary formation, cloud microphysics, and the role of photochemistry under diverse irradiation conditions.