Exploring Exo-Venuses with JWST

Supervision team:

Dr Joanna Barstow, Professor Carole Haswell and Professor Stephen Lewis

Lead contact: Dr Joanna Barstow

Description:

Over the last decade, we have started to uncover details of exoplanet atmospheres using the technique of transmission spectroscopy. When the planet crosses in front of its parent star during orbit, some of the starlight is filtered through the atmosphere, emerging with a fingerprint of any absorbing gases and aerosols that are present. Currently, we are most capable of doing this for hot, gas giant planets with hydrogen-helium atmospheres, and smaller, cooler planets present a challenge.

Venus is the planet in the Solar System with the greatest similarity to Earth in terms of its size and mass, yet its evolutionary history has culminated in an incredibly hot, acidic and inhospitable world. Studying Venus-like planets around other stars will help us to understand how this might have happened.

In October 2021 we expect the James Webb Space Telescope to launch, which will enable us to perform the sort of measurements for Earth-sized exoplanets that have, until now, only been possible for gas giants. Among these will be a population of planets with temperatures similar to that of Venus. Rocky planets are expected to have atmospheres dominated by nitrogen or carbon dioxide, rather than hydrogen and helium, and therefore modelling tools specific to these types of atmosphere must be developed in order to interpret the observations.

Comparing results for ‘exo-Venuses’ with the detailed information we have for Venus itself will provide insights into the uniqueness of Venus’s evolution. In turn, Venus can be used as to benchmark our expectations of Venus-like exoplanets.

The student will contribute to:

- Further development of the NEMESIS atmospheric modelling and retrieval suite, which has been applied to numerous scenarios in Solar System and exoplanet science.
- Developing new modelling templates and strategies suitable for JWST observations of warm, rocky planets
- Applying new modelling techniques to Guaranteed Time observational data from JWST, and proposing further observations
- Analysis of modelling results and comparison of results from different planets
- Publication of results via journal articles
- Presentation at national and international conferences

Continued

Whilst normally conference attendance would involve international travel, in the current climate participation is virtual. There will also be the opportunity to become involved in planning for the European Space Agency Ariel mission, which aims to launch in 2029 and characterise the atmospheres of 1000 exoplanets.

The scheduled start for this project is February 2022.

References:

1. Irwin, P. G. J. et al. 2008, The NEMESIS planetary atmosphere radiative transfer and retrieval tool, JQSRT, 109, 1136 https://ui.adsabs.harvard.edu/abs/2008JQSRT.109.1136I/abstract
2. Barstow, J. K. et al. 2015, Transit spectroscopy with James Webb Space Telescope: systematics, starspots and stitching, MNRAS, 448, 2546 https://ui.adsabs.harvard.edu/abs/2015MNRAS.448.2546B/abstract
3. Barstow, J. K. et al. 2016, Telling twins apart: exo-Earths and Venuses with transit spectroscopy, MNRAS, 458, 2657 https://ui.adsabs.harvard.edu/abs/2016MNRAS.458.2657B/abstract
4. Kostov, V. B. et al. 2019, The L 98-59 System: Three Transiting, Terrestrial-size Planets Orbiting a Nearby M Dwarf, AJ, 158, 32 https://ui.adsabs.harvard.edu/abs/2019AJ....158...32K/abstract

Qualifications required: Equivalent to 4-year integrated masters. Experience in either Fortran or Python would be desirable, but is not a requirement.