Detectors and Science Implications for the Habitable Worlds Telescope

Supervision team:

Dr. Jesper Skottfelt, Dr. Jo Barstow

Lead supervisor: Jesper Skottfelt (jesper.skottfelt@open.ac.uk)

Artist's impression of the current HWO design
(Credits: NASA's Goddard Space Flight Center Conceptual Image Lab)

Project highlights:

- The Habitable World Observatory is the next NASA flagship mission, and the development of UV-optimised detectors is of key importance to its success
- Gaining experience in UV imaging and instrumentation for space applications
- Linking detector performance to the scientific output
- The work will be done in collaboration with numerous national and international partners, especially NASA, and will allow the student to build an invaluable professional network

Project description:

The Ultra-Violet (UV) part of the spectrum, which lies between X-rays and visible light, is very important for several astronomical topics, including the characterisation of exoplanet atmospheres and surface compositions, star formation and evolution, and chemical enrichment of nearby galaxies and clusters. However, UV light is very effectively blocked by Earth's atmosphere, and spaceborne UV telescopes are therefore essential, especially if faint objects are targeted.

The next NASA flagship space telescope, the Habitable Worlds Observatory (HWO), will be targeting a wide wavelength range, with special emphasis on the UV. The development and testing of UV-optimised detectors are therefore of great importance. Silicon-based detectors are still preferred, but silicon is highly absorbing at UV wavelengths, and the incoming photons get stopped in the "dead layers" covering the top few nanometres of the surface. Even with UV-optimised anti-reflective coatings, silicon detectors will only detect <50% of incoming photons at UV wavelengths (70-350 nm). To maximise the scientific return from these missions, technologies are being developed to maximise the detection efficiency in the UV band.

The Centre for Electronic Imaging is involved in the development and testing of detectors for HWO and other UV space telescopes and has extensive testing facilities that can be used to assess the performance of these detectors.

The student will be working closely with Teledyne e2v (Te2v), a world-leading provider of detectors for space and ground-based telescopes, and the team at the Open University that is working on the detectors for HWO and a Canadian-led UV space telescope called CASTOR. This work involves testing, developing, and space qualifying UV coatings and detectors for the instruments on these missions, and is part of a collaboration with NASA/JPL and several UK, EU, and Canadian research institutions.

The other part of the project would be to model how the performance of the detectors, especially in the UV region, impacts the spectroscopic information that can be recovered from the scientific data. HWO will be the first telescope that will allow direct imaging of temperate and cool planets, analogous to those in our own solar system. The student will use NEMESISPY, a radiative transfer and spectral inversion tool, to simulate the reflected light spectra of a range of hypothetical HWO target planets, including Jupiter, Venus and Earth-like worlds. They will use these simulations to determine how different short wavelength limits in the UV would affect the information that can be recovered about these targets, in particular, whether different atmospheric gases would be detectable or not. Key UV-detectable species include ammonia and phosphine for cool gas giant targets, and sulphur dioxide and ozone for rocky Venus or Earth-like planets.

The project therefore offers the opportunity to gain knowledge of both the technical and scientific side of HWO and be a part of a large international team in the early phase of the definition of a large space telescope.

References:

1. https://arxiv.org/abs/2408.07242
2. https://oro.open.ac.uk/99688/
3. https://arxiv.org/pdf/1604.05370
4. https://arxiv.org/pdf/2308.08490
5. https://arxiv.org/pdf/2407.06932

Qualifications required: a BSc 2:1 or a MSc in physics, astronomy, or similar area.