Infrared image sensors for space and Solar System exploration

**Supervision team:** Dr Konstantin Stefanov, Dr Martin Prest  
**External supervisor:** Ross Wheeler (Teledyne e2v)  
**Lead contact:** Dr Konstantin Stefanov

**Project highlights:**
- Characterisation and development of novel space-qualified infrared image sensors.
- Applications include search for ice deposits and valuable minerals on the Moon, Mars and elsewhere in the Solar System, as well as Earth observation.
- Research and training in infrared image sensors, characterisation techniques, radiation damage effects, cryogenic irradiation.
- In partnership with Teledyne e2v, a world-leading manufacturer of scientific image sensors.

**Project description**

**Summary:** The project will help characterise and develop a new generation of medium wave infrared (MWIR) image sensors and assist in creating a UK capability with relevance to the scientific, commercial and defence markets. Using InAsSb/InAs as an absorber, the image sensors have disruptive potential for future space-based instrumentation and Solar System exploration missions.

**Background:** Imaging in the MWIR band is one of the key techniques for the investigation of the chemical composition of materials and gases in remote observations. Covering the 3 to 5 micrometre band, space-based MWIR imaging and spectroscopy is used to monitor hydrocarbons and other greenhouse gasses, as well as crop hydration and condition. Elsewhere in the Solar System, prospecting for ices and hydrated mineral deposits using the MWIR band is an important precursor to in-situ resource utilisation (ISRU). The vast majority of IR sensors deployed in space, such as those in many Earth observation satellites, are based on HgCdTe (MCT) technology [1]. MCT has excellent performance, but is expensive and often subject to export restrictions, limiting its availability. Recently, novel barrier-based III-V
semiconductor devices have shown great promise as MWIR sensors. Using InAsSb/InAs as an absorber, they can operate at temperatures in the 77-150 K range and have great potential for future space-based imaging instrumentation.

**Project plan:** The project will carry out detailed characterisation of the electro-optical parameters of III-V MWIR image sensors and their radiation hardness for space applications. Initial studies will concentrate on the performance of diode arrays, developed in a collaboration between Teledyne e2v and Amethyst Research Ltd [2]. Preliminary studies have indicated that the radiation damage largely anneals at room temperature, which necessitates that the sensor is kept at cryogenic operating temperatures throughout the irradiation and characterisation. The CEI is one of the pioneers of cryogenic irradiation and has extensive know-how in this technique, which was successfully used in the characterisation of the CCDs for the EUCLID space telescope. The barrier-based InAsSb/InAs photodiodes developed by Amethyst have a potential for increased radiation hardness using a built-in electric field, and wider spectral bandwidth with the help of strained layer superlattice structures. Later in the project, hybrid focal plane arrays will be available from Te2v, and the task will be to perform comprehensive electro-optical characterisation of their quantum efficiency, dark current, and radiation hardness.

**References:**


**Qualifications required:**

At least 2:1 BSc or a MSc in physics, electronic engineering, or a related discipline.