Development of Next-Generation X-ray Detectors for Astronomy

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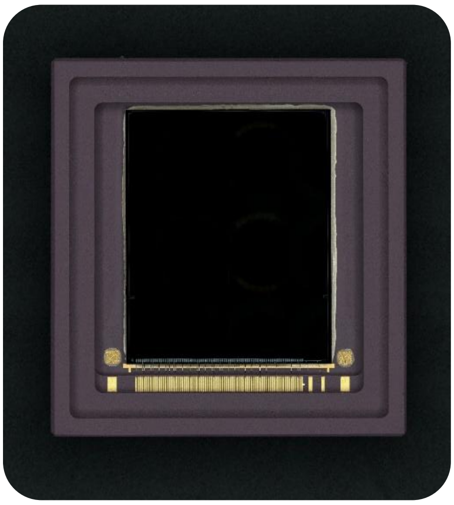

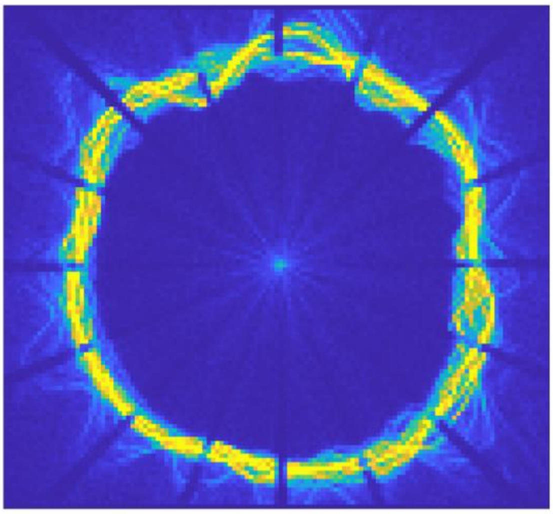

Project highlights:

- Work closely with the European Space Agency (ESA) and Teledyne e2v (UK), a world-leading manufacturer of image sensors for space applications
- Contribute to and work on cutting-edge detector technology for future X-ray space instrumentation
- Hands-on laboratory training and experience of characterising novel detectors within a large multidisciplinary research group
- Combined academic and industrial supervision and training in a best-of-both-worlds studentship
- Potential for national and international travel to experimental facilities, and to conferences and meetings to showcase research

Project description:
The Centre for Electronic Imaging (CEI) is a large multidisciplinary research group at the Open University specialising in the design, characterisation, radiation testing and optimisation of detectors for space and planetary science. The CEI works with global space agencies including ESA, NASA, CSA, and ISRO, developing and testing detector technologies that have now flown successfully on numerous missions, including Gaia and Euclid, alongside detector design work for the upcoming NASA Nancy Grace Roman mission. It benefits from knowledge exchange with its industrial partner, Teledyne e2v – a world leader in space imaging technology. Our expertise spans from modelling radiation doses to detectors to, more recently, post-launch ground support for large space missions in astronomy and planetary science.

Although CCD technology has dominated imagers for space and planetary science instruments thus far, CMOS image sensors (CIS) are fast becoming a preferred option due to improvements in the technology – already ubiquitous in smartphone cameras – alongside their greater tolerance to radiation damage effects and lower power requirements. CIS technology was thus adopted for the JANUS camera on board ESA's JUICE mission (launched April 2023), and later generations of CIS detectors have been developed in collaboration with Teledyne e2v.

More recently, a CIS prototype detector was developed by the CEI under ESA funding, utilising novel pixel design to enable soft (i.e. low energy) X-ray detection for the proposed ESA THESEUS mission. The new detector, named CIS221-X, shows great promise in fulfilling the requirements of the soft X-ray imager (SXI) instrument on board THESEUS [1,2], but the technology must be developed further over the coming years. This includes the delivery of a significantly larger sensor, which is underway now. This detector has also gained the attention of researchers at MIT Kavli Institute, and a collaboration with the CEI is now focusing on potential future applications in NASA missions.

The CEI is also working on exploiting the detector technology in X-ray imaging telescopes of the future, such as an X-ray interferometer [3]. A future X-ray interferometer (XRI) will improve the spatial resolution over the current state of the art by a factor of ~10,000, potentially enabling numerous new discoveries and entirely new fields of study. This studentship will evaluate dedicated XRI pixels in the HDR2 CIS test device, recently fabricated through CEI's internal R&D. HDR2 contains three pixel variants with size of 10×50 μm as a close match to the preliminary detector requirements, made on 24 μm and 40 μm-thick reverse-biased silicon. The pixels use shaped pinning implants to eliminate image lag, as pioneered for the CIS221-X, and exhibit readout noise below 2 e^- RMS.

A new test system will be built for the laboratory characterisation of the spectral resolution, linearity, uniformity and dark current of HDR2 at temperatures reaching -40 °C. The spatial resolution will be characterised at the PolLux X-ray facility at the Swiss Light Source (SLS), which can provide narrowly focused monochromatic beams, and will be compared to theoretical models. Testing of this kind was pioneered in the CEI for synchrotron applications and will be further developed for the XRI requirements for the first time.

The student will be provided with training and support to perform laboratory characterisation alongside post-doctoral researchers in the group, and will participate in experimental campaigns involving international travel to specialist test facilities. The student would have opportunities to collaborate closely with ESA, and support any ongoing collaborations with other external groups.

Please note that the award of this studentship is contingent on receiving matched funding from the European Space Agency, once a suitable candidate has been identified.

References:

1. Townsend-Rose, C., Buggey, T., Ivory, J., Stefanov, K.D., Jones, L., Hetherington, O., Holland, A.D. and Prod'homme, T., 2023. Electro-optical characterization of a CMOS image sensor optimized for soft x-ray astronomy. Journal of Astronomical Telescopes, Instruments, and Systems, 9(4), pp.046001-046001.
2. Townsend-Rose, Charles; Buggey, Thomas; Ivory, James; Dazzazi, Imane; Stefanov, Konstantin and Hall, David (2024). Non-ionizing radiation effects in a soft X-ray CMOS image sensor. Journal of Astronomical Telescopes, Instruments, and Systems, 10(3), article no. 036002.
3. Buggey, Thomas W.; Hubbard, Michael W.J; Stefanov, Konstantin; Holland, Andrew D. and Hall, David J. (2024). CMOS image sensors for x-ray interferometry. In: *Proc. SPIE 13103, X-Ray, Optical, and Infrared Detectors for Astronomy XI* (Holland, Andrew D. and Minoglou, Kyriaki eds.), SPIE, article no. 131030A.

Qualifications required: Minimum of a BSc 2:1 or a MSc in a relevant discipline.