CCD quantum efficiency in the UV and soft X-ray regime: impact on calibration for the ESA-CAS SMILE mission and beyond

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Description: SMILE, the Solar wind Magnetosphere Ionosphere Link Explorer, is a joint science mission between the European Space Agency (ESA) and the Chinese Academy of Sciences. SMILE's instruments will explore the interaction between the Earth's magnetosphere-ionosphere system and the solar wind, using in-situ instruments, an ultraviolet imager and a Soft X-ray Imager (SXI). The SXI is a UK-led instrument with two detectors (CCD370s) designed and manufactured in the UK by Teledyne-e2v, a world leading provider of semiconductor imaging devices and systems for science applications.

Through support from the UK Space Agency, the Centre for Electronic Imaging at the Open University is leading the test, characterisation and optimisation of the CCD370s. This builds on expertise which traces back to the group leader's involvement in XMM-Newton, through to our current research on present-day sensors for ESA and NASA missions such as Gaia, WFIRST, JUICE and Euclid. The group's world-leading research in these areas is enhanced by its very strong collaborative links with Teledyne-e2v, which encourages knowledge transfer in both directions on topics from device testing procedures to device physics.

The CCD370s will be optimised for soft X-rays to improve the efficiency of photon detection (Quantum Efficiency, QE) by being manufactured using an enhanced passivation process. This minimises the thickness of non-sensitive layers on the entrance window of the device. The QE must be well characterised in the SXI flight devices to enable accurate processing of the spacecraft's science data.

QE measurement campaigns have demonstrated that the enhanced passivation process is up to 50% better than the standard process at soft X-ray energies with the shortest attenuation lengths. However, the performance does not match current models, signifying that the interaction process is poorly understood.

The PhD will begin by modelling the enhanced passivation process, followed by the soft X-ray interactions and charge dynamics. Experimental synchrotron campaigns that form part of the SXI CCD characterisation study will be used to measure soft X-rays to compare against the models. Parameters and modelling techniques will feed into the SXI calibration activities, working with the team at the Open University to improve the quality of SXI's data processing pipeline, whilst also improving the fundamental understanding of soft X-ray detection at the back surface of CCDs. Once the X-ray detection processes are better understood, recommendations for improved manufacturing process and device architectures would feed into Teledyne-e2v development, and be realised in the manufacture of demonstration CCDs to be tested in the final year of the PhD.

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Understanding the X-ray and charge dynamics at the back-surface of CCDs is essential for optimum reconstruction of the SXI data, and will demonstrate Teledyne-e2v's technology can achieve more constricting science requirements for future soft X-ray observatories. Teledyne-e2v are world-leaders in the supply of scientific imaging sensors, so manufacturing process developments will impact the quality of instrumentation (and therefore science return) in a wide range of future ground and space-based applications, particularly in the soft X-ray and UV regimes.

Qualifications required: Suitable for graduates with a physics (or related) undergraduate degree.