EMCCD detector development for space applications: from WFIRST to future mission opportunities

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Description: (the text below is the full summary text submitted to STFC, however the grey text is included only for completeness and possible use in an advert but is not necessary for the purposes of this internal review)

The Electron-Multiplying (EM) CCD has formed the basis of a successful STFC-funded research programme in the CEI over the last decade. A successful STFC mini-IPS with Teledyne-e2v (Te2v) translated EMCCD technology to applications in synchrotron research, ultimately generating >GBP1M in worldwide sales for a local SME. Following this early success, an STFC-funded CASE student studied the EMCCD gain register; this is the key to the technology, allowing electron signals to be multiplied before conversion to the digital domain, reducing the noise floor to near-zero regardless of the readout speed to enable observation of the faintest of objects in the sky. The student's research [1-3] led to contracts from NASA JPL to further develop EMCCD technology for use in NASA's WFIRST Coronagraph, using the photon-counting capabilities to directly image exoplanets. Te2v produced two test devices containing a selection of variants, designed by the student, with one now selected for use on the mission. Further CEI-developed test structures are also in development. However, the risk-averse and time-pressured nature of space mission development left some of the most interesting design changes yet to be fully explored. With further detailed simulations and testing, there is potential to develop a new, fully optimised detector to dramatically expand the use of this exciting UK technology and provide a step-change for both space and ground-based applications.

Through a combination of complex device simulations and the laboratory study of the aforementioned test structures, in this studentship the student will develop a deeper understanding of the intricacies of the gain process and the generation of all noise sources in the detector currently limiting performance, and study their operation in the highly damaging space radiation environment. Armed with this new knowledge, the student will be able to better optimise current device performance and, most importantly, develop a new and improved design - an EMCCD for future space applications, allowing astronomers and space scientists to look deeper into the sky at objects fainter than ever seen before.

With new test structures freshly available now the project is very timely. Indeed, there is potential for designs produced at the end of the studentship to provide dramatically

improved performance just as the first-light from an EMCCD in space is received through the WFIRST Coronagraph, capitalising on the increased interest in the technology for future missions. Previous STFC-funded CASE studentships with the CEI and Te2v related to novel device development have had great and proven success and provided exceptional scientific return, with major impacts on ESA's Euclid VIS, JUICE JANUS, Athena WFI and SMILE SXI, alongside new device development programmes at Te2v.

This studentship will be hosted by the Centre for Electronic Imaging (CEI) at the Open University. The group has successfully trained many STFC CASE students, all of whom have moved directly into employment following completion, be that with the space agencies (ESA/NASA), related industries, or continuing in academia. Through working closely with our industrial partner, Teledyne-e2v (Te2v), the student will have access to key details and expertise on device design and the subtleties required to understand the complex issues presented. This information is only available through the OU and Te2v's close and long-running collaboration.

Teledyne e2v has been trusted to design and deliver CCD and CMOS imaging sensors and sub-systems for over 150 space missions by the world's largest space agencies, including NASA, ESA, JAXA, CNSA and most recently for the Russian-led World Space Observatory.

References:

1. http://oro.open.ac.uk/58189/
2. http://oro.open.ac.uk/47723/
3. http://oro.open.ac.uk/45133/

Qualifications required: A first class or upper second class MSc/BSc degree in Physics, Electronic Engineering or a related discipline.