Report on the UV Detector Workshop

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A recent workshop at Herstmonceux Castle on 17-19th November 1986 hosted by the Royal Greenwich Observatory brought together some 40 leading experts from all over the world to study "Open-window Detectors for Ultraviolet Astronomy". Workshop participants undertook scientific and technical discussions of detector concepts and designs for the wavelength region 100-2000 Angstroms. The meeting was particularly timely in the context of two potential space projects in this wavelength region: SOHO which is directed toward solar observations and Lyman, a proposed Far and Extreme Ultraviolet observatory for cosmic astronomy. The meeting concentrated on the physical principles underlying each detector as well as performance data. Scientists from commercial research laboratories were present as well as those from universities and government laboratories. Described by one participant as the biggest collection of "detector sharks" ever assembled, the meeting also included a leavening of observing astronomers to provide a strong interest in the eventual use of the detectors.

The workshop started with brief overviews of the Lyman and SOHO missions, covering the general requirements that the foreseen instruments put on detectors. Panoramic photon counting systems are required by both missions. The Lyman requirements are most severe for detector size and number of pixels: detectors 15-25 cm in length with a few million pixels are needed. SOHO is more demanding in its maximum count-rate requirements: a velocity spectrometer covering the Lyman alpha line might need to handle 10 million counts per second over a few pixels. Both missions would like to push pixel sizes as small as feasible toward 10 micron pixels and 20 micron resolution. High quantum efficiency in the wavelength region of interest is always needed but both missions also require good rejection of visible and near ultraviolet light: a ratio in sensitivity of one hundred thousand. There was some mirth however at the application of the phrase "solar-blind" (commonly used in cosmic ultraviolet astronomy) to the SOHO detectors.

After this introduction the meeting covered three main topics. The first was microchannel plates and photocathodes. Microchannel plates (MCPs) are leading contenders for the amplification stage in detectors for this wavelength region. Workshop participants heard of ways of decreasing dark-count by removing radioactive potassium from the glass, of new ways of twisting the channels to avoid ion feedback and of the prospects for MCP's with finer bore sizes less than the currently available 8 micron channel separation. There was considerable discussion of the way MCP's should be prepared by "scrubbing" and back-out. There is a gain loss after exposure to some thousand million photoelectrons but, after increasing the voltage to retain the same gain, eventually a stable detector results.

In the ultraviolet the photoelectrons to be amplified in the MCP's must come from a photocathode. Currently the best developed photocathode for the far ultraviolet is CsI. It offers quantum efficiencies at least up to 30 per cent and can be deposited on the web and in the channels of MCP's. The alternative of KBr photocathodes were also discussed at the meeting and these may have a somewhat better quantum efficiency below 1050 Angstroms. In addition MgF and CuI may be useful photocathodes for some SOHO experiments. There was much debate as to whether CsI photocathodes on a solid substrate had better quantum efficiency that those deposited on an MCP. The workshop concluded that there was no conclusive evidence in favor of this at present but that the issue needed study.

The second main area covered in the workshop was the ways in which the pulses emerging at the back of an MCP or other amplification stage can be read-out. These include wedge-and-strip anodes, coded anodes, multi-anodes, delay-line technology and television techniques. Wedge-and-strip anodes provide an analogue method of locating and centroiding a photon and can achieve very high resolution (15 microns) in small formats (5 millimetres). Predictions of 20 micron full width at half maximum (FWHM) resolution over a 50mm detector were made but the wedge-and-strips are limited in the count rate they can achieve so that a partitioned system would be necessary for the largest formats. It was noted that for special applications the anode pattern can be shaped individually to match the format of the spectrum. Anodes can also be coded to give a binary readout of the photon location.

The same effect with additional centroiding possibilities are available with multi-wire anodes (MAMAs). Space qualified variants of the MAMA detector now exist and a large (four million pixel) version is under development for a second generation Space Telescope instrument. Currently the MAMA pixels are large and laboratory experiments into the best attainable resolution are still in progress but smaller pixels may be possible.

A new exciting possibility of using a delay-line method for locating photons was presented at the meeting. This uses a pair of zigzag delay lines to read out the MCP charge cloud in the spectral direction and wedge-and-strip techniques in the orthogonal spatial direction where the resolution demanded is cruder. Developments will be watched with interest.

Finally television techniques of read-out are available in which the charge image is transfered directly or indirectly to a charge-coupled device (CCD). One scheme employing a photocathode on a solid substrate uses electromagnetic focussing to accelerate and transfer the photoelectrons to the CCD. A small version has been demonstrated in a rocket flight and study of extending the concept to the much larger Lyman format is under way. Design of a suitable permanent magnet assembly is in progress and it is believed that this can be done without a severe weight penalty. An alternative well-developed concept involves the use of a phosphor and fibre-optic boules to transfer the MCP output to the CCD. This solid and physically stable device is a development in regular use in ground-based astronomy and a space-qualification programme is in progress. Current pixel sizes give a 50 per cent modulation at 20 line pairs per millimetre.

The third main topic at the workshop was the capabilities offered by direct CCDs. The key to the use of CCD detectors in the far and extreme ultraviolet lies in understanding and improving the electrical properties of the surface layer of back-illuminated CCDs. Normal CCDs have a dead layer on the surface some 1000 Angstroms deep, controlled by the oxide that traps negative charges and grows on the surface in hours. Ideas to remove this include charging the backside by an ultraviolet flood, implanting a conducting layer of boron and using an electron donor layer (e.g. platinum) to fill the electron traps. In these ways CCDs with 20 to 30 per cent quantum efficiencies near 1000 Angstroms can be made but the main problem is that the CCDs also are excellent detectors of optical photons. Various ideas to make CCDs optically-blind were proposed but this field obviously needs further work.

In a final general discussion, other concerns emerged. The radiation environment of the detectors and their associated electronics was discussed since both missions may operate above the Earth's radiation belts. What is known from previous missions suggests problems are not severe if the detectors are shut down during transit of the belts themselves but data on the effects on the ultraviolet spectrometer on Voyager during its passage through planetary radiation belts might be useful. Another general concern was whether some of the types of detectors presented might show fringing effects between the MCP pores and the pixel spacing: fourier transforms of flat-field calibration exposures should reveal any such micro-nonuiformities. Maximum count-rate limits are a concern in two areas. Firstly the time required for high signal-to-noise flat-field calibration frames is of order of hours and a stable detector therefore has the important advantage that it requires less calibration. Secondly high local count-rates will be needed to observe the bright stars studied by the Copernicus satellite and to link with the current astrophysical flux scale. A recurrent topic throughout the meeting was the relationship of pixel size to resolution and the need to understand exactly the specifications to be put on detector performance by the requirement to observe blended spectral features (e.g. weak deuterium in the wings of strong hydrogen lines).

The participants appeared to enjoy and benefit from the meeting and there were many comments on the fine conference centre Herstmonceux Castle provides.