DETECTORS

CCDs have a bit of a problem

Publ. Astron. Soc. Pacific (in the press); preprint at

<https://arxiv.org/abs/1802.06914>

Credit: IOP

Astronomers involved in a supernova survey have noticed a detector-related instrumental effect in their data, with potentially far-reaching consequences. The problem concerns the charge-coupled device (CCD) detectors that are a fundamental component of modern astronomical instrumentation, and over 70% of the CCDs subsequently tested by the group, including those on the Hubble Space Telescope, suffer from the same effect. Specifically, the issue arises in the CCD's readout electronics when the analogue-to-digital converter reads out pixels as binary zeros when they are following on from a binary one — an offset is introduced that could masquerade as scientifically significant data.

Through investigation of dome flat exposures and other calibration data, Kyle Boone and members of the Nearby Supernova Factory collaboration have found that this 'binary offset effect' is roughly proportional to the number of '1' bits in the binary encoding of the pixel value, and can alter values by up to 4.5 ADU (analogue-to-digital units, an electronic measure of intensity). As an example, transitioning from a pixel value of 1,279 ADU (100 1111 1111 in binary notation) to a pixel value of 1,280 ADU (101 0000 0000) introduces a large

residual of 2.5 ADU, because eight '1' bits change to '0's (see figure).

Mainly this effect can be seen in background subtractions, and in particular it has an impact on those instruments that have low background noise (such as space-based detectors, like in the Hubble Space Telescope's STIS spectrograph and WFIRST's proposed Integral Field Spectrograph) or are observing low signal-to-noise targets. Since the binary offset is applied to subsequent pixels in the CCD readout process, high-resolution spectrographs may experience shifts in the recovered wavelengths of emission lines. Similarly, images may be shifted by 1–3 pixels, affecting the shape of galaxies and potentially weak lensing measurements. Across the Nearby Supernova Factory collaboration's dataset, the binary offset effect affects measured flux values at the 2–4% level (B and U bands) but in low signal-to-noise data in particular, fluxes can be affected by up to 11% (B) and 60% (U). Photometry is less likely to be influenced.

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Published online: 21 May 2018

<https://doi.org/10.1038/s41550-018-0494-0>