Dark Energy Imaging Using CCDs

Charged-coupled devices (CCDs) transfer electrical charge produced by the photoelectric effect. The charge transfer takes place between adjacent capacitors operating as clocked shift registers (Peterson). Once the charge has been transferred in the final capacitor it is converted into a voltage proportional to the intensity of the light which struck the first capacitor. In order to produce an image a 2-dimensional array of CCDs are exposed and processed. Focusing the light from an object requires a lens. Color images are produced by applying specific color filters to adjacent individual CCDs (pixels) such that different pixels sense the intensity of specific colors. Algorithms are used to average the colors near adjacent pixels and produce color images (Peterson).

Astronomy was one of the first and continues to be one of the main applications utilizing CCDs. Since CCD cameras offer a digital image which can be analyzed by computers, astronomers can apply custom software algorithms helping them make better observations. CCD cameras can operate at very low temperatures allowing for better imaging of very distant objects. This is possible because at very low temperatures the noise produced by heat is minimized allowing for very long exposures (Peterson).

National Public Radio recently reported that “a giant and powerful digital camera” designed and built at Fermilab will be utilized in Chile to study dark energy. The same article mentions how dark energy was only recently discovered in 1998. One of the 1998 researchers is quoted saying:

“‘What we were really measuring was how far away the galaxies were, and they were much farther away than they should be, just based on gravitation,’ says Nicholas Suntzeff, an astronomer at Texas A&M University.” (Greenfieldboyce).

The article continues to mention that the galaxies move apart at an accelerating rate acting like an opposite of gravity. The 1998 observations sparked the interests of researchers at Fermilab to design the 570 megapixel camera to observe the effects of dark energy by “gathering data on more than 300 milion galaxies” (Greenfieldboyce).

The Fermilab camera will be part of the Dark Energy Survey (DES), “a collaboration proposing an ambitious new experiment to measure the properties of dark energy” (Yurkewicz). The Fermilab camera’s CCDs were developed at Lawrence Berkeley National Labs with specialized sensitivity to near-infrared wavelengths. The specialization is to allow the camera to better analyze the redshifts of the galaxies observed. Redshift is essentially the astronomical equivalent of the Doppler Effect, increasing with distance (Yurkewicz).

References

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