Topic: Creating a better CCD camera

Reason for being interested: A few years ago, I took an observational astronomy class that involved some astronomy imaging. We used a CCD (charge-coupled device) camera to take images of whatever object we chose to observe during that night. I remember having to calibrate the CCD camera at twilight so that the "gains" would be correct. We also had to take many "flat" images of just a dark sky so that the CCD can calibrate correctly (I was rereading this guide to help me remember all of the calibration steps: https://starizona.com/acb/ccd/advimcal.aspx). Anyway, I remember that we had to go through all of these calibration steps because a CCD camera worked by collecting electrons in bins (the photons would come in and excite (?) electrons that would be collected in bins to create an image) but there could be noise that would allow you to not be able to get a precise image.

Recent research in this area: creating a CCD that has single electron sensitivity per pixel
This new development of a new CCD camera that can have sensitivity down to a single electron is exciting because it allows for our image to be sensitive to even one photon in the optic or Infrared spectrum. Scientists have developed a new read-out system that allows for the CCD to have less noise in the data collection process. I plan on looking into the physics that went into this read-out system and what sort of applications from classical E/M were utilized.

Related papers:
https://physics.aps.org/synopsis-for/10.1103/PhysRevLett.119.131802
This paper is an overview from APS announcing the fact that research has led to the Skipper CCD (single electron sensitivity).

https://arxiv.org/pdf/1706.00028.pdf
This is the ArXiv paper that goes into the physics of the new readout system that allows the CCD to have such a small sensitivity. I am particularly interested in the portions of this paper that talk about applications for the CCD in different areas of physics. I think that it would be interesting to explore the idea that classical E/M research can influence fields such as particle and astro- physics. This paper specifically mentions how this new CCD could be sensitive enough to aid in the search of low mass dark matter particles.

http://ericfossum.com/Publications/Papers/Scientific%20CCD%20technology%20at%20JPL.pdf
This paper provides an in depth explanation of how charged coupled devices work. I am particularly interested in the history of CCDs given in the introduction portion of the paper.

https://link.springer.com/article/10.1007/s10686-012-9298-x
This article is geared toward CCD use in astronomy but they discuss the Skipper CCD and its advantages for low noise data.