CCD Blooming in the Hawkeye Instrument

Alan Holmes

9/8/2017

Overview: CCD detectors in general tend to suffer from a phenomena called blooming when subjected to light levels beyond saturation. This is commonly seen in old video camera images of nighttime football games, where vertical streaks appear below the floodlights. The Hawkeye instrument has some bands that can saturate on high, white clouds and it is important that this blooming not corrupt nearby areas of the image that do not saturate. To measure this effect, I looked at sphere stray light images for Unit 2, from June 29th, 2017, where I have a nice sequence of images with exposure times separated by a factor of two. The test technique is discussed in another report, "HawkeyeDiffuseStrayLight-090517.pdf". We collected images of the NASA sphere with an aperture in a dark room.

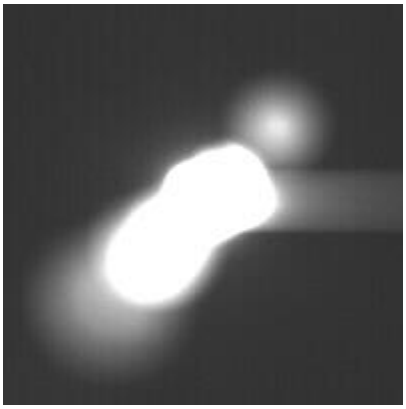
A good example of blooming can be seen in the four band 4 images below.

Figure One-A: Exposure of 4.8 ms per row

Figure One-B: Exposure of 9.6 ms per row

Figure One-C: Exposure of 19.2 ms per row

Figure One-D: - Exposure of 19.2 ms – Contrast pushed



In Figure One-A, the image of the aperture backlit by the sphere is below saturation, and no protrusion to the right is visible. The faint artifacts are filter ghosts. In Figure One-B, the protrusion is just becoming visible. In Figure One-C, it is obvious, putting a nose on the round aperture image. Figure One-D shows the same exposure as One-C, but with the contrast pushed harder to show fainter details. Note that there is a stripe appearing to the right of the saturated area, and elevation of the background counts. This is barely visible in Figure One-B, but is not present at all in Figure One-A. These two features mark over-saturation – the bleeding of the saturated area to higher pixel numbers, and the background elevation. Both seem to have a sudden onset as the light level increases.

In Table One I summarize the blooming data from the sphere stray light test. What is tabulated is the counts that would have been sensed had the CCD not saturated, along with whether or not blooming was seen. The counts were extrapolated from shorter exposure data.

Table One: Onset of Bloom – In ADU Counts

	Counts in	No Bloom	Bloom	Counts,	Counts,	
	0.6 ms	Exposure	Exposure	No Bloom	Bloom	
Band		(ms)	(ms)			
1	1006	19.2	None	32192	?	
2	2052	19.2	None	65664	?	
3	5471	9.6	19.2	87536	175072	
4	7318	4.8	9.6	58544	117088	(Barely Visible)
5	12440	4.8	9.6	99520	199040	
6	23856	2.4	4.8	95424	190848	
7	20966	2.4	4.8	83864	167728	
8	37908	1.2	2.4	75816	151632	

It is clear that blooming occurs between 100,000 and 115,000 counts, which, considering the electronic gain of all channels is 2.0 electrons per count, implies a level of near 205,000 electrons. This is about 1.7X the saturation for each band, which is the value used in modeling this effect previously. Exposures for orbital operation should be set such that high clouds do not exceed 1.7X saturation. Picking an optimal exposure for orbital operation will be discussed in another report, but it may come down to considerations such as correcting filter ghosts, which would require not saturating anywhere.