COR1-A Vacuum Recalibration, April 2005

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The SECCHI-A SCIP bench, with the COR-1A instrument, was installed in the NRL A13 vacuum tunnel, for a final recheck and calibration before delivery to APL for integration into the STEREO-A spacecraft. The primary objective of this test was to confirm that the instrument performance—particularly the stray light properties—still met requirements. Thus, instead of the week-long testing that had been initially performed in July 2004, these tests were performed in a single day. In addition, these tests allowed the performance of the flight Camera Electronics Box (CEB) to be established.

1 Stray light

Stray light is measured by illuminating an aperture at the far end of the vacuum chamber with a bright Xenon arc source. Two different photometers were used to measure the brightness of the light reaching the instrument, a white-light photometer, and a Gamma Scientific photometer with a spare flight bandpass filter. The results of the measurements in the two cases are shown in the following table.

	White light		Gamma Scientific	
	ft-lamberts	$B/B_\odot$	W/m^2	$B/B_\odot$
July 2004	345	0.02803	0.975	0.02958
April 2005	600	0.04875	2.600	0.07889

While the results are in good agreement for the July measurements, they disagree by quite a bit for the April measurements. It's believed that some light was getting around the bandpass filter in front of the Gamma Scientific photometer, and thus giving too high a signal. We intended to redo the calibration measurements after the chamber was reopened, but the Xenon lamp broke down before this could be done.

Using the white-light measurements is a more conservative approach. Because the white-light measurements from July 2004 had a correction factor of 1.18 applied to them, we apply the same correction factor to the April 2005 data. The results are shown in Figure 1. To within the limits we can measure, the two images are indistinguishable. There is a slight difference in overall brightness, as shown in Figure 2, but that is attributable to the uncertainty in the relative calibrations between the two data sets.

Because one of the motors in the vacuum tank was not working properly during the April 2005 tests, the alignment may not be quite as good as in July 2004. This is not expected to have a large effect on the overall scattered light, but may affect the small circular or arc-shaped features

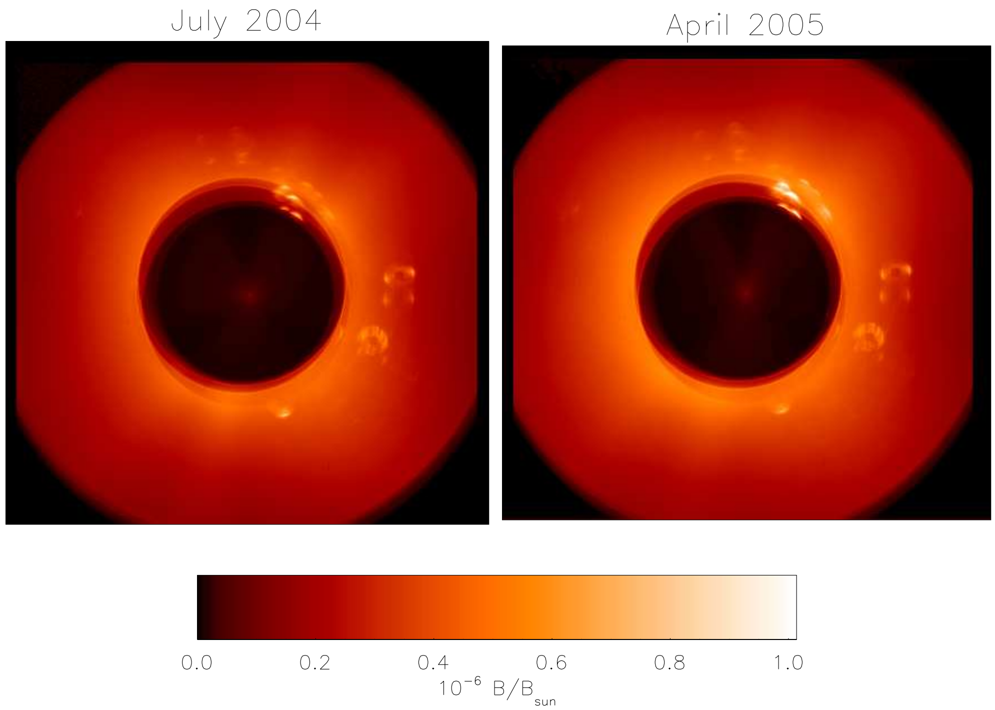

Figure 1: Comparison of the scattered light patterns from the July 2004 and April 2005 measurements.

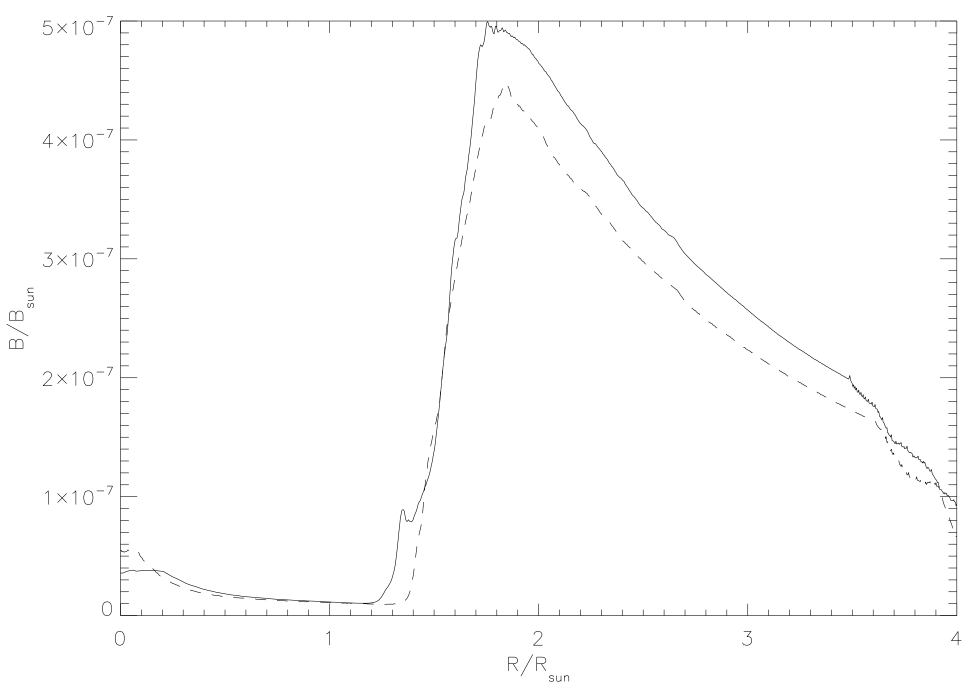

Figure 2: Average radial profiles of the data from Figure 1. Solid: April 2005, dashed: July 2004.

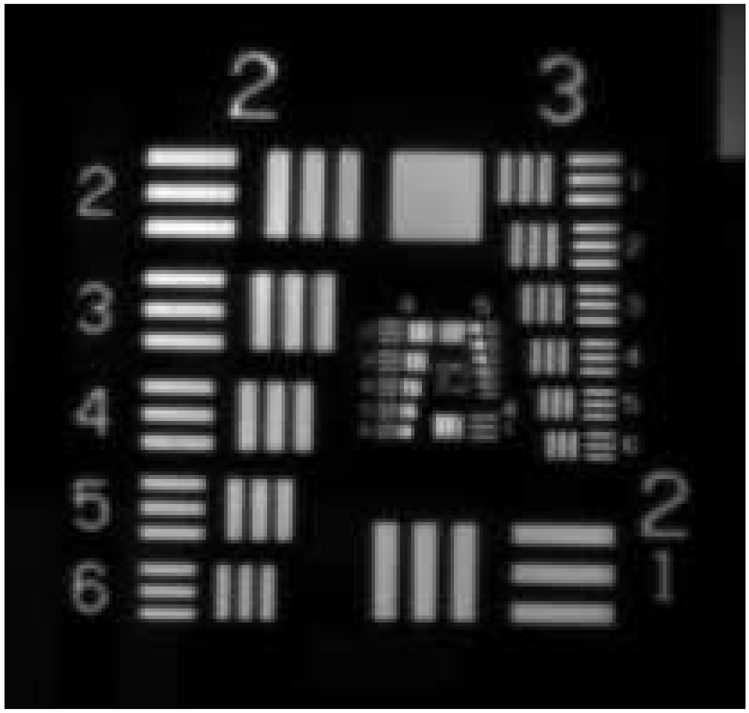

Figure 3: Air Force 1951 resolution test target image.

which had been previously determined to be from the front surface of the field lens. The small features near the edge of the occulter at the 1 o'clock position are brighter than they appeared in April 2004, but that is probably due to the alignment.

The April 2005 image in Figure 1 was taken with an exposure time of 32 seconds. Since the source irradiance was 0.04875 of a solar irradiance, the same results in flight would be achieved in 1.56 seconds. A few points are saturated in this image, at around the 1 o'clock position. Analysis of a similar image taken at an exposure time of 8 seconds, shows that an exposure time of 1 second would keep these points below saturation during flight.

2 Resolution

Focus was tested by projecting an Air Force Target (AFT) onto the instrument (Figure 3. Details can be seen down to the full-resolution Nyquist frequency. As before, we measured the contrast for group 3-6, whose bars are 1.5 pixels wide. The maximum contrast was 0.32 for the horizontal bars, and 0.46 for the vertical bars, which is as good as, or better than, the previously measured contrast.

One can also use the AFT images to test the movement of the image on the detector as the polarizer is rotated. By cross-correlating images taken at polarization angles 120° apart, one can determine that each image is 0.151 ± 0.038 pixels off from the average image. This agrees well with the 0.19–0.27 pixels measured during final assembly.

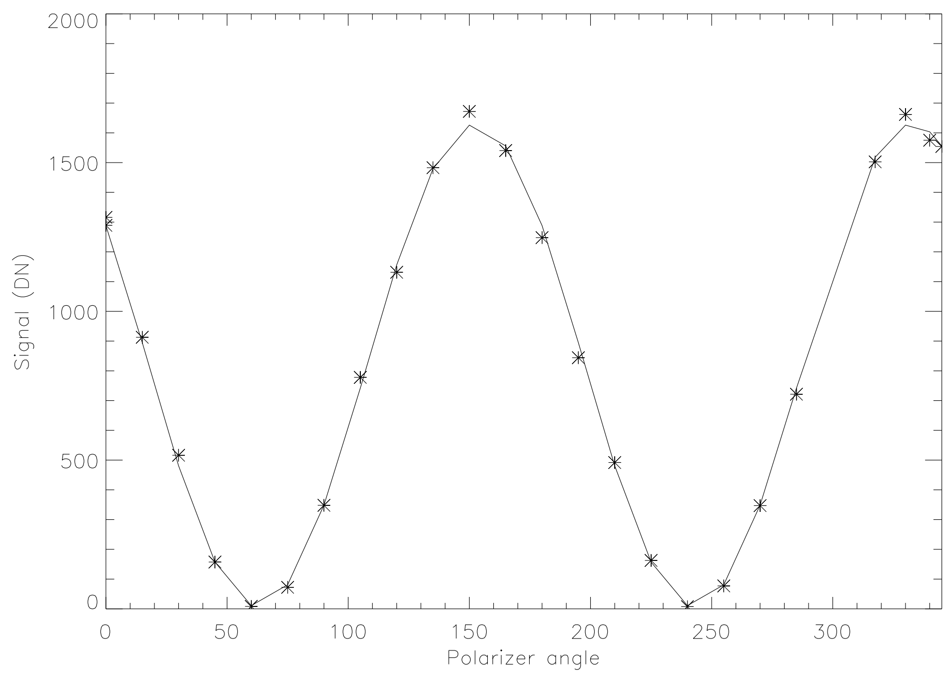

Figure 4: Instrumental response to polarized light.

3 Polarization response

Figure 4 shows the instrument response to polarized light as a function of hollow core motor (HCM) position. The results are consistent with 100% polarization. This shows that the HCM is stepping correctly. In this plot, the zero angle position is defined as HCM step #4, which was determined from the previous tests. The orientation of the incoming polarized light was uncontrolled.

4 Photon curve

Figure 5 shows the response of the instrument to light as a function of exposure time. These measurements were made with the bright Xenon lamp illuminating the diffuser window in the door. The values are averages over the region where the instrument response is flat. Also shown is a straight-line fit. Within the limits of the lamp variability, the response is linear.

5 Photometric calibration

The photometric calibration of the instrument was measured by illuminating the aperture at the end of the tank with a diffuse unpolarized light source of known intensity. The resulting illumination pattern on the detector is shown in Figure 6. Because the aperture is not in focus, the brightness decreases linearly around the edge of the image. Note the flattening at the top, where the image is cut off by the occulter.

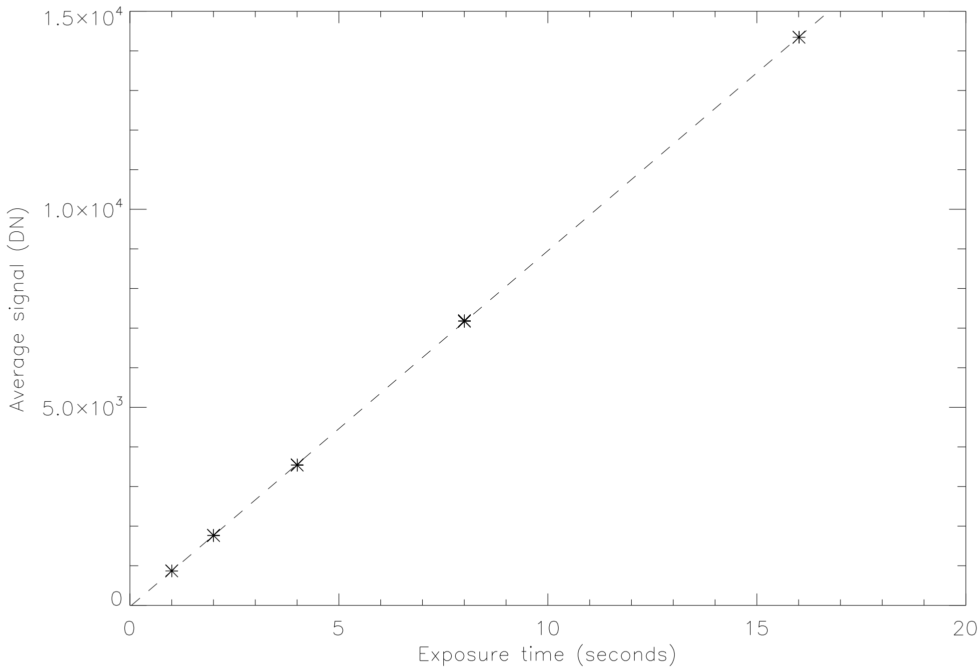

Figure 5: Instrumental response as a function of exposure time.

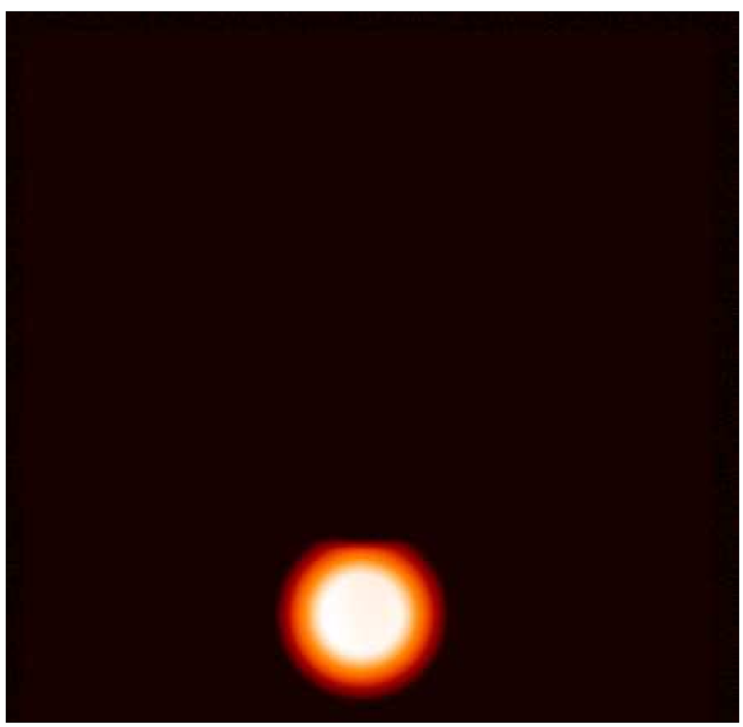

Figure 6: Image of the test aperture at the end of the vacuum tank.

The response was measured by taking the average in the center of the pattern, where the image is unvignetted. The average response was 47.98 ± 1.41 DN/sec. Since the lightbox had a brightness of $6.8 \times 10^{-9} B/B_{\odot}$, this means that the photometric calibration of the instrument is $1.42 \times 10^{-10} B_{\odot}$/DN, which agrees well with the value of 1.2×10^{-10} measured during the original calibration. (The data in Figures 1 and 2 are based on the original calibration—if the most recent calibration is used, then both the July 2004 and April 2005 would be raised by $\sim$18%, and the relative comparison between them would remain unchanged.)

Note that these numbers are based on the average signal at the detector. Because the internal polarizer only allows one state of polarization through, and thus cuts unpolarized light in half, the calibration parameter to be applied to B or pB values derived by rotating the polarizer is 7.1×10^{-11}.

6 Conclusions

The performance of the COR-1A instrument has not changed since it was delivered in July 2004.