Utah State University

DigitalCommons@USU

Spring 2014

Constructing a Flat Field for Scientific Astronomical Imaging

Catharine Bunn
Utah State University

Recommended Citation

Utah State University
MERRILL-CAZIER LIBRARY

Constructing a Flat Field for Scientific Astronomical Imaging

Catharine Bunn

Mentor: Dr. Shane Larson

USU Physics 4900 Report

Spring 2014

Abstract

There are consistent problems that occur during the process of capturing astronomical images which cause defects to be present on the raw image captured. Some of these problems include vignetting, dust on the lens or the digital sensor's surface, and dead or less sensitive pixels. This is a problem when the images are meant to be used in photometry, where the brightness of each pixel is taken into account. One can simply clean all surfaces of dust, but it will always come back. A more solid solution is to use a calibration frame called a "flat field" to correct each image before processing it. This "flat field" is created by pointing a telescope at an area characterized by uniform luminosity and color— white is preferred— then capturing an image. The only things visible in these calibration images will be the anomalies previously mentioned, and that's the flat field: a portrait of the dust and shadows seen by the camera. After the astronomical image is captured, the flat fields are averaged and then divided out of the astronomical image. All that is left then is what was captured from the cosmos, rather than what was on the lens or sensor. The purpose of this project is to create a flat field box that could be used to calibrate the 20-inch telescope in USU's observatory. This box will be fitted with two panels of translucent opal plexiglass and a panel of evenly spaced miniature incandescent light bulbs. The bulbs will illuminate the acrylic sheets from behind and the telescope will have a view of a uniform "flat field." This calibration instrument will allow the telescope to be used for photometric purposes and other areas of astronomy.

Motivation

Why use a flat field?

Raw images captured through a telescope are subject to distortion due to the optical apparatus through which they are taken. These distortions include vignetting, dust on the lens or the digital sensor's surface, and dead or less sensitive pixels. This is a problem when the images are meant to be used in photometry, where the brightness of each pixel is taken into account. You can simply clean all surfaces of dust, but it will always come back. A more solid

Figure 1: Antenna Galaxies, image taken by ESA/Hubble Space Telescope which utilizes flat fields.

solution is to use a calibration frame called a "flat field" to correct each pixel's brightness before processing it.

What is a flat field?

A flat field is an image that is meant to calibrate raw scientific astronomical images. The process of obtaining a flat field goes like this: The telescope is pointed at an illuminated flat white field and an image is captured. This image will show only the distortions of the optical apparatus. Normally 15 to 20 of these images are captured and then normalized. Next, the desired raw image is captured. Each pixel is designated a number depending on its brightness. The numbers of each pixel of the raw image are then divided by the numbers of the corresponding pixels in the normalized flat field. The resulting image is the raw image without the distortions present in the flat field.
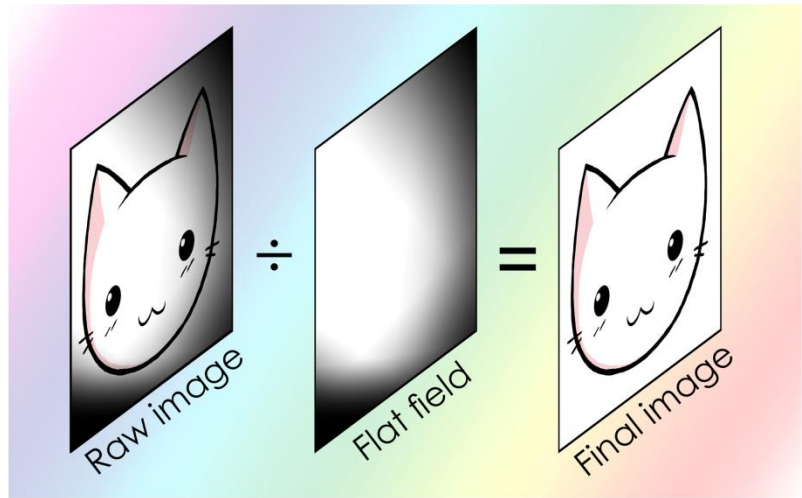

Figure 2: Diagram of how a flat field image corrects the raw image data.

Construction

Flat Field Box Design

This version of a flat field box utilizes a multi-layer design. At the rear of the flat field box there is a panel of evenly distributed incandescent lights bulbs, which were chosen for their blackbody-like spectrum, which provides the most even spread of wavelengths. The light from those bulbs then passes through a series of two diffusive translucent acrylic sheets. As the light travels toward the end of the box where the telescope sits, it is diffused by the translucent sheets so that by the time it reaches the telescope, it has blurred from an array of individual bulbs to a flat, evenly illuminated field. The interior walls of the box are fitted with white panels, meant to assist in diffusing the light. The exterior is made of light-weight corrugated plastic, meant to make affixing the box to the end of the telescope easier. Finally, the box fits to the telescope using the telescope sleeve.
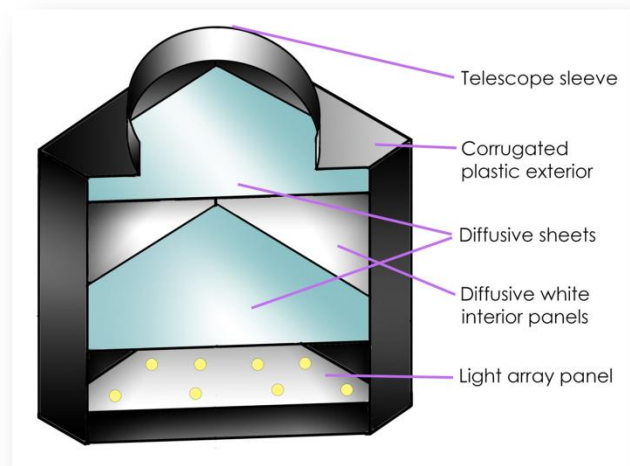

Figure 3: Schematic of the flat field box.

Demonstration

Telescope Testing

After completion, the flat field box was attached to Utah State's 20" Plane Wave Telescope in order to test it. Numerous flat field images were captured and can be seen below.

Captured Flat Field Images

Samples of the flat field images captured using this flat field box design can be seen below. The red arrows point to some distortions that would otherwise appear in raw scientific images. The upper arrows in each image show a dust particle that is physically present on either the digital sensor or lens. The lower arrows denote what is assumed to be a part of the camera's filter system; this can be assumed because the distortion can be seen in two different locations when imaged with different filters.
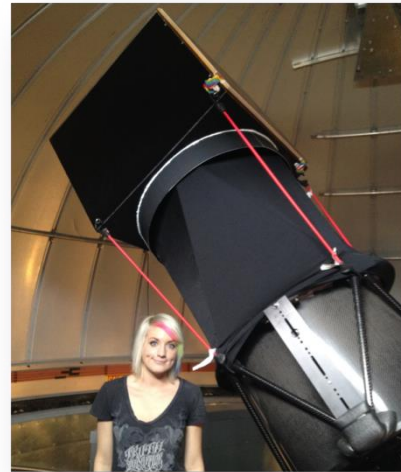

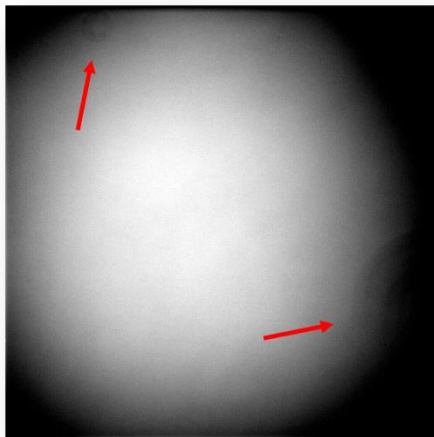Figure 4: Flat field box attached to telescope.
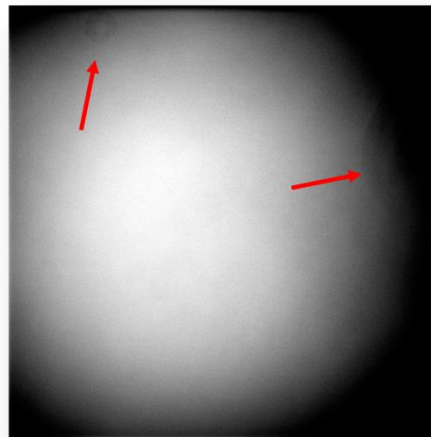

Figure 5: Captured flat field image.

Figure 6: Captured flat field image with blue filter.

Acknowledgements