Astrometry from CCD Images

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Abstract

Astrometry is used to measure properties of celestial objects such as their position on the sky, their movement and their velocities. In this experiment, we used a charged coupled device(CCD). The CCD used mapped the sky on 2D plane. Observations were made using the Dunlap Institute Telescope located in New Mexico, United States. The object of interest for this experiment is 30 Uania which is an asteroid. We will measure the plate constants of the CCD using a data collection of stars field in order to correct for the sheerness of the CCD pixels and then we apply it to the data from 30 Uania over the course of three nights to measure the velocity of this asteroid.

1   Introduction

2   Experimental Procedure

2.1   Equipment

We used the Dunlap Institute Telescope(DIT) which is a 50-cm robotic telescope dedicated to search for optical counterparts of gamma-ray bursts. The telescope was located at New Mexico on Mt. Joy(32:54:10 N +105:31:46 W). The telescope is equipped with a 4096×4096 pixel CCD array and the resultant field of view is approximately 36×36 arc minutes. Pixel size of this CCD is 9μ. This CCD operated in binning mode to collect the data. Binning is useful since it reduces the size of the resultant FITS file and reduces the effect of read-out noise. For 2×2 binning the resultant array is 2048×2048 pixels.

2.2 Data Collecetion

Data from asteroid 30 Uania was collected in three consecutive nights.

3 Analysis

3.1 CCD Calibration

In order to have good images from the CCD we need to calibrate it. A good image is one that is dark subtracted and divided by flat frames. Therefore, in order to use the data from the CCD, we subtracted the dark data from the actual data. Dark data was taken with the same exposure time as the actual data while the shutter was closed. Dark current is produced due to the noise in the CCD and it might come from the thermal energy of the electrons; therefore, CCDs are kept in cool places in order to reduce the noise. We also divide the dark subtracted data by the flat frames. Flats are morning and evening twilight sky images that are used to normalize the image. Another factor to consider are the bias frames, which are zero second exposures that provide a measure of digital offset when the signal is zero. Here, the bias is assumed to be zero for this long exposure with DIT.

3.2 Detection of Stars

Next step is to find the stars from the CCD image of NGC7331 taken with DIT. The way we did it was to write a python program to check all of the pixels and find the ones that have intensity higher than a specific number, which for me was higher than 20000 ADU. It considered each pixel and then compared it with the pixel on the left, right, bottom and top of it and if it had higher intensity, considered it as a maxima point.This way the program found all of the maxima points; however, there was a problem. For the larger stars, the code put more than one dot on the object since the object consisted of more than one pixel and the code put dots on each of the pixels of the star. Therefore, we need to find the centroids of these maxima points in order for the code to only point to the centroid of the stars and to put only one dot on each star. In order to calculate the centroids, we modified the code so that now it only takes the maxima points and considers a small box around each of the stars and for the maxima points in the specified box finds the centroids. This way we would only have one dot pointing to each star instead of a few. This is shown in figure 1.
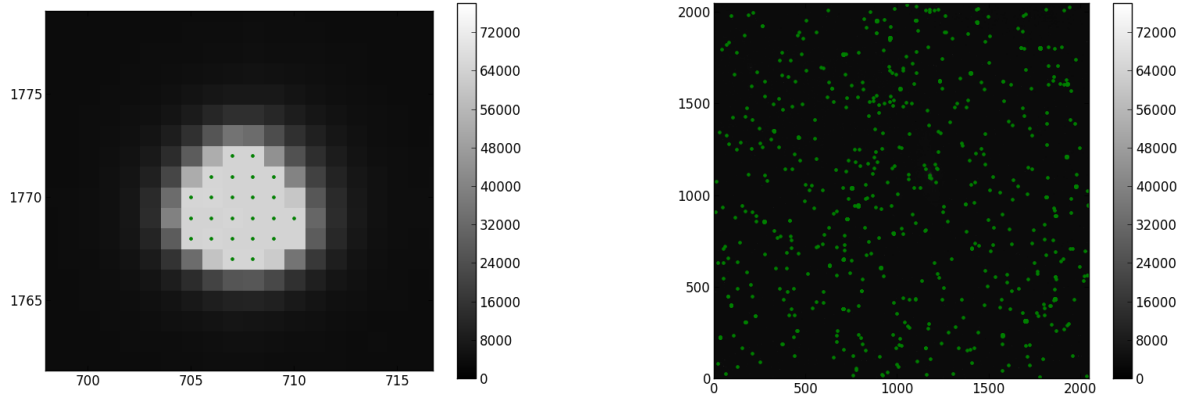
3.3 Matching Stars and Standard Coordinates

Figure 1: The image on the right shows the maxima points that correspond to the pixels that have intensities higher than 20000 ADU. The image on the left is a random zoomed in part of the right hand side plot in order to show that some of the dots shown on the right image are actually more than one dot. Therefore, we need to find the centroids in order to eliminate the extra dots for one star and only assign one dot to each star.