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IR Astrometry and Photometry of the Abell 1882 Supergroup

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Infrared Astrometry and Photometry of the Abell 1882 Supergroup

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Introduction

This poster details the research practices learned and used as part of a Research Experience for Undergraduates program from January through March 2011 in La Serena, Chile. Previous observations of the Abell 1882 supergroup had already been made and analyzed to determine redshift of member galaxies of the supergroup. These observations suggested the supergroup to be in the early stages of cluster formation. The intent of this project was to measure magnitudes of member galaxies and develop a combined catalog of this data and previously determined values.

Observations

Observations were made in May 2010 at the Cerro Tololo Inter-American Observatory (CTIO, MPC 807) using the Infrared Side Port Imager (ISPI) on the Victor Blanco 4.0-m telescope. ISPI has a 10.25 x 10.25-arcminute field of view. Images were unbinned; J, H, and K filters were used.

Data were collected using a Charge-Coupled Device (or CCD). Most current digital cameras also use CCD technology. During exposures at a telescope, photons are collected in an array of pixels and stored as built-up electrical charge. At the end of an exposure, the detector reads the charge on each pixel and stores it to create the final image.

Data analysis was carried out using Image Reduction Analysis Facility (IRAF) software and additional Linux-based tools. The supergroup was chosen for investigation based on work done by Gomez's previous students. The following sections detail the procedures used for data reduction.

Linearity Correction

ISPI images are known to need minor adjustments to attain a linear relationship between the stored charge and the observed brightness. ISPI data are corrected using the following equation:

$$x_{correct} = 0.99893x_0 + 0.0288x_0^2 + 0.0233x_0^3$$

Coefficients were obtained from Nicole van der Bliek, a scientist in charge of the ISPI instrument. These corrections are applied to all images to ensure accurate final data.

Bad Pixel Masking

CCDs are sensitive detectors and, over time, various pixels or columns of pixels inevitably stop working correctly. To avoid any incorrect readings caused by these pixels, we use a mask, which defines the bad pixels. The brightness values for bad pixels are then replaced with the average of the pixels to either side of the bad pixels. A bad pixel mask is shown in Figure 1.

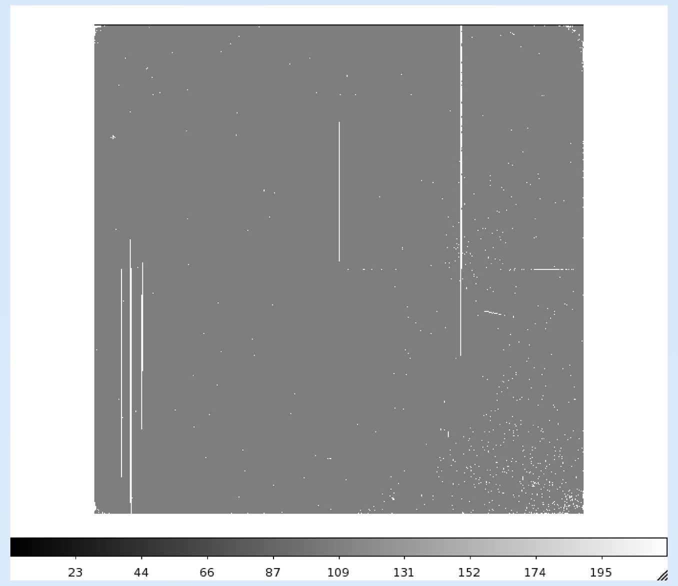

Figure 1: Bad pixel mask

Sky Subtraction

A unique feature of infrared (IR) data is that the sky is not invisible. This is addressed by subtracting consecutive images from one another. To avoid subtracting targets out, the position of the telescope is adjusted between each exposure. With these position adjustments, the images can be cleanly subtracted. Figures 2 and 3 are versions of an image before and after the sky has been subtracted.

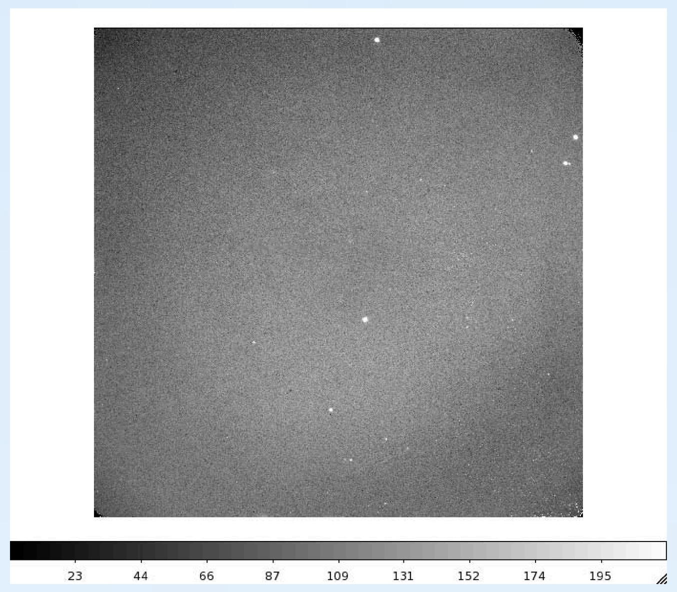

Figure 2: Non-sky-subtracted image (few objects visible)

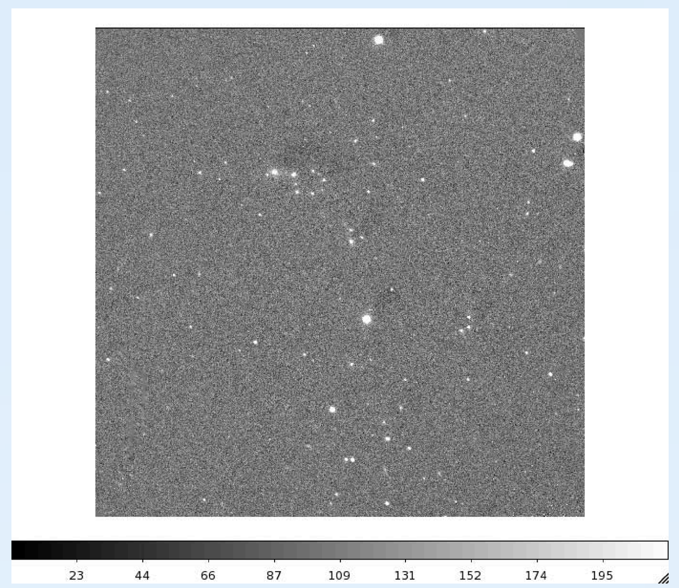

Figure 3: Sky-subtracted image (many objects visible)

Finding Objects

While it is easy for humans to spot stars and galaxies in images, IRAF needs defined parameters to specify what to look for. The parameters define minimum brightness for objects and the form of light distribution (half width at half maximum). This eliminates the chance of falsely detecting a cosmic ray because cosmic rays do not have smooth light distributions. Once objects are found, their positions can be calibrated and detailed coordinate information can be added to the images.

Warping and Combining Images

Images are subject to distortion based on the positioning of instrumentation and the optics of the telescope. Due to this distortion, they must be warped to align correctly when they are combined. Figure 4 demonstrates the uncorrected distortion of an image before it can be combined. The warping process takes into account the detailed coordinate positions and aligns all images correctly. As shown in Figure 5, images taken with various pointings of the telescope can be combined.

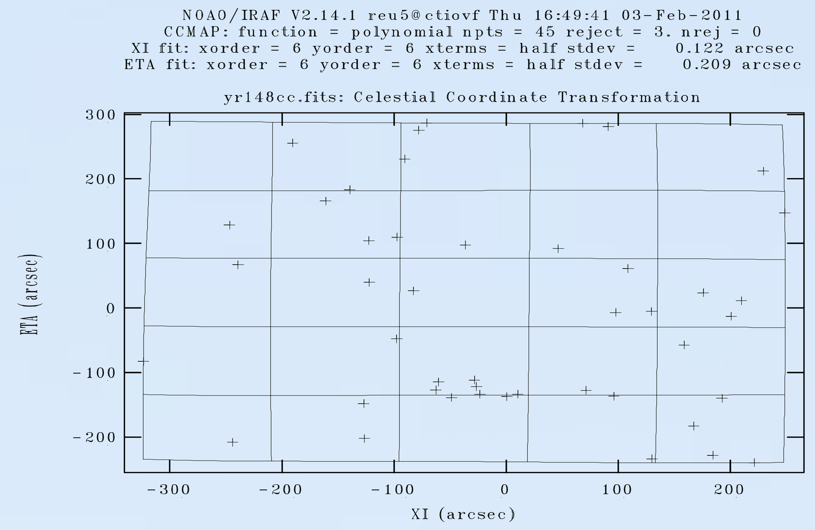

Figure 4: ccmap program screenshot

Figure 5: Final, combined image

Preliminary Results

The brightness of various objects is measured from the combined images. Using multiple wavelength filters allows additional color information to be determined for the targets. The research project also involved combining this data with values from other catalogs to create a master catalog. As shown in Figure 6, the objects in our combined catalog were grouped into two distinct redshift groups, with the majority of our galaxies belonging to the second. One possibility was that the first group consisted of mostly fainter objects; however, Figure 7 shows the opposite to be true. We have yet to determine the cause of the distinct groupings of redshifts.

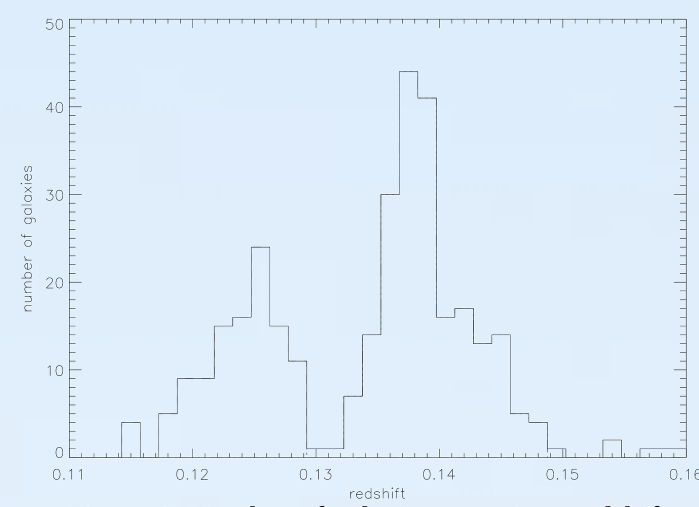

Figure 6: Number of galaxies at various redshifts

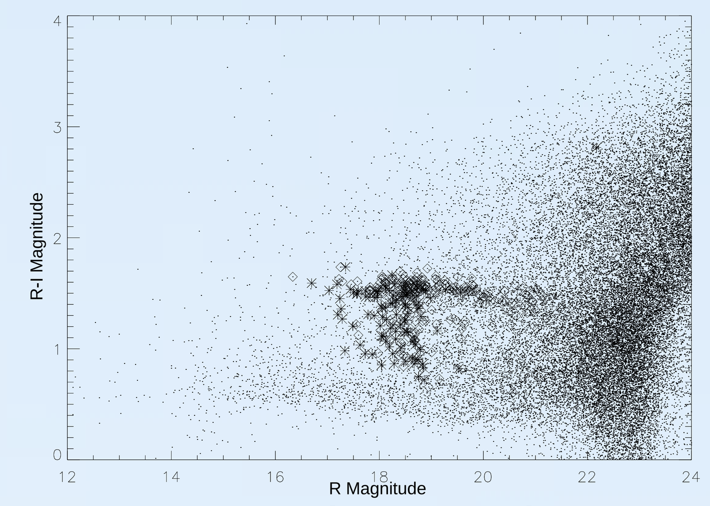

Figure 7: Color vs. magnitude

♦ = Group 1, ◇ = Group 2

Future Work

We plan to continue analyzing the results and working with the catalog. Future possibilities include color-magnitude and color-color diagrams, as well as working with data from additional wavelength filters. Color coefficients can offer additional information about age and temperature of galaxies, which will provide insight into properties the formation process from a supergroup to a cluster.

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