Physics 344 Lab 4

Observing with a CCD: Photometry of the Galaxies M31 and M32

Take Data: October 9 – 14 (weather permitting)
Report Due: Thursday, October 29
Text Reference: Chapters 9 & 10

**Purpose:** This lab continues the introduction to taking and analyzing data with the direct-imaging CCD system on the 0.5 m telescope. It provides more practice in planning observations so as to use your time at the telescope effectively and in the basic procedures of focusing the camera and setting up the guider, which are necessary for obtaining images of good quality. Analyzing images of the galaxies M31 and M32 will introduce a fundamental astronomical measurement: determining the brightness of an objects in the sky using a CCD image. M31 is a spiral galaxy and M32 is a (dwarf) elliptical galaxy that is a satellite of M31. So our data will allow us to compare the two basic kinds of galaxies.

**Background:** Telescopic observations of galaxies go back hundreds of years, with the earliest predating our understanding of galaxies as gravitationally bound assemblages of stars. Galaxies are extended on the sky, unlike the point-like stars, and early observations focused on morphology – the shape of the light distribution – and on the total brightness. These kinds of observations continued into modern times and were important in determining our ideas about the structure galaxies. Measuring the brightness of galaxies in different wavelength passbands yields information about the kinds of stars present, since young stellar population contain hot, blue stars whereas old stellar populations contain only red main sequence stars and red giants.

M31 is the nearest large galaxy to our own Milky Way Galaxy, at a distance of about 780 kpc. The Galaxy and M31 are the two most massive members of the gravitationally bound Local Group of galaxies, with the less luminous spiral M33 being the next most massive. Most of the remaining 70 or so members are satellite galaxies of M31 or our Galaxy. New members of the Local Group continue to be discovered today with the number known more than doubling since 2000. We can only discover the faintest galaxies when they are nearby and we can make the most detailed studies of nearby galaxies. For these reasons, studies of the Local Group continue to be important for understanding the properties of galaxies and how they formed.

Galaxies do not have sharp edges and their outer regions are fainter than the night sky. Removing the contribution of the sky is an important step for any measurement of the brightness of an astronomical object and it is particularly important for galaxies. Determining the brightness of the sky is not easy for the largest of the Local Group galaxies because they are larger than the field of view of most telescopes, including our own. We will use two overlapping fields, one approximately centered on M31 and the other on M32 to obtain an estimate of the brightness of the sky in a region away from the center of M31. Even the part of the second image farthest from the center of M31 will still contain some galaxy light, but it will be a very small contribution to our (rather bright) sky.
As discussed in class and in the last lab, carrying out astronomical observations and their analysis typically involve the following steps.

1. Planning before going to the telescope in order to optimally use the scarce resource of time at the telescope. Determine when your targets are visible, how to find them, and what science and calibration data to take.
2. Taking both science data and calibration data at the telescope. Includes assessing data quality in real time – are you pointed in the right place, are the images focused, are your exposure times too short (not enough signal) or too long (target saturated)?
3. Calibrating the science data. The first step(s) of data analysis.
4. Scientific analysis of the calibrated images.

I. Preparation and Planning:
We will observe the two galaxies M31 and M32 for this lab. The locations of these objects are shown in The Sky.

1. Use The Sky running on a computer in the classroom or dome to find where these objects will be in the sky during your observing session. How close are they to the horizon? Will taking your flat-field images at the beginning or end of your session result in the galaxies being higher in the sky when you observe them?
2. Zoom in with The Sky at the location of M31 until you can see the red rectangle that is the “footprint” of the CCD camera field of view on the sky. Also locate M32, which is about 30 arcminutes south of M31. It will be helpful to turn off the galaxy picture representation for M31, if it is not already, so that you can identify the stars in its vicinity. Identify a 7th – 8th magnitude star within a few degrees of M31 that can be used to focus the CCD.
3. Click on the red rectangle of the CCD field of view to select it and, if necessary, change the orientation of the autoguider field of view (smaller box) to 90°, since M31 is east of the meridian. Then explore how to place two overlapping CCD fields, one approximately centered on M31 and the other on M32. The field placements will be constrained by the need to have a sufficiently bright star in the autoguider field of view. Ideally a guide star will be 10th magnitude or brighter. In this case you will have to use fainter stars, but keep them brighter than 11th magnitude. Once you have selected your guide stars, record them and plan how you will point the telescope so as to get your guide stars into the autoguider field.

II. Observations of M31 and M32:
If you decided that observing your flat-field images first will result in M31 and M32 being higher in the sky, do the first six steps below and then go to part III. Then go back and finish the rest of part II.

1. Ensure that the fold mirror in the red instrument adapter box is in the “CCD” position, that the spectroscopic pick-off mirror is out (rivet in the “direct” location) and make sure that the plastic plug is in the eyepiece tube. Turn on the imaging CCD system with the power strip in the telescope mount base.
2. Start *The Sky, IDL*, and the imaging *CCDSoft* program. In *IDL* start *RUPhAst* to view the saved images.

3. In *CCDSoft*, connect to the CCD and set the cooling to a temperature that is 35 to 40 °C below ambient. Allow about 5 minutes for the temperature to stabilize before taking science or flat-field images. If it takes more than about 90% power to maintain the temperature setpoint, raise it a bit.

4. Set up the *AutoSave* tab to save your images in a subdirectory named with the date and your initials in G:/home/ph344/lab4 (e.g., oct10tp). Set the *starting number* to 1.

5. In the *Take Image* tab, set the *Bin* to 2x2.

6. The telescope is focused by moving the secondary mirror using the stepper-motor controller on the observing desk. Turn on the encoder readout above these controls with the green button. Use the focus motion buttons on the panel below to set the encoder to a reasonable first guess at a good focus. Because the encoder keeps resetting its zero-point, this value will be about 0.000 mm. If the air temperature is colder than it has been on previous nights, note that the best focus increases by about 0.100 mm for every 5 °C decrease in temperature.

7. Open the dome, remove the telescope cover, and initialize the pointing of the telescope starting from the zenith position in the same way as for visual observing. The only difference is that you will take images instead of looking through the eyepiece and center the star in the field of view of the camera. Centering is performed using the *Telescope/Motion Controls* in *The Sky*.
   a. After slewing to the first bright star, take a 1 second exposure.
   b. The bright star should be in the image – shrink the displayed image in the *CCDSOFT* window so that you can see all of it (change the cursor to “zoom out” and click one or more times on the image; then go back to the “select” cursor; click once on the frame of the image to get it to resize).
   c. Display the image in *RUPhAst* and note that it is flipped top-to-bottom compared to the *CCDSOFT* display.
   d. Center the bright star in the field using the telescope motion controls, taking an exposure after each move. The long axis of the CCD is north/south and about 32 arcminutes across.
   e. Once the star is centered, sync the telescope coordinates.

8. Slew to a star near M31 that is magnitude 3 or brighter. Take another 1-second exposure to check and, if necessary, refine the pointing.

9. Slew to the focus star you selected. Set *Reduction* to Autodark, *Filter* to *V*, and take a 5-second exposure. Confirm that you are pointed where you expect to be.

10. Focus the camera.
   a. Set *Bin* to 1x1 and *Reduction* to None. Take a 1-second exposure.
   b. Shrink the *CCDSOFT* display to see the whole image, if necessary. Click and drag a selection box to include your focus star and several other stars in the *CCDSoft* image.
display. Note that this automatically checks the Subframe box. Take another test image and verify that everything is ok in the subframe display box. Then select Reduction: AutoDark and take one more image.

c. Select the AutoSave tab and set a reasonable filename (i.e., focus) and then go back to the Image tab. Set the telescope focus value to about 0.150 mm less than the estimated optimum value. (E.g., if the best focus is guessed to be $-0.450$, start the focus series at $-0.600$). Take a set of 7 exposures, all with a 5 second exposure time, increasing the focus value in steps of 0.050 mm between exposures. You should thus take the last exposure at 0.150 mm above the central value.

d. Examine these 7 images with RUPhAst, measuring the FWHM of the focus star in each using the radial profile routine (“p” key or left mouse button in Imexam mode). There should be a clear minimum in FWHM and the best value may be between two of the sampled positions. If the best focus is at either end of the sequence, repeat step 10-c using the best focus value so far as the center of the focus series.

e. Set the telescope focus to your optimum value. Include the value of your best focus and the air temperature in your lab report. This same focus value should be OK for images taken through the B, V, and R filters.

11. Take your science images. We will use Reduction set to None because the 300-sec autodark exposure would disrupt the autoguiding.
   a. Slew to your first target. Set Bin to 2x2, Subframe off, and, in the AutoSave tab, change the filename to something more reasonable than focus. Take two 300-second dark exposures.
   b. Take a 5-second exposure and examine the image in RUPhAst. Adjust the pointing to place your guide star in the autoguider field. Set up the guider. I or the TA will guide you through the procedure.
   c. With the autoguider running and Reduction set to None, take 300-sec exposures of your first field through the V, R, and B filters.
   d. Stop the autoguider and take another 300-sec dark.
   e. Slew to your second field and set up the autoguider.
   f. With the autoguider running and Reduction set to None, take 300-sec exposures of your second field through the V, R, and B filters.
   g. Stop the autoguider and take another two 300-sec darks.

III. Acquisition of Flat Field Images:

1. If you have obtained your M31 and M32 images, start shutting down the telescope by sending it to the home position. Drop the link with the computer and turn off the black telescope interface box. Point the telescope horizontally by hand and close the dome shutter.

2. Turn on the dome white lights and point the telescope to a region of the inside of the dome that is unshadowed and as free of “structures” as possible.

3. Take seven well-exposed (about 30,000 ADU per pixels in the center) in each of the B, V, and R filters with Reduction set to Autodark. Use the AutoSave tab to set prefix filenames of flatB, flatV, and flatR, respectively. Good exposure times are about 35, 9, and 7 seconds for B, V, and R, respectively
4. Cover the telescope and point it to the zenith. End the CCDSoft program and turn off the power to the CCD at the plug strip in the telescope base (if this is the last data that you are taking in your lab period).

IV. Data Analysis – Data Calibration

Data analysis can be done at any time, using IDL running on the server computer (astrolab). Using VNC, you can connect to astrolab from anywhere and analyze your data.

The first step in measuring the brightness of objects in a CCD image is to remove from the image those features that are solely due to the instrument itself. For the data from this lab, that means subtracting an average dark image and dividing by an average flat-field.

1. Copy all of your Lab 4 CCD images from the folder for your night in /home/ph344/lab4 to a lab4 folder in your home area. Make sure that you always work on these copies, not the original images! Use the file manager tool to copy the images (or the Linux cp command on the command line if you are a Linux wizard). Also copy the file /home/ph344/lab4/phast.conf into your lab4 folder. This configuration file initializes certain quantities in RUPhAst, most notably the CCD gain and readnoise. Examine the contents of this file.

2. Create a subdirectory in your lab4 folder called calib and move your dome flat-field images and dark images into it. Delete any flat-field images with NOAUTODARK in the name (these are images before the automatic dark subtraction). This step is at least very useful because the IDL routine that combines the darks and flats is not very flexible in the way that it selects multiple files – in a file listing all of the darks or all of the flats taken through a particular filter need to appear in a block together.

3. Start IDLDE and then change the path to the folder with your calibration files using the IDL cd command:

   cd, "/home/yourusername/lab4/calib"

Recall that the quotes are important, as is the comma. The IDL program mkflatru combines your individual flat-field images into an average flat-field image, scaled to be close to one at its center. When combining the images, mkflatru, measures the average signal in the central half of each image, divides the image by this number, and then takes the median of all of these normalized images to eliminate cosmic-ray events. Combine your seven dome flats taken through the V-band filter using mkflatru and save the resulting image as FlatV.FIT. Similarly, combine your B-band and R-band dome flats.

4. Use the IDL program mkdarkru to combine your five (or however many you got) dark exposures and save the resulting average image as Dark.FIT. Note that mkdarkru takes a while to complete since it does a somewhat more sophisticated rejection of discrepant pixels – be patient.

5. At the IDL command line, cd back to your lab4 folder (cd, “.” will do this; the . is a shorthand for the folder above the current one). Start RUPhAst and examine your average dark and flat-field images with RUPhAst to check that they look reasonable. Briefly describe its appearance in your report. If any of your average images do not look OK, return to steps 3 and 4 to determine what you did wrong. For example, display the
individual files that went into the average to make sure that they contain what you think they do.

6. Process each of your images of the M31 and M32 using the Calibration (NOT Batch calibrate) item in the Pipeline menu of RUPhAst program. Use the Dark.FIT image as the dark frame for all of your images. Use the FlatV.FIT image as the flat-field image for the V-band images, the FlatB.FIT image for the B-band images, etc. Name your calibrated galaxy images something reasonable (i.e., shorter than the original names, while preserving the important information about the image).

V. Data Analysis – Photometry

The goal here is to make some simple measurements of the magnitude and colors of the centers of M31 and M32, estimate their shapes on the sky, and to find their surface brightness profiles. We will use stars with known brightness in our images to determine the relation between magnitude and signal levels in the images (in ADU’s). Much of the photometry will be done with RUPhAst, but measuring the galaxy surface brightness profiles with a separate IDL program. After some thought, I decided that the variation between images of both the atmospheric absorption and the brightness of the sky made combining photometry from different images somewhat complicated. Thus, in this lab you will make measurements in just the M31 images and M32 images alone.

Table 1 below list standard B-, V-, and R-band magnitudes for stars in the direction of M31 and M32. The stars are identified in Figures 1 and 2 below using V-band images that I took October 10 (these finding charts are also available on the class website). These data are taken from the paper “BRVI CCD Photometry of 361,281 Objects in the Field of M31” by E. A. Magnier et al. (1992, Astron. Astrophys. Suppl., 96, 379). In practice, I identified bright, unsaturated stars in the M31 and M32 images using The Sky and used the resulting right ascension and declination to search an online version of the catalog of photometry. For this search I used the VizieR online compendium of 13,348 (as of October 2015) astronomical catalogs (http://vizier.u-strasbg.fr/viz-bin/VizieR). Magnier et al. (1992) estimate that for stars brighter than 19th magnitude their photometric uncertainties are dominated by systematic effects at the level of about 0.02 magnitude for B and V and about 0.05 magnitude for R and I. Larger errors are possible since we must be close the bright saturation limit of the Magnier et al. (1992) photometry.

1. If you have not done so previously, copy the file /home/ph344/lab4/phast.conf into your lab4 folder. This configuration file initializes certain quantities in RUPhAst, most notably the CCD gain and readnoise. Examine the contents of this file. Start IDL, use the “cd” command to navigate to your lab4 folder (similar to the command described in IV.3.). Then start RUPhAst and load in your processed M31 B, V, and R images and your processed M32 B, V, and R images. Use the aperture photometry tool to measure (x,y) location of the center of M31 and M32 in the images and report these.

2. In the Scaling menu at the top of the RUPhAst window, select Log. This basically takes the logarithm of the image values before displaying them. Use the t-key to obtain a contour plot of the 100 pixel × 100 pixel region (the default range) centered on M32 in your V-band image. With Log scaling selected, the contours are equally
spaced in the logarithm of the pixels values. Because the images of the galaxies extend over a wide range of surface brightnesses, logarithmic spacing is more useful than linear. Use the outermost and 5th-brightest contours in your contour plot to estimate the ellipticity of M32 ($\epsilon = 1 - b/a$, where $b$ is the length of the minor axis and $a$ is the length of the major axis). Also estimate the position angle of the major axis, which is the angle between the major axis and the direction north. Position angles are measured increasing from north towards east by convention. Remember that for CCD images taken when the telescope is looking east, the orientation of images in RuPhAst is north to the left and east down. Estimate approximate uncertainties for your ellipticities and position angles. Is there any evidence of either quantity changing with radius?

3. Produce contour plots for 100 pixel $\times$ 100 pixel and 600 pixel $\times$ 600 pixel regions centered on M31 in your V-band image. Measure the ellipticity and position angle for 4th-brightest and outermost complete contours in 100 pixel $\times$ 100 pixel region and for the outermost complete contour in the 600 pixel $\times$ 600 pixel region. Again estimate approximate uncertainties and comment on any changes with radius.

Table 1 - Standard Photometry

<table>
<thead>
<tr>
<th>Name</th>
<th>B</th>
<th>V</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>2801:2073</td>
<td>11.475</td>
<td>11.232</td>
<td>11.056</td>
</tr>
<tr>
<td>2805:2145</td>
<td>13.015</td>
<td>12.044</td>
<td>11.495</td>
</tr>
<tr>
<td>2801:2055</td>
<td>12.835</td>
<td>11.681</td>
<td>11.047</td>
</tr>
<tr>
<td>2801:2061</td>
<td>12.358</td>
<td>12.169</td>
<td>12.087</td>
</tr>
<tr>
<td>2801:2030</td>
<td>13.075</td>
<td>12.569</td>
<td>12.319</td>
</tr>
<tr>
<td>2801:2046</td>
<td>12.528</td>
<td>11.434</td>
<td>10.822</td>
</tr>
<tr>
<td>2801:2085</td>
<td>12.724</td>
<td>12.231</td>
<td>11.911</td>
</tr>
<tr>
<td>UCAC</td>
<td>13.651</td>
<td>12.420</td>
<td>11.723</td>
</tr>
<tr>
<td>2801:2010</td>
<td>14.004</td>
<td>12.750</td>
<td>12.016</td>
</tr>
</tbody>
</table>

4. Use the RUPhAst aperture photometry tool to measure instrumental magnitudes for at least three stars from Table 1 in each of your M31 B, V, and R and M32 B, V, and R images. For these measurements, in the Photometry Settings window select the IDLPhot sky algorithm, output units of Arcsecs Magnitudes, an instrumental magnitude system and yes to calculating photometric errors. Also check that RuPhAst has correctly read a CCD gain of 1.8 and a readout noise of 15.5 from the phast.conf file. Use an aperture radius of that is twice your typical stellar FWHM (rounded up to the nearest integer) and inner and outer sky radii of 15 and 25 pixels, respectively. Remember that you have to hit carriage return
after typing a number into the box. Calculate your best estimate of \( \Delta m = m_{\text{std}} - m_{\text{inst}} \) and its uncertainty for each of the six images. As we will discuss when measuring a color-magnitude diagram, the transformation from instrumental to standard magnitudes can depend on the color of the star (or galaxy) being measured. In this lab we will just use the simple offsets, in part because I am not sure that the Magnier et al. (1992) photometry is accurate enough to determine a more complicated transformation.

5. Obviously, galaxy photometry requires much larger inner and outer sky radii than does photometry of stars. In RUPhAst examine your V-band M32 image and decide what inner sky radius is outside of the visible galaxy. You will want to adjust the brightness and contrast of the display to show a lot of contrast around the background level so you can decide the extent of the faint outer parts of M32. Make the outer sky radius 25 pixels larger than your inner radius. Measure the instrumental B, V, and R magnitudes of M32 with an aperture radius of 11 pixels (about 10 arcseconds) and 100 pixels (about the largest radius that does not have contamination from bright foreground stars). Judge the sensitivity of your measurements to the adopted sky annulus by repeating them after increasing the sky radii by 25 pixels. Convert your instrumental magnitudes to standard magnitudes using your \( \Delta m \) values and report them along with their uncertainties. Also calculate B−V for the two apertures and its uncertainty. To get an idea of the average type of star contributing to the light in the two apertures, use the relation between B−V and main-sequence spectral type given at [http://www.stsci.edu/~inr/intrins.html](http://www.stsci.edu/~inr/intrins.html) to find spectral type corresponding to your average B−V colors.

6. Repeat part V.5. for your M31 images with aperture radii of 11 and 50 pixels. Choosing radii for the sky annulus is more problematic in this image since the galaxy really fills the entire field. In this case, just use inner and outer sky radii of (400,425) and (425,450) pixels. These sky annuli clearly still contain galaxy light, but it is much less than the bright inner parts of the galaxy.

7. It is of interest to calculate how bright our sky is in standard magnitudes per square arcsecond. Identify the region of your M32 images that is least contaminated by light from M31 and M32. Use the image statistics tool (i key) in RUPhAst to the measure the average pixel value in this region and its uncertainty using a few samples. I recommend a box size of 51 pixels so that each of your samples is itself based on many pixels and using the median instead of the mean to remove the effect of any stars in the box. Stay away from the extreme corners of your images (particularly the lower right corner) since the flat-field corrections are larger (hence, more uncertain) there. Do this for all three filters. RUPhAst calculates instrumental magnitudes using the formula \[ m = 20.3 - 2.5 \times \log(c/t), \] where \( c \) is the total counts (in ADU) and \( t \) is the exposure time (in seconds). Remember that the logarithm in the definition of magnitudes is base 10. Convert your average counts per pixel in the sky into counts per square arcsecond using the image scale of 0.89 arcsec/pixel, calculate the instrumental magnitude per square arcsecond, and convert these to standard magnitudes.

8. Measuring the surface brightness profile of a galaxy consists of finding the average pixel value in rings centered on the galaxy. This could be done with the aperture photometry tool, but would be tedious. I have written an IDL program, `galsbmag_ru`, that does this for 21 rings logarithmically spaced from the center out to a specified maximum radius and both prints out and plots the result. Since the rings at large radius will contain foreground stars,
the program calculates a “robust” average pixel value that removes (or, at least, greatly reduces) the effect of discrepant pixel values. I could have used the median, but instead used the biweight estimate of the average and the standard deviation around that average. The program divides the standard deviation around the average value by the square root of the number of pixels to estimate the uncertainty in the mean. To ease comparison with published data, the program converts the average pixel value to a standard magnitude per square arcsecond. To do this conversion it needs the standard magnitude corresponding to a signal of 1 ADU (not 1 ADU/second). Calculate this magnitude, \( m_1 \), for your V-band images of M31 and M32 using the relation between counts and instrumental magnitude in V.7. and your correction from instrumental to standard magnitudes (\( \Delta m \)) from V.4.. We will just measure surface brightnesses from the V-band images.

9. The `galsbmag_ru` program is run from the IDL command prompt, so exit from `RUPhAst` and make sure that the current directory is set to your lab 4 folder with the `cd` command (see section IV. of this lab; note that the command `pwd` will print the current directory and `dir` will list the files in it). To run `galsbmag_ru` on the image `m31V.0045.FIT`, say, the commands are:

```idl
img=readfits('m31V.0045.FIT',h) * 1.0

galsbmag_ru, img, xcen, ycen, rmax, sky, sky_unc, img_scale, m1, title
```

In the above, replace `xcen` and `ycen` with the coordinates for the center of the galaxy from section V.1., `rmax` with the radius to which the profile is computed, `img_scale` with the arcseconds per pixel in the image (0.89), `m1` with your value from the previous part, and `title` with a title for your plot (a string enclosed in double quotes). The program plots surface brightness in magnitudes per square arcsecond versus log(radius). The value for every pixel within `rmax` appears as a gray point and the average values for the bins as black triangle with error bars. A horizontal line shows the input sky level. The program prints out for each bin the average log(radius), the average signal per pixel, the corresponding surface brightness, the estimated uncertainty in the surface brightness (including the uncertainty in the sky value), and the number of pixels in the bin. The `galsbmag_ru` program needs the “sky” signal level to subtract from the average pixel values in the rings. Since the galaxy profile rather quickly becomes fainter than the sky, the derived profile depends sensitively on the adopted sky value. We could use the sky values derived in V.7. for this value, but M32 is seen projected against the disk of M31 and so the “local sky” is somewhat brighter. For M31, there is the problem that the sky in the M32 image may not be the same as that in the M31 image. For M32, the most accurate estimate of the sky probably results from using the `galsbmag_ru` program itself with an initial estimate of 0 for the sky and adopting the level that the profile flattens out at at large radii (say with a maximum radius of 700 pixels). Use the scatter between the bins at large radii to estimate the uncertainty in this level rather than the very small estimated uncertainty in the average pixel value. For M31 we don’t have a good estimate of the sky since the galaxy fills the field of view. It is probably best to use the approach of section V.7. with the part of the M31 image with the least amount galaxy light in it. Because of the difficulty in estimating the sky and because of the complications introduced by the interaction of the ellipticity of the light distribution with the edges of the field of view, we will confine ourselves to measuring the inner surface brightness profile of M31. Once you have decided on your
best values for the sky, generate surface brightness profiles for M31 and M32 with a maximum radius of 500 pixels.

10. Finally, at the IDL command prompt use the command `tctoolru` to make a color image from your B, V, and R images of M31 and M32. Also make a color image of M33 using the images in the `/home/ph344/lab4` folder. Try different scalings and choose the one that you think produces the best image. In my experience, reducing the Max values for the images to the Min plus the same constant can be useful.

![Image of Stars with Standard Magnitudes in the M31 Field]

**Figure 1: Stars with Standard Magnitudes in the M31 Field**
Figure 2: Stars with Standard Magnitudes in the M32 Field