“PHOTOMETRIC IDENTIFICATION OF STANDARD STARS BY HCT”

Project Report Submitted to

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In partial fulfilment of the requirement for the award of the degree of

MASTER OF SCIENCE IN SPACE SCIENCE

Submitted By

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To: Whomsoever it may concern.

This is to certify that the material presented in the project report titled "OBSERVATIONS OF PHOTOMETRIC STANDARD STARS WITH THE HCT" by Anjali G., was carried out under my supervision at the Indian Institute of Astrophysics, Bangalore, India, during Apr-Jun 2022.

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CERTIFICATE

This is to certify that the dissertation entitled **"PHOTOMETRIC IDENTIFICATION OF STANDARD STARS BY HCT"** Submitted by **Ms. Anjali G** is a bonafide record of the work based on the investigation carried out by her under the guidance of **Dr. Firoza Sutaria, Assistant Professor, IIA Banglore** towards the partial fulfilment of the requirements for the award of Degree of Master in Space Science at Bharata Mata College, Thrikkakara affiliated to Mahatma Gandhi University during the academic year 2020-2022. The work presented in the dissertation is the original work of the candidate and is worth of the degree of Master of Space Science.

Dr. Anu Philip

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DECLARATION

I hereby declare that the dissertation entitled **"Photometric Identification of Standard stars using HCT"** uniquely prepared by me is an original work submitted to Mahatma Gandhi University towards the fulfilment of the final year MSc project in Space Science. I further declare that the work reported in this project has not been submitted and will not be submitted either in part or full, for the award of any other degree or diploma or to any other university for any examination.

Place : Thrikkakara **ANJALI G**

Date :

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CONTENTS

ABSTRACT

Aperture Photometry is performed on photometric standards observed on several nights during the period 2020-2022, with the Himlayan Chandra Telescope (HCT). The HCT is a 2m class telescope, located at the Indian Astronomical Observatory (IAO), Mt. Saraswati, Digpa-ratsa Ri, Hanle at an altitude of 4500m (15000 ft) above sea level. The HCT faint object Spectroscopic camera (HFOSC), and the Bessel U, B, V, R and I broad band filters were used for this observation. Image processing was carried out using the Ds9 and IRAF astronomical soft wares. After bias subtraction and flat fielding of the raw data, the standard stars were identified from each night's observations using the IRAF utility *daofind*, an automatic star finding program. The magnitudes of the identified standard stars are obtained by performing aperture photometry with the IRAF utility *phot*. Aperture corrections were done using the curve of growth method, with the IRAF utility *mkapfile*, in the PHOTCAL package. These photometric results can be later used to obtain and study the local extinction at Hanle in these broad band filters.

CHAPTER 1

INTRODUCTION

Photometry is the measurement of intensity of electromagnetic radiation from a celestial body far away from us in a given wavelength band. Its measurement gives the brightness, size and other physical properties of the celestial body. Photometric observations are made using telescopes mounted with charge coupled device (CCD) detectors and broad band filters. The filters used in this project are U, B, V, R and I. these cover the Ultraviolet, Blue, Visible, Red and Infrared ranges of wavelength [1]. The central wavelengths for these filters is[2]:

U - 365.6nm

B – 435.3nm

V – 547.7nm

R – 634.9nm

I – 879.7nm

Figure 1: UBVRI Filters used in Photometry

(image source: http://slittlefair.staff.shef.ac.uk/teaching/phy241/lectures/L07/index.html)

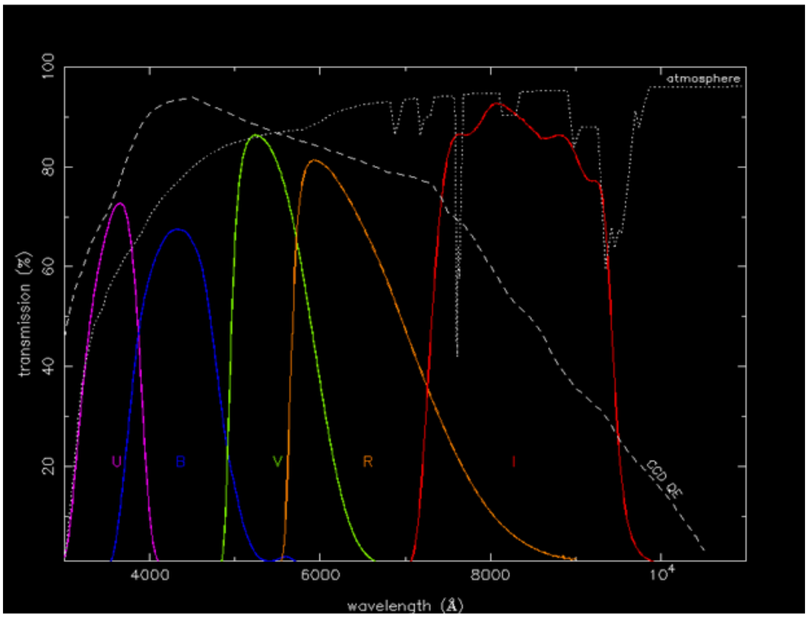

Figure 2: Filter Profiles of UBVRI filter set

(image source : http://slittlefair.staff.shef.ac.uk/teaching/phy241/lectures/L07/index.html)

Detector: A CCD is an integrated circuit. It is light sensitive and works on the principle of photoelectric effect. The CCD receives a certain number of photons which are converted into electrons and builds up an image of the sky. For correct photometry, the CCD is operated in the linear region of its response i.e the number of electrons emitted is linearly proportional to the number of incident photons. The images produced may be affected by random error which should be removed before doing photometry. For this we use the Image Reduction and Analysis Facility (IRAF), and the image manipulation toll Ds9. IRAF is a software used to reduce and analyze astronomical data [3] whereas Ds9 is an application used for the visualization, and visual manipulation of astronomical images [4].

1.1 CCD REDUCTIONS

The images taken by a CCD can contain several errors. To minimize these we have two calibration images: Bias Frames and Flat fields. Bias frames have zero exposure time and the camera shutter is closed. We combine these bias frames and do the bias subtraction in order to reduce the readnoise in CCD. Readnoise is the amount of noise present when charge produced by electrons are converted to voltage for analogue to digital conversion [5]. A CCD shows pixel to pixel variations towards the photons received. This is because each pixel have different quantum efficiency. The quantum efficiency of a CCD is defined as the fraction of photons received by a CCD which are successfully converted into electron-hole pairs. Hence to correct for this variation, we can take images of an evenly illuminated sky called Flat frames and do Flat fielding [6].

THIS IS THE PROCEDURE: To make images free of errors we need to perform Bias Subtraction and Flat Fielding. For Bias Subtraction, we have to create a list file of all the bias frames and then combine them using the task **zerocombine** from the package *ccdred*. Hence we obtain Master Biases. Now we subtract the master bias from the list of non-bias frames using the arithmetic operation *imarith*. After completing Bias Subtraction, we have to do Flat Fielding for each filter used. Create a list of all flat frames and combine all flats using the task **flatcombine**. Then normalize the flats by dividing it with the mean value obtained from *imstat*. Now divide the object frame for each filter with the normalized flat in the same filter to be done with flat fielding.

Once the Bias Subtraction and Flat fielding are done we can proceed to Aperture Photometry which is the measurement of light falling inside a circular aperture.

For this we use the *Daofind* and *Phot* utilities in IRAF. The program *daofind* is used for the automatic detection of stars and this will produce a .coo file containing the coordinates of the identified stars. These stars are marked using the task **tvmark**. By running *phot*, we obtain a .mag file which contains the magnitude of the stars identified. Now create an mkapfile which contains all the .mag files and run it in the *photcal* package to obtain the Aperture corrections. The magnitudes are then used to study the extinction of the standard stars.

The general methodology followed in this project is discussed below. The data reduction logs for each night are included in the appendix to this project report.

1.2 SETTING UP IRAF

All CCD reductions and photometric analysis were carried out in the software IRAF. It was developed by the National Optical Astronomy Observatory. It is the most commonly used software for data reduction in astronomy.

Having installed IRAF in the system, it is invoked by opening a terminal (Ctrl+Alt+T) and then running **mkiraf** at the prompt. This sets up the file login.cl, which identifies and marks all parameters and paths required to run IRAF. Subsequently, typing cl at the command prompt in an xgtrem operand to the working directory will launch IRAF.

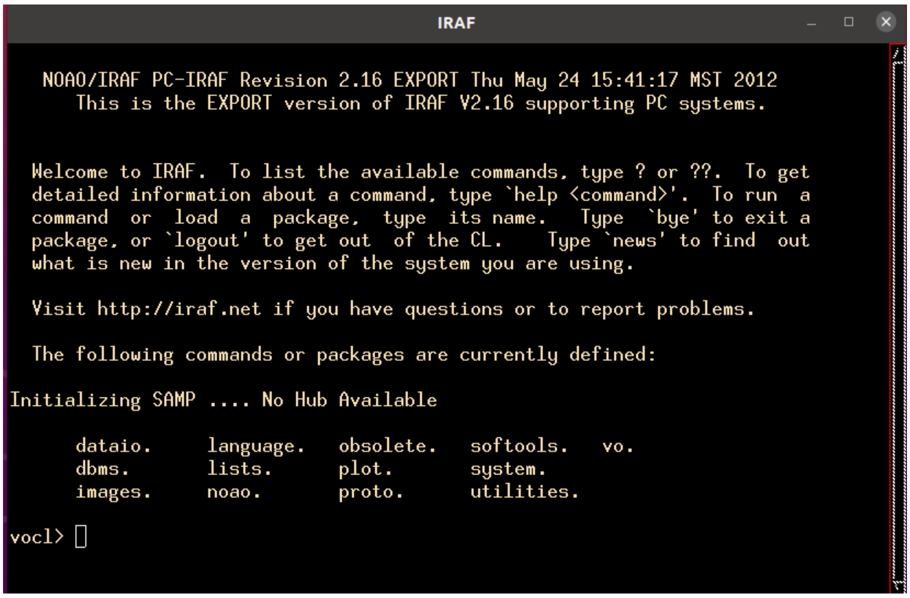

Figure 3: IRAF window

To open Ds9 along with IRAF, create a loginuser.cl file in the same directory containing login.cl file. We have to set the command to open Ds9 in the first line of loginuser.cl file, specify the size in which every image should be displayed by typing set stdimage = imt2048 in the second line. This will automatically set the size of images to 2048x2048 pixels. Type ‘keep’ in the last line. An image is displayed in the Ds9 window using the command given below in IRAF.

vocl> display imagename.fits

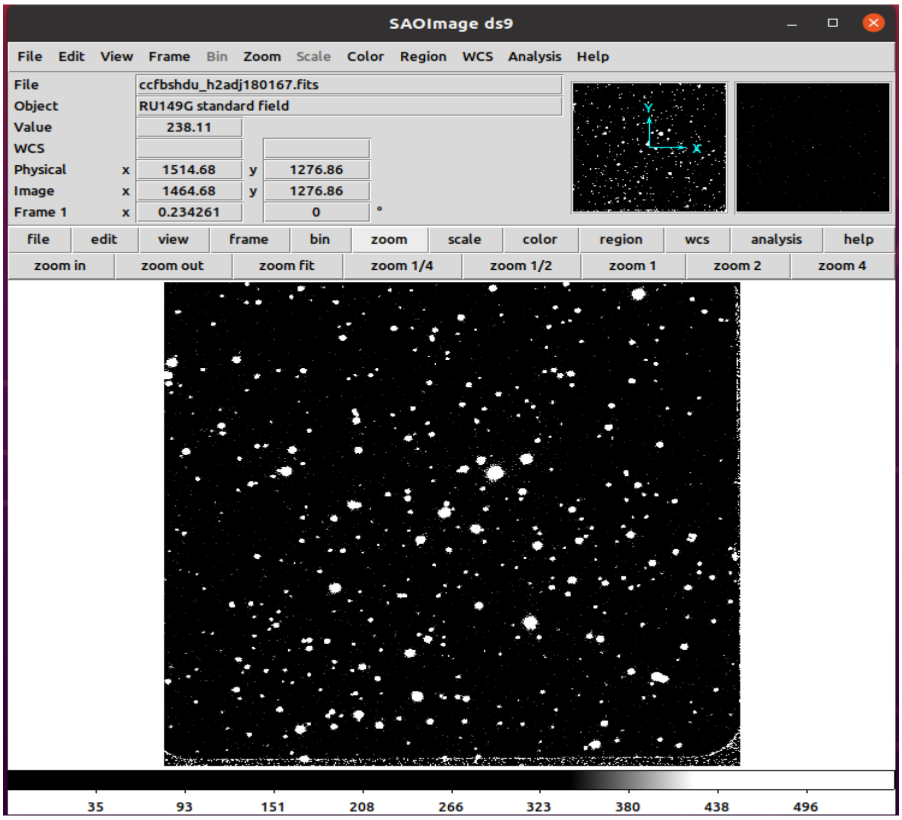

Figure 4: Example of an image displayed in Ds9 window

1.3 BIAS SUBTRACTION

In IRAF, move to the directory containing all the bias frames and create a list file called Bias_img.list of all these bias frames. Run **epar zerocombine** on this file from the package **ccdred** to combine all the files in Bias_img.list together. We can change the package to ccdred from vocl as follows:

vocl> noao

artdata.	digiphot.	nobsolete.	onedspec.
astcat.	focas.	nproto.	rv.
astrometry.	imred.	observatory.	surfphot.

astutil. mtlocal. obsutil. twodspec.

noao> imred

argus. crutil. echelle. iids. kpnocoude. specred.

bias. ctioslit. generic. irred. kpnoslit vtel.

ccdred. dtoi. hydra. iris. quadred.

imred> ccdred

badpiximage ccdmask flatcombine mkskyflat

ccdgruops ccdproc mkfringecor setinstrument

ccdhedit ccdtest mkillumcor zerocombine

ccdinstrument combine mkillumflat ccdlist

darkcombine mkskycor

```
ccdred> epar zerocomb
PACKAGE = ccdred
   TASK = zerocombine

input   =       @Bias_img.list  List of zero level images to combine
(output =        Bias_img.fits) Output zero level name
(combine=              average) Type of combine operation
(reject =               minmax) Type of rejection
(ccdtype=                     ) CCD image type to combine
(process=                   no) Process images before combining?
(delete =                   no) Delete input images after combining?
(clobber=                   no) Clobber existing output image?
(scale  =                 none) Image scaling
(statsec=                     ) Image section for computing statistics
(nlow   =                    0) minmax: Number of low pixels to reject
(nhigh  =                    1) minmax: Number of high pixels to reject
(nkeep  =                    1) Minimum to keep (pos) or maximum to reject (neg)
(mclip  =                  yes) Use median in sigma clipping algorithms?
(lsigma =                   3.) Lower sigma clipping factor
(hsigma =                   3.) Upper sigma clipping factor
(rdnoise=                 4.87) ccdclip: CCD readout noise (electrons)
(gain   =                 1.22) ccdclip: CCD gain (electrons/DN)
(snoise =                   0.) ccdclip: Sensitivity noise (fraction)
(pclip  =                 -0.5) pclip: Percentile clipping parameter
(blank  =                   0.) Value if there are no pixels
(mode   =                   ql)
```

Figure 5: Parameters of Zerocombine set for the night 2022-03-07

The Gain and Rdnoise values should be specified for running zerocombine. Gain is defined as the number of electrons per count [7] and readnoise is the amount of noise present when charge produced by electrons are converted to voltage for analogue to digital conversion. Here Gain = 4.87 and rdnoise = 1.22.

The master bias so created i.e. Bias_img.fits is then subtracted from all non-bias frames using the arithmetic operation *imarith*. To run imarith, the names of all the non-bias frames (including flat field etc.) are written in a single file Object.list, and a matching list file Object_b.list is created, which mentions the names of all the output files. *Imarith* is set up as show in figure 6, and run to complete bias subtraction.

```
ccdred> epar imarith
PACKAGE = imutil
   TASK = imarith

operand1=        @Object.list   Operand image or numerical constant
op      =                   -  Operator
operand2= Bias/Img/Bias_img.fits  Operand image or numerical constant
result  =      @Object_b.list   Resultant image
(title  =                     ) Title for resultant image
(divzero=                   0.) Replacement value for division by zero
(hparams=                     ) List of header parameters
(pixtype=                     ) Pixel type for resultant image
(calctyp=                     ) Calculation data type
(verbose=                   no) Print operations?
(noact  =                   no) Print operations without performing them?
(mode   =                   ql)
```

Figure 6: Parameters for Imarith for the night 2022-03-07

Operand 1 is the file containing all the non-bias frames, operand 2 is the file containing the master biases and operator corresponds to the arithmetic operation being performed.

1.4 FLAT FIELDING

In IRAF, move to the directory containing all the flat frames. Flat Fielding is done for each filters, hence the following steps should be done for each of the U, B, V, R and I filters. Create a list of flats, Flat_I.list (this is for I filter), to be combined. Run **epar Faltcombine** from the package ccdred on them.

vocl> .noao .imred .ccdred

imred> ccdred

badpiximage	ccdmask	flatcombine	mkskyflat
ccdgroups	ccdproc	mkfringecor	setinstrument
ccdhedit	ccdtest	mkillumcor	zerocombine
ccdinstrument	combine	mkillumflat	ccdlist
darkcombine	mkskycor		

```
ccdred> epar flatcombine
PACKAGE = ccdred
   TASK = flatcombine

input   =          @Flat_I.list  List of flat field images to combine
(output =           Flat_I.fits) Output flat field root name
(combine=                median) Type of combine operation
(reject =             avsigclip) Type of rejection
(ccdtype=                      ) CCD image type to combine
(process=                    no) Process images before combining?
(subsets=                    no) Combine images by subset parameter?
(delete =                    no) Delete input images after combining?
(clobber=                    no) Clobber existing output image?
(scale  =                  mode) Image scaling
(statsec=                      ) Image section for computing statistics
(nlow   =                     1) minmax: Number of low pixels to reject
(nhigh  =                     1) minmax: Number of high pixels to reject
(nkeep  =                     1) Minimum to keep (pos) or maximum to reject (neg)
(mclip  =                   yes) Use median in sigma clipping algorithms?
(lsigma =                    3.) Lower sigma clipping factor
(hsigma =                    3.) Upper sigma clipping factor
(rdnoise=                  4.87) ccdclip: CCD readout noise (electrons)
(gain   =                  1.22) ccdclip: CCD gain (electrons/DN)
(snoise =                    0.) ccdclip: Sensitivity noise (fraction)
(pclip  =                  -0.5) pclip: Percentile clipping parameter
(blank  =                    1.) Value if there are no pixels
(mode   =                    ql)
```

Figure 7: Parameters for Flatcombine for the night 2022-03-07

The output file flatcombine is Flat_I.files. This is called a Master flat. Doing imstat on Flat_I.files gives the statistical properties of the image, including the mean value of the pixels, and their standard deviation. The master flat is divide by this mean to normalize it. This is performed using the arithmetic operation imarith. Finally, divide the object frame in each filter by the corresponding normalized flat to complete Flat fielding.

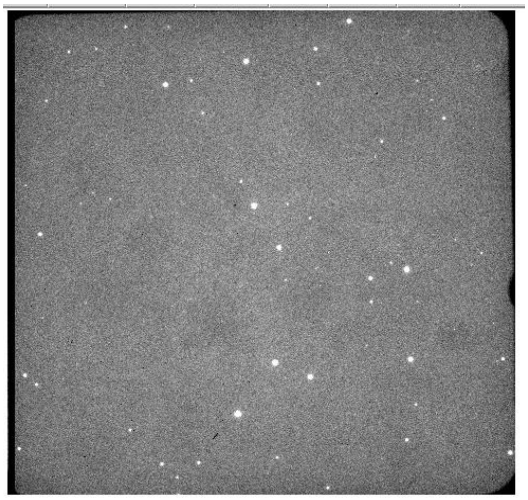

Figure 8: Bias Subtracted Image

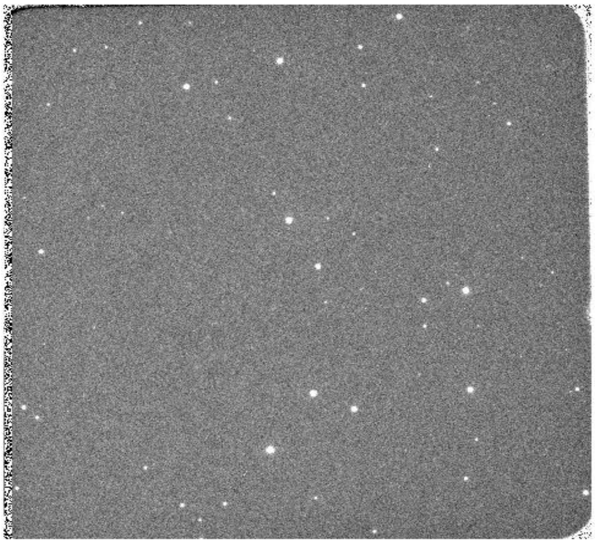

Figure 9: Flat Fielded Image

CHAPTER 2

METHODOLOGY

2.1 APERTURE PHOTOMETRY

2.1.1 Standard Star Identification

In IRAF, move to the directory containing the bias subtracted, flat fielded images. For each U, B, V, R, I filters, compare the field with that of the standard star field given by Landolt Equitorial Standards. The stars are identified and marked within a circle and labelled exactly as in the standard field. This is then saved in the Ds9 field region.

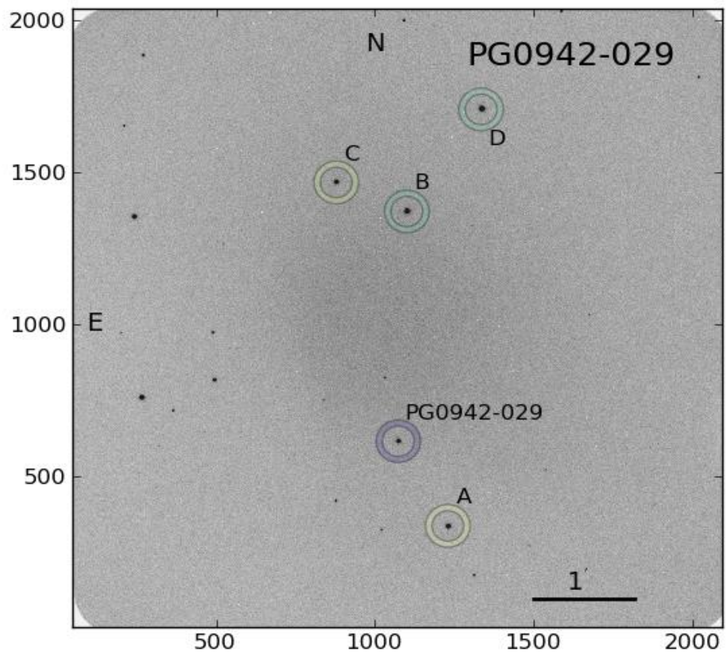

Figure 10: An example of a Standard Star Field. Here the Standard star is PG0942-029

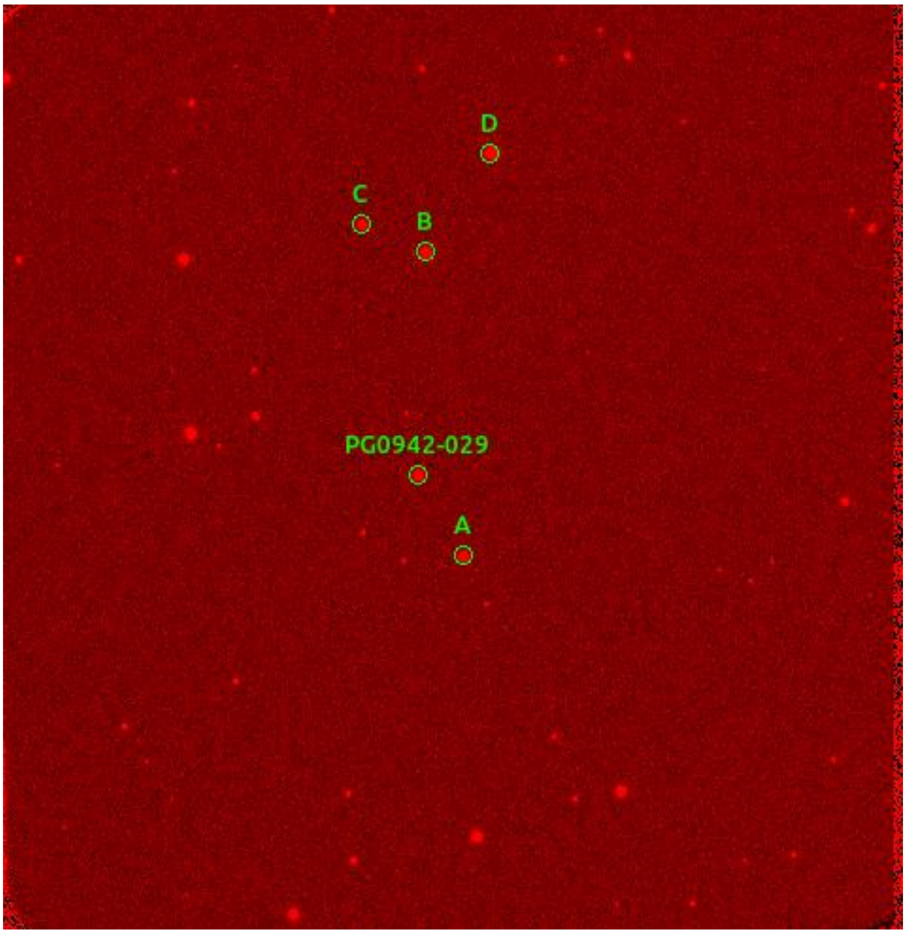

Figure 11: The field of PG0942-029 identified on comparison with its Standard field for the night 2022-03-07

2.1.2 Automatic Detection of Stars using Daofind

We begin by examining the header parameters of images in each filter. For this we use the command:

imhead imagename.fits l+ | page

This will display the header of the image as:

```
No bad pixels, min=0., max=0. (old)
Line storage mode, physdim [2048,2048], length of user area 4131 s.u.
Created Fri 16:41:01 01-Apr-2022, Last modified Fri 16:41:01 01-Apr-2022
Pixel file "bf_afc07053.fits" [ok]
EXTEND  =                    F / File may contain extensions
ORIGIN  = 'NOAO-IRAF FITS Image Kernel July 2003' / FITS file originator
IRAF-TLM= '2022-04-01T11:11:01' / Time of last modification
OBSERVAT=  '                '   /
TELESCOP=  '                '   /
INSTRUME= 'HFOSC    '  /
DETNAME =  'Site 2kx4k      '   /
DATE    = '2022-04-01T11:11:01' /
DATE-OBS=  '2022-03-07'         /
FILENAME=  'afc07053'           /
OBJECT  = 'PG0942-029'          /
EXPTIME =              30.000 /
TM_START=               67260 / 18/41/00          UT start time
TM_END  =               67404 / 18/43/24          UT end time
CRVAL1  =                   1 /
CRPIX1  =                   1 /
CDELT1  =                   1 /
CRVAL2  =                 950 /
CRPIX2  =                   1 /
CDELT2  =                   1 /
COMMENT1=
COMMENT = 'I 30s 18:41ut '
GAINM   =  'HIGH    '           / High or Low
AMPLM   =  'A 0942-029         ' / A / B or AB
CCDTEMP =              -141.2 /
LN2TEMP =              -188.3 /
COMMENTX= 'B 120s 18:06ut '
MPP     =                   1 /
CHIPID  =  'SYTe002 2K x 4K '   /
XOVERSC =                   0 /
YOVERSC =                   0 /
P_DEWAR =             4.2E+05 /
UT      =               67260 / 18/41/00          UT start time
SHSTAT  =  'OPEN           '    /
APERTUR = '1 Free          '     / FOSC Aperture ID,   step position =      0
FILTER  = '3 Bes I         '     / FOSC Filter Description
FILTID  =                   6  / Filter number. 0 = Empty or N/A
FILTPOS =               80000  / FOSC Filter wheel step position
GRISM   = '8 Free          '     / FOSC Grism ID,     step position = 280000
CAMERA  = 'Timeout '             / FOSC Camera focus
AFILTER = '   1 Free       '     / FU #A Filter description
AFILTID =                   0  / NOT Filter number. 0 = Empty or N/A
AFILTPOS=                   0  / FU #A filter position
BFILTER = '    1 Free      '     / FU #B Filter description
BFILTID =                   0  / Filter number. 0 = Empty or N/A
BFILTPOS=                   0  / FU #B filter position
LAMP    = 'OFF      '            / Calibration lamp value =  0
OBSERVER= 'Firoza Sutaria       '/
```

```
PROPOSAL= 'HCT-Cyc1_2022_P11'   /
RA      = '09:45:12'   /
DEC     = '-3:09:24'   /
EPOCH   =                    2000   /
KEYWORDS= 'std      '   /
WEATHER = 'Clear    '   /
IMAGETYP= 'object   '   /
```

Figure 12: Header Parameters

Note that we have to update the keywords airmass, gain and readnoise if they are not given in the header parameters. During an observation of stars, the amount of air present along the line of sight of observation is defined as Airmass[8].

To update these header parameters, we have to set the correct date of observation in iao_precess.data file and then create an All_files.list file containing all bias corrected, flat fielded frames.

```
observat = "iao"
ut       = sexstr ((@'tm_start'+0.1) / 3600.)
#ut_end    = sexstr ((@'tm_end'+0.1) / 3600.)
epoch    = epoch ("2022-03-07", ut)
#itime    = ((@'tm_end'-112.0) - @'tm_start')
#Note: in above expression for itime, the CCD readout time is 112 s.
itime    = @'exptime'
st       = mst ("2022-03-07", ut, obsdb (observat, "longitude"))
rap      = ra_precess(ra, dec, 2000, epoch)
decp     = dec_precess(ra, dec, 2000, epoch)
#airmass  = airmass (rap, decp, st, obsdb (observat, "latitude"))
airmass = eairmass (rap, decp, st, itime, obsdb (observat, "latitude"))
#Note that the ra and dec used for airmass caculation are precessed to the epoch of observation!
print(ut)
print(rap)
print(decp)
#print(ut_end)
#print(epoch)
print(itime)
print(st)
print(airmass)
```

Figure 13: Setting correct date of observation, airmass, gain and read noise

Then we use the following commands:

hedit images=@All_files.list fields=GAIN value=1.22add+

hedit images=@All_files.list fields=RDNOISE value=4.87 add+

ashedit images=@All_files.list commands=iao_precess.dat update=yes

hselect@files.list $I,ra,dec,airmass yes

After the header parameters are updated, display an image of nay filter in Ds9 window and do an imexamine on it.

imexamine imagename.fits

We can see the cursor blinking on the Ds9 window. This allows us to point the cursor on each of the identified stars and hitting different keys gives the required parameter values.

Hitting an ‘r’ by placing the cursor on the stars gives its radial plot.

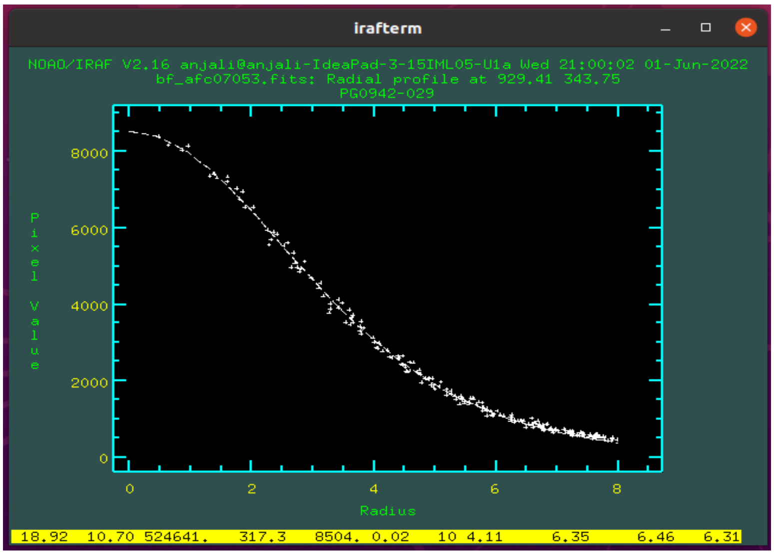

Figure 14: Radial plot of the I filter image from 2022-03-07 of the star PG0942- 029

Hit ‘a’ by placing the cursor on each of the identified stars gives and Full Width Half Maximum (FWHM) value of each stars. Then calculate the average FWHM.

Hitting 'm' on random places in the background locals to stars in Ds9 window gives the mean, median and standard deviation. Then calculate the average standard deviation and take the average of the median values to obtain the average sky value.

Now, we can perform automatic star detection by Daofind. But before this we have to edit certain parameter files. For this change package to 'daophot' as follows:

vocl > .noao > .digiphot

apphot.	daophot.	photcal.	ptools.

digiphot > daophot

addstar	daotest	nstar	pexamine	psf
allstar	datapars@	pcalc	pfmerge	psort
centerpars@	findpars@	pconcat	phot	pstselect
daoedit	fitskypars@	pconvert	photpars@	seepsf
daofind	group	pdump	prenumbe	setimpars
daopars@	grpselect	peak	pselect	substar

We have to edit the parameter files datapars, daopars, centerpars, fitskypars and findpars.

```
daophot> epar datapars
PACKAGE = daophot
   TASK = datapars

(scale  =                  1.) Image scale in units per pixel
(fwhmpsf=                6.34) FWHM of the PSF in scale units
(emissio=                 yes) Features are positive?
(sigma  =                  17) Standard deviation of background in counts
(datamin=                   0) Minimum good data value
(datamax=               65000) Maximum good data value
(noise  =             poisson) Noise model
(ccdread=                    ) CCD readout noise image header keyword
(gain   =                    ) CCD gain image header keyword
(readnoi=                4.87) CCD readout noise in electrons
(epadu  =                1.22) Gain in electrons per count
(exposur=             EXPTIME) Exposure time image header keyword
(airmass=             AIRMASS) Airmass image header keyword
(filter =              FILTER) Filter image header keyword
(obstime=            UTMIDDLE) Time of observation image header keyword
(itime  =               INDEF) Exposure time
(xairmas=               INDEF) Airmass
(ifilter=               INDEF) Filter
(otime  =               INDEF) Time of observation
(mode   =                  ql)
```

Figure 15: Parameters for Datapars for the I filter image of PG0942-029 from the night 2022-03-07

```
daophot> epar daopars
PACKAGE = daophot
   TASK = daopars

(functio=               gauss) Form of analytic component of psf model
(varorde=                   0) Order of empirical component of psf model
(nclean =                   0) Number of cleaning iterations for computing psf
(saturat=                  no) Use wings of saturated stars in psf model comput
(matchra=                  3.) Object matching radius in scale units
(psfrad =                 13.) Radius of psf model in scale units
(fitrad =                  4.) Fitting radius in scale units
(recente=                 yes) Recenter stars during fit?
(fitsky =                  no) Recompute group sky value during fit?
(groupsk=                 yes) Use group rather than individual sky values?
(sannulu=                 15.) Inner radius of sky fitting annulus in scale uni
(wsannul=                   5) Width of sky fitting annulus in scale units
(flaterr=                0.75) Flat field error in percent
(proferr=                  5.) Profile error in percent
(maxiter=                  50) Maximum number of fitting iterations
(clipexp=                   6) Bad data clipping exponent
(clipran=                 2.5) Bad data clipping range in sigma
(mergera=               INDEF) Critical object merging radius in scale units
(critsnr=                  1.) Critical S/N ratio for group membership
(maxnsta=               10000) Maximum number of stars to fit
(maxgrou=                  60) Maximum number of stars to fit per group
(mode   =                  ql)
```

Figure 16: Parameters for Daopars for the I filter image of PG0942-029 from the night 2022-03-07

The radius of psf model (psfrad) is given by 2xFWHM and the fitting radius (fitrad) is given by FWHM/2.

```
PACKAGE = daophot
   TASK = centerpars

(calgori=          centroid) Centering algorithm
(cbox   =                6.) Centering box width in scale units
(cthresh=                3.) Centering threshold in sigma above background
(minsnra=                1.) Minimum signal-to-noise ratio for centering algo
(cmaxite=                10) Maximum iterations for centering algorithm
(maxshif=                1.) Maximum center shift in scale units
(clean  =                no) Symmetry clean before centering
(rclean =                1.) Cleaning radius in scale units
(rclip  =                2.) Clipping radius in scale units
(kclean =                3.) K-sigma rejection criterion in skysigma
(mkcente=                no) Mark the computed center
(mode   =                ql)
```

Figure 17: Parameters for Centerpars for the I filter image of the star PG0942- 029 from the night 2022-03-07

The centering box width is the size of the box used by iraf to find the center of the stars.

```
PACKAGE = daophot
   TASK = fitskypars

(salgori=                  mode) Sky fitting algorithm
(annulus=                   15.) Inner radius of sky annulus in scale units
(dannulu=                    5.) Width of sky annulus in scale units
(skyvalu=                   306) User sky value
(smaxite=                    10) Maximum number of sky fitting iterations
(sloclip=                    0.) Lower clipping factor in percent
(shiclip=                    0.) Upper clipping factor in percent
(snrejec=                    50) Maximum number of sky fitting rejection iteratio
(sloreje=                    3.) Lower K-sigma rejection limit in sky sigma
(shireje=                    3.) Upper K-sigma rejection limit in sky sigma
(khist  =                    3.) Half width of histogram in sky sigma
(binsize=                   0.1) Binsize of histogram in sky sigma
(smooth =                    no) Boxcar smooth the histogram
(rgrow  =                    0.) Region growing radius in scale units
(mksky  =                    no) Mark sky annuli on the display
(mode   =                    ql)
```

Figure 18: Parameters for Fitskypars for the I filter image of the star PG0942- 029 from the night 2022-03-07

```
PACKAGE = daophot
   TASK = findpars

(thresho=               100.) Threshold in sigma for feature detection
(nsigma =                1.5) Width of convolution kernel in sigma
(ratio  =                 1.) Ratio of minor to major axis of Gaussian kernel
(theta  =                 0.) Position angle of major axis of Gaussian kernel
(sharplo=                0.2) Lower bound on sharpness for feature detection
(sharphi=                 1.) Upper bound on sharpness for  feature detection
(roundlo=                -1.) Lower bound on roundness for feature detection
(roundhi=                 1.) Upper bound on roundness for feature detection
(mkdetec=                 no) Mark detections on the image display?
(mode   =                 ql)
```

Figure 19: Parameters for Findpars for the I filter image of the star PG0942-029 from the night 2022-03-07

The threshold value is calculated by dividing the lowest of the peak values of stars obtained from imexamining the image by pressing ‘a’ by 17 the average sigma deviation.

Once these parameters are set, we can run daofind on the displayed image. This will result in an output .coo file containing the coordinates of the identified stars. This file contains unnecessary stars identified by daofind which can be removed.

```
daophot> epar daofind
PACKAGE = daophot
   TASK = daofind

image   =      bf_afc07053.fits Input image(s)
output  =               default  Output coordinate file(s) (default: image.coo.?)
(starmap=  bf_afc07053_density.fits) Output density enhancement image(s)
(skymap =      bf_afc07053_sky.fits) Output sky image(s)
(datapar=                      ) Data dependent parameters
(findpar=                      ) Object detection parameters
(boundar=               nearest) Boundary extension (constant|nearest|reflect|wra
(constan=                    0.) Constant for boundary extension
(interac=                    no) Interactive mode?
(icomman=                      ) Image cursor: [x y wcs] key [cmd]
(gcomman=                      ) Graphics cursor: [x y wcs] key [cmd]
(wcsout =             )_.wcsout) The output coordinate system (logical,tv,physica
(cache  =              )_.cache) Cache the image pixels?
(verify =             )_.verify) Verify critical daofind parameters?
(update =             )_.update) Update critical daofind parameters?
(verbose=            )_.verbose) Print daofind messages?
(graphic=           )_.graphics) Graphics device
(display=            )_.display) Display device
(mode   =                    ql)
```

Figure 20: Parameters for Daofind for the I filter image of the star PG0942-029 from the night 2022-03-07

To select only the stars identified from the standard field we use the task ‘pselect’ and then we can mark these stars using the task ‘tvmark’.

```
daophot> epar pselect
PACKAGE = daophot
   TASK = pselect

infiles = bf_afc07053.fits.coo.1  Input apphot/daophot database(s)
outfiles=       PG0942-029.coo  Output apphot/daophot database(s)
expr    =   (x>880)&&(x<1280)&&(y>270)&&(y<1270) Boolean expression for record selection
(inlist =                    )
(outlist=                    )
(mode   =                  ql)
```

Figure 21: Parameters for pselect for the I filter image of the star PG0942-029 from the night 2022-03-07

The Boolean expression represents the width of Box which encloses area containing the stars to be identified using tvmark[9] .

```
daophot> epar tvmark
 PACKAGE = tv
   TASK = tvmark

frame   =                    1  Default frame number for display
coords  =     PG0942-029.Icoo  Input coordinate list
(logfile=                     ) Output log file
(autolog=                   no) Automatically log each marking command
(outimag=                     ) Output snapped image
(deletio=                     ) Output coordinate deletions list
(command=                     ) Image cursor: [x y wcs] key [cmd]
(mark   =               circle) The mark type
(radii  =                   10) Radii in image pixels of concentric circles
(lengths=                    0) Lengths and width in image pixels of concentric
(font   =               raster) Default font
(color  =                  250) Gray level of marks to be drawn
(label  =                   no) Label the marked coordinates
(number =                   no) Number the marked coordinates
(nxoffse=                    0) X offset in display pixels of number
(nyoffse=                    0) Y offset in display pixels of number
(pointsi=                    3) Size of mark type point in display pixels
```

Figure 22: Parameters for tvmark for the I filter image of the star PG0942-029 from the night 2022-03-07

Now, this is repeated for each of the remaining U, B, V, R filter also and the resultant is subject to Simple Aperture Photometry.

2.2 SIMPLE APERTURE PHOTOMETRY USING PHOT

To do simple aperture photometry and obtain the magnitudes of stars identified by daofind using phot, we have to edit the parameter files datapars, centerpars, fitskypars, findpars and photpars first from the package 'apphot'. Then run epar phot to get a .mag file. This .mag file contains the magnitude of the identified stars.

```
vocl > .noao > .digiphot

apphot.        daophot.        photcal.        ptools.

digiphot > apphot

aptest         findpars@       pconvert        polymark        psort
center         fitpsf          pdump           polypars        qphot
centerpars@    fitsky          pexamine        polyphot        radprof
daofind        fitskypars@     phot            prenumber       wphot
datapars@      pcalc           photpars@       pselect
```

```
PACKAGE = apphot
   TASK = photpars

(weighti=           constant) Photometric weighting scheme for wphot
(apertur= 3,4,6,8,10,12,14,16,18,20,22,24) List of aperture radii in scale units
(zmag   =                25.) Zero point of magnitude scale
(mkapert=                 no) Draw apertures on the display
(mode   =                 ql)
```

Figure 23: Parameters for photpars for the I filter image of the star PG0942-029 from the night 2022-03-07

```
PACKAGE = apphot
   TASK = phot

image   =     bf_afc07053.fits  The input image(s)
skyfile =                       The input sky file(s)
(coords =     PG0942-029.coo) The input coordinate files(s) (default: image.co
(output =     PG0942-029.I.mag) The output photometry file(s) (default: image.ma
(plotfil=                    ) The output plots metacode file
(datapar=                    ) Data dependent parameters
(centerp=                    ) Centering parameters
(fitskyp=                    ) Sky fitting parameters
(photpar=                    ) Photometry parameters
(interac=                  no) Interactive mode ?
(radplot=                  no) Plot the radial profiles in interactive mode ?
(icomman=                    ) Image cursor: [x y wcs] key [cmd]
(gcomman=                    ) Graphics cursor: [x y wcs] key [cmd]
(wcsin  =            )_.wcsin) The input coordinate system (logical,tv,physical
(wcsout =           )_.wcsout) The output coordinate system (logical,tv,physica
(cache  =            )_.cache) Cache the input image pixels in memory ?
(verify =           )_.verify) Verify critical parameters in non-interactive mo
(update =           )_.update) Update critical parameters in non-interactive mo
(verbose=          )_.verbose) Print messages in non-interactive mode ?
(graphic=         )_.graphics) Graphics device
(display=          )_.display) Display device
(mode   =                  ql)
```

Figure 24: Parameters for Phot for the I filter image of the star PG0942-029 from the night 2022-03-07

2.3 APERTURE CORRECTION

Once we have obtained the magnitude of stars, calculate the Aperture correction. Aperture correction becomes necessary since the lowest aperture we used for photometry extends to a higher order when displayed in the Ds9 frame. As given in photpars the lowest radius of the aperture we used was 3pixels which extended to 8 pixels when displayed (fig 14). This will leave some of the star light at the tail of the point spread function (PSF). In order to have precise photometry we should collect all the light from the stars since this will be used in computing the magnitude of a single star observed for more than one night. We observe the same star for several nights only because seeing changes from night to night. Thus we measure the magnitude over a radius from about 3pixels to a maximum radius value ranging just inside the background annulus. We do not choose a gigantic aperture because this may lead to bad pixels. Hence plotting the magnitude against this aperture radius gives the variation of magnitude as aperture radius increases.

For this, we have to create an mkapfile.list containing all the .mag files. Run epar mkapfile to obtain a plot of Aperture correction against aperture radius. The mkapfile gives the aperture correction between the smallest aperture and the largest aperture using a computed curve of growth and theoretical curve of growth (see figure 26). A good fit is obtained when the residuals are minimum (figure 27). Then the difference between the asymptotic magnitude and the magnitude at r=3 gives the aperture correction at radius 3 pixels. Hence the output files mkapfile.out and mkapfile.bests of this gives the aperture correction and best corrected magnitude values for the images in each filter of that night.

```
  PACKAGE = photcal
  TASK = mkapfile

photfile=       @mkapfile.list  The input list of APPHOT/DAOPHOT databases
naperts =                       The number of apertures to extract
apercors=         mkapfile.out  The output aperture corrections file
(smallap=                    1) The first aperture for the correction
(largeap=                    0) The last aperture for the correction
(magfile=       mkapfile.bests) The optional output best magnitudes file
(logfile=         mkapfile.log) The optional output log file
(plotfil=         mkapfile.plt) The optional output plot file
(obspara=                     ) The observing parameters file
(obscolu=              2 3 4 5) The observing parameters file format
(append =                   no) Open log and plot files in append mode
(maglim =                  0.1) The maximum permitted magnitude error
(nparams=                    3) Number of cog model parameters to fit
(swings =                  1.2) The power law slope of the stellar wings
(pwings =                  0.1) The fraction of the total power in the stellar w
(pgauss =                  0.5) The fraction of the core power in the gaussian c
(rgescal=                  0.9) The exponential / gaussian radial scales
(xwings =                   0.) The extinction coefficient
(interac=                  yes) Do the fit interactively ?
(verify =                   no) Verify interactive user input ?
(gcomman=                     ) The graphics cursor
(graphic=             stdgraph) The graphics device
(mode   =                   ql)
```

Figure 25: Parameters for epar mkapfile

The mkapfile gives the aperture correction between the smallest and largest apertures using a computed curve of growth and a theoretical curve of growth. From the resultant cog model fit of epar mkapfile, an $'r'$ key gives the plot of residuals v/s radius, 'b' gives plot of residuals v/s magnitude and 'a' gives the plot of aperture correction v/s radius. We can delete points using ‘d’ and undo it using 'u' and refit the curve using ‘f’ [10].

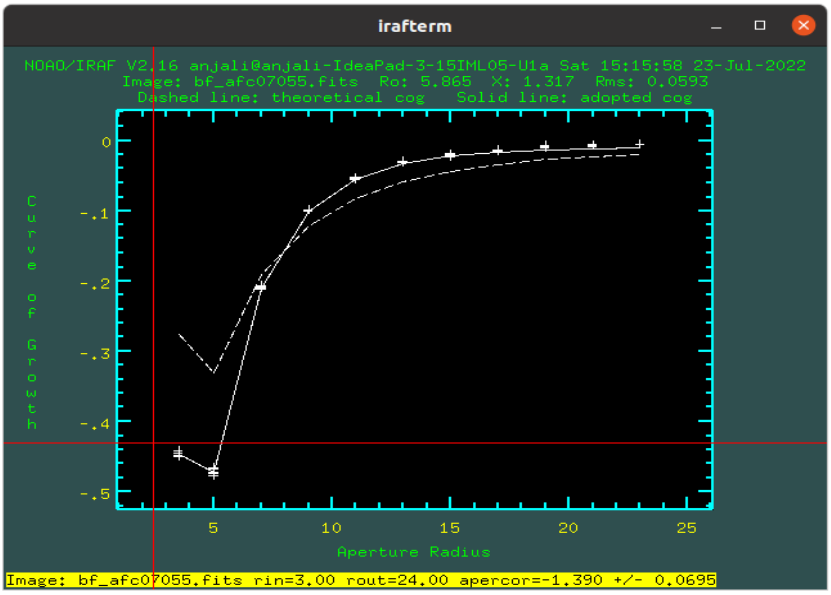

Figure 26: The resultant curve of growth obtained from epar mkapfile

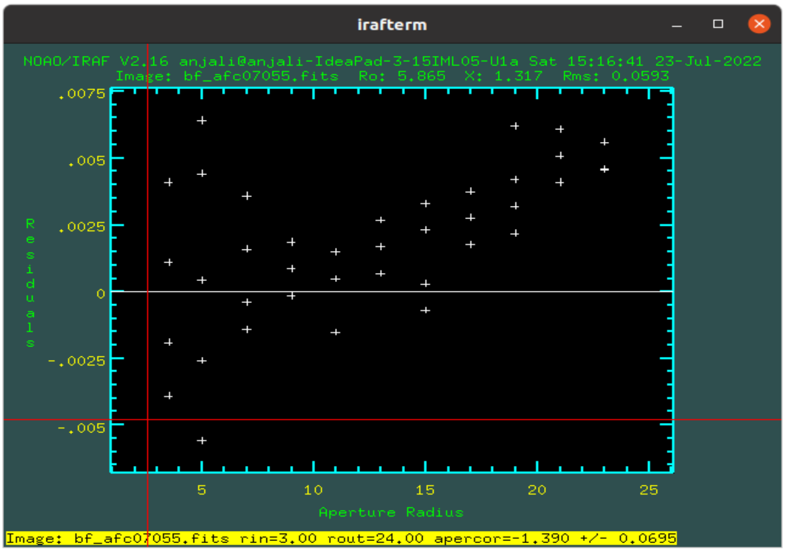

Figure 27: The plot of Residuals against Aperture radius

Here, we can delete the unnecessary points which deviates more from the other points called Residuals using the 'd' key and do a new fit of the curve by pressing the ‘f’ key.

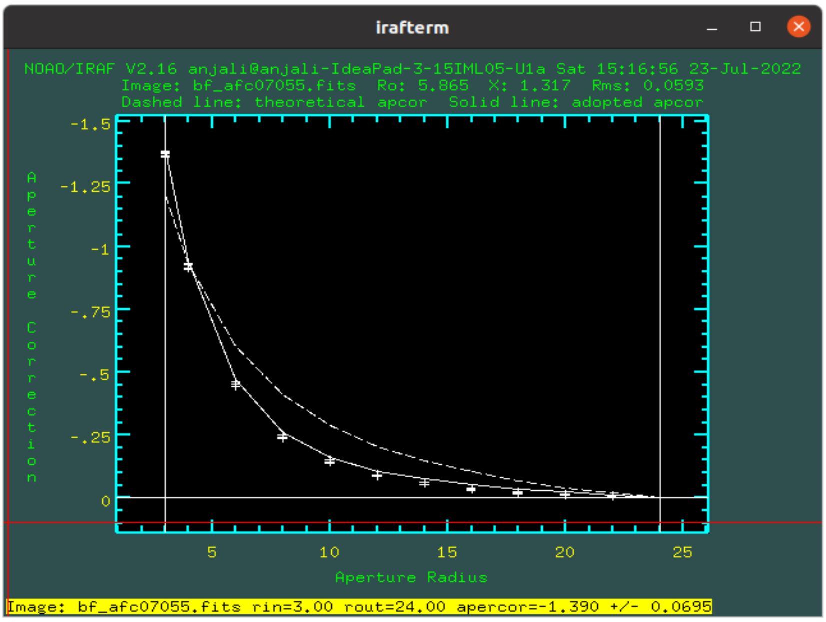

Figure 29: Plot of Aperture correction against Aperture radius

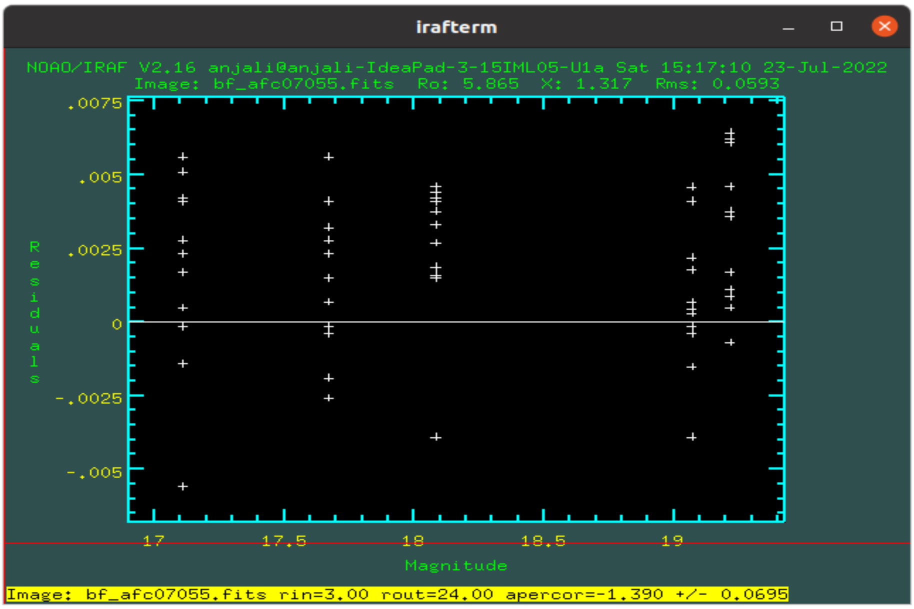

Figure 28: The plot of Residuals against Magnitude

Now use the 'w' key to window the plot and :vshow to show the error and results of fit.

The mkapfile.out contains the aperture correction from 1 to 12 in magnitudes. The mkapfile.bests contains aperture corrected to magnitude 12 and this gives the corresponding aperture corrected magnitude, magnitude error, exposure time, airmass, Xcenter and Ycenter with respect to the radius to which correction was made. The mkapfile.bests shows at what aperture size we get the minimum magnitude error. However this is not neccessary for fainter stars (r=3pixels). This can happen when (a) a star is faint which leads to the inclusion of background as the aperture size increases, (b) asymmetric smearing of star light due to poor seeing and (c) when there are occasional cosmic rays in the wings of the PSF, and leading to spurious brightening within the aperture. Thus mkapfile makes an aperture correction for each aperture radius, checks for error and give a true "magnitude" with the minimum error.

```
# The aperture correction from apertures 1 to 12 in magnitudes

bf_afc07055.fits -1.375372 0.0695131
bf_afc07053.fits -1.190747 0.06104514
bf_afc07052.fits -1.183288 0.06086404
bf_afc07056.fits -1.425958 0.07236902
bf_afc07054.fits -1.175048 0.06063901
```

Figure 30: Result obtained in mkapfile.out

\# Magnitudes corrected to aperture 12

# Image	Filter	Exptime	Airmass	Otime	Xcenter	Ycenter	Mag	Merr	Radius
bf_afc07055.fits	6BesB	120.00	1.317	INDEF	933.78	340.76	16.295	0.003	22.000
bf_afc07055.fits	6BesB	120.00	1.317	INDEF	1225.10	496.13	17.853	0.007	18.000
bf_afc07055.fits	6BesB	120.00	1.317	INDEF	1082.78	557.02	16.720	0.004	20.000
bf_afc07055.fits	6BesB	120.00	1.317	INDEF	1099.54	1041.95	15.730	0.004	16.000
bf_afc07055.fits	6BesB	120.00	1.317	INDEF	997.26	1218.98	17.687	0.005	16.000
bf_afc07053.fits	3BesI	30.00	1.304	INDEF	929.48	343.73	14.367	0.003	24.000
bf_afc07053.fits	3BesI	30.00	1.304	INDEF	1220.82	499.03	15.405	0.005	14.000
bf_afc07053.fits	3BesI	30.00	1.304	INDEF	1078.53	560.02	14.771	0.005	16.000
bf_afc07053.fits	3BesI	30.00	1.304	INDEF	1095.11	1044.99	15.683	0.006	14.000
bf_afc07053.fits	3BesI	30.00	1.304	INDEF	993.02	1221.94	15.080	0.004	20.000
bf_afc07052.fits	4BesR	30.00	1.298	INDEF	937.84	343.64	14.481	0.061	3.000
bf_afc07052.fits	4BesR	30.00	1.298	INDEF	1229.16	499.01	15.653	0.005	16.000
bf_afc07052.fits	4BesR	30.00	1.298	INDEF	1086.93	559.95	14.921	0.003	22.000
bf_afc07052.fits	4BesR	30.00	1.298	INDEF	1103.57	1044.94	15.370	0.045	4.000
bf_afc07052.fits	4BesR	30.00	1.298	INDEF	1001.34	1221.96	15.354	0.007	22.000
bf_afc07056.fits	7BesU	300.00	1.331	INDEF	930.79	344.80	18.817	0.008	12.000
bf_afc07056.fits	7BesU	300.00	1.331	INDEF	1222.02	500.14	20.687	0.018	8.000
bf_afc07056.fits	7BesU	300.00	1.331	INDEF	1079.81	561.13	19.218	0.008	14.000
bf_afc07056.fits	7BesU	300.00	1.331	INDEF	1096.41	1045.69	17.351	0.005	16.000
bf_afc07056.fits	7BesU	300.00	1.331	INDEF	994.52	1222.43	20.775	0.018	8.000
bf_afc07054.fits	5BesV	45.00	1.309	INDEF	932.80	341.82	14.898	0.003	24.000
bf_afc07054.fits	5BesV	45.00	1.309	INDEF	1224.05	497.08	16.193	0.006	16.000
bf_afc07054.fits	5BesV	45.00	1.309	INDEF	1081.83	557.98	15.333	0.004	24.000
bf_afc07054.fits	5BesV	45.00	1.309	INDEF	1098.50	1043.06	15.291	0.005	24.000
bf_afc07054.fits	5BesV	45.00	1.309	INDEF	996.29	1220.11	15.943	0.004	22.000

Figure 31: Result obtained in mkapfile.bests

It is observed from this result that the error in observed magnitude increases from smaller to larger radius i.e. the brightness of star increases.

Once we get the results from epar mkapfile, another file called mkconfig.mag is created, which lists all the aperture corrected magnitudes of all the stars from each night's observation reduced so far. In this mkconfig.mag the filter names are replaced by numbers, 00 corresponds to U filter, 10 for B filter, 20 for V filter, 30 for R filter and 40 for I filter.

FIELD	Filter	Exptime	Airmass	Xcenter	Ycenter	Mag	Merr	Radius
PG0942-029A	00	300.00	1.331	994.52	1222.43	20.775	0.018	8.000
PG0942-029B	00	300.00	1.331	1079.81	561.13	19.218	0.008	14.000
PG0942-029C	00	300.00	1.331	1222.02	500.14	20.687	0.018	8.000
PG0942-029D	00	300.00	1.331	930.79	344.80	18.817	0.008	12.000
PG0942-029	00	300.00	1.331	1096.41	1045.69	17.351	0.005	16.000
PG0942-029A	10	120.00	1.317	997.26	1218.98	17.687	0.005	16.000
PG0942-029B	10	120.00	1.317	1082.78	557.02	16.720	0.004	20.000
PG0942-029C	10	120.00	1.317	1225.10	496.13	17.853	0.007	18.000
PG0942-029D	10	120.00	1.317	933.78	340.76	16.295	0.003	22.000
PG0942-029	10	120.00	1.317	1099.54	1041.95	15.730	0.004	16.000
PG0942-029A	20	45.00	1.309	996.29	1220.11	15.943	0.004	22.000
PG0942-029B	20	45.00	1.309	1081.83	557.98	15.333	0.004	24.000
PG0942-029C	20	45.00	1.309	1224.05	497.08	16.193	0.006	16.000
PG0942-029D	20	45.00	1.309	932.80	341.82	14.898	0.003	24.000
PG0942-029	20	45.00	1.309	1098.50	1043.06	15.291	0.005	24.000
PG0942-029A	30	30.00	1.298	1001.34	1221.96	15.354	0.007	22.000
PG0942-029B	30	30.00	1.298	1086.93	559.95	14.921	0.003	22.000
PG0942-029C	30	30.00	1.298	1229.16	499.01	15.653	0.005	16.000
PG0942-029D	30	30.00	1.298	937.84	343.64	14.481	0.061	3.000
PG0942-029	30	30.00	1.298	1103.57	1044.94	15.370	0.045	4.000
PG0942-029A	40	30.00	1.304	993.02	1221.94	15.080	0.004	20.000
PG0942-029B	40	30.00	1.304	1078.53	560.02	14.771	0.005	16.000
PG0942-029C	40	30.00	1.304	1220.82	499.03	15.405	0.005	14.000
PG0942-029D	40	30.00	1.304	929.48	343.73	14.367	0.003	24.000
PG0942-029	40	30.00	1.304	1095.11	1044.99	15.683	0.006	14.000
PG0918+029A	00	300.00	1.235	1263.71	1292.44	20.240	0.099	3.000
PG0918+029B	00	300.00	1.235	1152.25	957.38	20.368	0.099	3.000
PG0918+029C	00	300.00	1.235	1626.47	1232.43	19.538	0.098	3.000
PG0918+029D	00	300.00	1.235	596.28	1060.30	19.344	0.017	10.000
PG0918+029	00	300.00	1.235	913.19	1351.61	17.527	0.005	18.000
PG0918+029A	10	150.00	1.223	1264.28	1289.77	17.360	0.004	16.000
PG0918+029B	10	150.00	1.223	1152.90	954.80	17.067	0.005	14.000
PG0918+029C	10	150.00	1.223	1627.31	1229.92	16.486	0.003	24.000
PG0918+029D	10	150.00	1.223	596.50	1057.42	15.660	0.003	24.000
PG0918+029	10	150.00	1.223	913.79	1348.99	15.364	0.003	24.000
PG0918+029A	20	60.00	1.216	1260.53	1291.84	15.791	0.004	18.000
PG0918+029B	20	60.00	1.216	1149.16	956.84	15.249	0.068	4.000
PG0918+029C	20	60.00	1.216	1623.71	1231.93	14.831	0.003	18.000
PG0918+029D	20	60.00	1.216	592.73	1059.56	13.531	0.003	24.000
PG0918+029	20	60.00	1.216	909.84	1351.18	14.686	0.003	16.000
RU149A	10	90.00	1.390	891.53	986.33	16.724	0.005	18.000
RU149B	10	90.00	1.390	1111.91	1031.62	15.202	0.002	20.000
RU149C	10	90.00	1.390	1099.16	894.29	16.508	0.005	16.000
RU149D	10	90.00	1.390	1001.10	968.61	13.323	0.002	24.000
RU149E	10	90.00	1.390	1155.18	667.37	16.126	0.005	16.000
RU149F	10	90.00	1.390	935.82	735.03	16.505	0.049	4.000
RU149G	10	90.00	1.390	826.54	801.01	15.279	0.005	14.000
RU149	10	90.00	1.390	950.16	1023.52	15.638	0.049	4.000
RU149A	10	180.00	1.373	893.21	986.06	16.724	0.004	18.000
RU149B	10	180.00	1.373	1113.48	1031.56	15.204	0.003	24.000
RU149C	10	180.00	1.373	1100.89	894.17	16.501	0.004	18.000
RU149D	10	180.00	1.373	1002.58	968.74	13.853	0.061	3.000
RU149E	10	180.00	1.373	1156.87	667.31	16.124	0.005	24.000
RU149F	10	180.00	1.373	937.34	734.95	16.512	0.007	18.000
RU149G	10	180.00	1.373	828.09	800.99	15.264	0.004	24.000
RU149	10	180.00	1.373	937.34	734.95	16.512	0.007	18.000

RU149A	20	30.00	1.401	888.59	987.34	15.662	0.057	3.000
RU149B	20	30.00	1.401	1108.85	1032.71	13.727	0.002	24.000
RU149C	20	30.00	1.401	1096.10	895.32	15.531	0.005	14.000
RU149D	20	30.00	1.401	998.09	969.82	12.598	0.003	24.000
RU149E	20	30.00	1.401	1152.12	668.41	14.774	0.042	4.000
RU149F	20	30.00	1.401	932.60	735.97	14.528	0.003	24.000
RU149G	20	30.00	1.401	823.42	802.02	13.916	0.004	22.000
RU149	20	30.00	1.401	947.12	1024.73	14.999	0.004	20.000
RU149A	30	20.00	1.410	883.90	994.14	15.395	0.005	16.000
RU149B	30	20.00	1.410	1104.18	1039.48	13.292	0.002	24.000
RU149C	30	20.00	1.410	1091.49	902.14	15.358	0.006	16.000
RU149D	30	20.00	1.410	993.50	976.53	12.508	0.003	24.000
RU149E	30	20.00	1.410	1147.54	675.18	14.406	0.004	20.000
RU149F	30	20.00	1.410	928.00	742.70	13.886	0.003	24.000
RU149G	30	20.00	1.410	818.81	808.85	13.529	0.004	22.000
RU149	30	20.00	1.410	942.52	1031.53	14.961	0.006	18.000
RU149A	40	20.00	1.420	889.48	988.99	15.381	0.009	14.000
RU149B	40	20.00	1.420	1109.54	1034.48	13.137	0.002	24.000
RU149C	40	20.00	1.420	1096.98	897.11	15.394	0.006	14.000
RU149D	40	20.00	1.420	998.92	971.51	12.670	0.003	24.000
RU149E	40	20.00	1.420	1152.91	670.26	14.279	0.003	20.000
RU149F	40	20.00	1.420	933.45	737.62	13.550	0.003	20.000
RU149G	40	20.00	1.420	824.28	803.77	13.407	0.004	20.000
RU149	40	20.00	1.420	947.99	1026.43	15.186	0.006	16.000

PG0942-029A	00	300.00	1.471	979.99	1179.18	20.699	0.085	3.000
PG0942-029B	00	300.00	1.471	1065.90	516.78	19.112	0.006	18.000
PG0942-029C	00	300.00	1.471	1208.09	456.02	20.587	0.021	8.000
PG0942-029D	00	300.00	1.471	917.02	300.81	18.709	0.005	18.000
PG0942-029	00	300.00	1.471	1082.03	1001.58	17.241	0.003	24.000
PG0942-029A	10	120.00	1.496	983.58	1172.97	17.593	0.005	18.000
PG0942-029B	10	120.00	1.496	1069.30	511.12	16.601	0.003	22.000
PG0942-029C	10	120.00	1.496	1211.56	450.30	17.752	0.005	14.000
PG0942-029D	10	120.00	1.496	920.37	294.83	16.174	0.003	24.000
PG0942-029	10	120.00	1.496	1085.59	995.77	15.613	0.005	24.000
PG0942-029A	20	30.00	1.511	981.59	1176.16	15.834	0.004	16.000
PG0942-029B	20	30.00	1.511	1067.14	513.98	15.213	0.003	16.000
PG0942-029C	20	30.00	1.511	1209.52	453.12	16.069	0.005	18.000
PG0942-029D	20	30.00	1.511	918.26	297.64	14.787	0.003	18.000
PG0942-029	20	30.00	1.511	1083.68	999.08	15.171	0.004	18.000
PG0942-029A	30	20.00	1.539	977.52	1181.39	15.237	0.005	16.000
PG0942-029B	30	20.00	1.539	1063.03	519.79	14.799	0.004	16.000
PG0942-029C	30	20.00	1.539	1205.49	458.99	15.532	0.009	18.000
PG0942-029D	30	20.00	1.539	914.22	303.28	14.363	0.004	24.000
PG0942-029	30	20.00	1.539	1079.57	1004.54	15.245	0.005	14.000
PG0942-029A	40	20.00	1.524	983.85	1178.39	15.010	0.053	4.000
PG0942-029B	40	20.00	1.524	1069.75	516.59	14.668	0.004	12.000
PG0942-029C	40	20.00	1.524	1211.97	455.83	15.298	0.005	12.000
PG0942-029D	40	20.00	1.524	920.80	300.43	14.226	0.004	20.000
PG0942-029	40	20.00	1.524	1085.94	1001.37	15.604	0.006	12.000

PG0231+051A	00	300.00	1.129	1028.46	1237.04	18.103	0.003	24.000
PG0231+051B	00	300.00	1.129	1304.65	1259.69	21.610	0.050	6.000
PG0231+051C	00	300.00	1.129	1435.93	678.03	18.848	0.006	20.000
PG0231+051D	00	300.00	1.129	727.97	864.54	20.433	0.014	14.000
PG0231+051E	00	300.00	1.129	464.89	802.26	19.023	0.006	18.000
PG0231+051	00	300.00	1.129	1094.89	1021.75	19.220	0.007	20.000

PG0231+051A	10	150.00	1.127	1029.27	1231.13	15.377	0.001	24.000
PG0231+051B	10	150.00	1.127	1306.16	1254.16	18.110	0.042	6.000
PG0231+051C	10	150.00	1.127	1436.88	671.75	16.295	0.002	24.000
PG0231+051D	10	150.00	1.127	728.54	858.20	17.020	0.003	24.000
PG0231+051E	10	150.00	1.127	465.34	795.90	16.405	0.042	6.000

PG0231+051A	20	45.00	1.127	1024.45	1233.76	13.852	0.002	24.000
PG0231+051B	20	45.00	1.127	1301.32	1256.65	15.759	0.004	24.000
PG0231+051C	20	45.00	1.127	1432.20	674.55	14.807	0.003	24.000
PG0231+051D	20	45.00	1.127	723.74	860.94	15.066	0.003	24.000
PG0231+051E	20	45.00	1.127	460.46	798.67	14.896	0.003	24.000
PG0231+051	20	45.00	1.127	1090.88	1018.15	17.246	0.009	16.000

PG0942-029A	20	30.00	1.511	981.59	1176.16	15.834	0.004	16.000
PG0942-029B	20	30.00	1.511	1067.14	513.98	15.213	0.003	16.000
PG0942-029C	20	30.00	1.511	1209.52	453.12	16.069	0.005	18.000
PG0942-029D	20	30.00	1.511	918.26	297.64	14.787	0.003	18.000
PG0942-029	20	30.00	1.511	1083.68	999.08	15.171	0.004	18.000

PG0942-029A	30	20.00	1.539	977.52	1181.39	15.237	0.005	16.000
PG0942-029B	30	20.00	1.539	1063.03	519.79	14.799	0.004	16.000
PG0942-029C	30	20.00	1.539	1205.49	458.99	15.532	0.009	18.000
PG0942-029D	30	20.00	1.539	914.22	303.28	14.363	0.004	24.000
PG0942-029	30	20.00	1.539	1079.57	1004.54	15.245	0.005	14.000

PG0942-029A	30	20.00	1.539	977.52	1181.39	15.237	0.005	16.000
PG0942-029B	30	20.00	1.539	1063.03	519.79	14.799	0.004	16.000
PG0942-029C	30	20.00	1.539	1205.49	458.99	15.532	0.009	18.000
PG0942-029D	30	20.00	1.539	914.22	303.28	14.363	0.004	24.000
PG0942-029	30	20.00	1.539	1079.57	1004.54	15.245	0.005	14.000

PG0942-029A	40	20.00	1.524	983.85	1178.39	15.010	0.053	4.000
PG0942-029B	40	20.00	1.524	1069.75	516.59	14.668	0.004	12.000
PG0942-029C	40	20.00	1.524	1211.97	455.83	15.298	0.005	12.000
PG0942-029D	40	20.00	1.524	920.80	300.43	14.226	0.004	20.000
PG0942-029	40	20.00	1.524	1085.94	1001.37	15.604	0.006	12.000

PG0231+051A	00	300.00	1.129	1028.46	1237.04	18.103	0.003	24.000
PG0231+051B	00	300.00	1.129	1304.65	1259.69	21.610	0.050	6.000
PG0231+051C	00	300.00	1.129	1435.93	678.03	18.848	0.006	20.000
PG0231+051D	00	300.00	1.129	727.97	864.54	20.433	0.014	14.000
PG0231+051E	00	300.00	1.129	464.89	802.26	19.023	0.006	18.000
PG0231+051	00	300.00	1.129	1094.89	1021.75	19.220	0.007	20.000

PG0231+051A	10	150.00	1.127	1029.27	1231.13	15.377	0.001	24.000
PG0231+051B	10	150.00	1.127	1306.16	1254.16	18.110	0.042	6.000
PG0231+051C	10	150.00	1.127	1436.88	671.75	16.295	0.002	24.000
PG0231+051D	10	150.00	1.127	728.54	858.20	17.020	0.003	24.000
PG0231+051E	10	150.00	1.127	465.34	795.90	16.405	0.042	6.000

PG0231+051A	20	45.00	1.127	1024.45	1233.76	13.852	0.002	24.000
PG0231+051B	20	45.00	1.127	1301.32	1256.65	15.759	0.004	24.000
PG0231+051C	20	45.00	1.127	1432.20	674.55	14.807	0.003	24.000
PG0231+051D	20	45.00	1.127	723.74	860.94	15.066	0.003	24.000
PG0231+051E	20	45.00	1.127	460.46	798.67	14.896	0.003	24.000
PG0231+051	20	45.00	1.127	1090.88	1018.15	17.246	0.009	16.000

PG0231+051A	30	30.00	1.126	1015.52	1241.90	13.378	0.007	24.000
PG0231+051B	30	30.00	1.126	1292.49	1264.84	14.736	0.071	3.000
PG0231+051C	30	30.00	1.126	1423.46	682.50	14.374	0.004	14.000
PG0231+051D	30	30.00	1.126	714.88	869.00	14.354	0.003	24.000
PG0231+051E	30	30.00	1.126	451.60	806.75	14.443	0.004	24.000
PG0231+051	30	30.00	1.126	1082.24	1026.15	17.342	0.011	12.000
PG0231+051A	40	30.00	1.126	1023.47	1241.14	13.186	0.003	24.000
PG0231+051B	40	30.00	1.126	1300.35	1264.02	13.986	0.003	18.000
PG0231+051C	40	30.00	1.126	1431.22	681.38	14.166	0.004	14.000
PG0231+051D	40	30.00	1.126	722.59	868.02	13.959	0.002	18.000
PG0231+051E	40	30.00	1.126	459.24	805.67	14.266	0.003	18.000
PG0231+051	40	30.00	1.126	1090.06	1025.17	17.732	0.074	3.000
PG0231+051A	00	300.00	1.129	1311.75	1266.90	21.437	0.022	8.000
PG0231+051B	00	300.00	1.129	1311.75	1266.90	21.437	0.022	8.000
PG0231+051C	00	300.00	1.129	1442.31	685.31	18.686	0.034	4.000
PG0231+051D	00	300.00	1.129	734.46	872.00	20.296	0.012	10.000
PG0231+051E	00	300.00	1.129	471.51	809.82	18.899	0.048	3.000
PG0231+051	00	300.00	1.129	1101.48	1028.98	19.056	0.007	20.000
PG0231+051A	10	120.00	1.131	1038.66	1239.86	15.230	0.002	24.000
PG0231+051B	10	120.00	1.131	1315.52	1262.70	17.953	0.006	12.000
PG0231+051C	10	120.00	1.131	1445.93	680.48	16.142	0.003	24.000
PG0231+051D	10	120.00	1.131	737.90	867.21	16.882	0.004	24.000
PG0231+051E	10	120.00	1.131	474.68	805.01	16.266	0.033	4.000
PG0231+051	10	120.00	1.131	1105.09	1024.39	17.511	0.004	14.000
PG0231+051A	20	60.00	1.133	1033.89	1243.20	13.728	0.002	24.000
PG0231+051B	20	60.00	1.133	1310.81	1265.95	15.619	0.003	24.000
PG0231+051C	20	60.00	1.133	1441.44	683.55	14.669	0.026	4.000
PG0231+051D	20	60.00	1.133	733.13	870.46	14.944	0.002	22.000
PG0231+051E	20	60.00	1.133	469.88	808.29	14.787	0.007	24.000
PG0231+051	20	60.00	1.133	1100.49	1027.57	17.123	0.006	12.000
PG0231+051A	20	45.00	1.127	1038.57	1238.47	13.731	0.003	24.000
PG0231+051B	20	45.00	1.127	1315.53	1261.29	15.622	0.003	18.000
PG0231+051C	20	45.00	1.127	1446.05	678.86	14.675	0.002	22.000
PG0231+051D	20	45.00	1.127	737.70	865.63	14.959	0.002	24.000
PG0231+051E	20	45.00	1.127	474.53	803.51	14.807	0.035	3.000
PG0231+051	20	45.00	1.127	1105.12	1022.88	17.122	0.008	12.000
PG0231+051A	30	30.00	1.137	1023.52	1244.18	13.288	0.004	24.000
PG0231+051B	30	30.00	1.137	1300.48	1267.01	14.652	0.004	24.000
PG0231+051C	30	30.00	1.137	1430.93	684.61	14.240	0.003	20.000
PG0231+051D	30	30.00	1.137	722.73	871.49	14.257	0.002	20.000
PG0231+051E	30	30.00	1.137	459.58	809.48	14.353	0.006	16.000
PG0231+051	30	30.00	1.137	1089.89	1028.47	17.227	0.009	10.000

PG0231+051A	30	30.00	1.126	1015.52	1241.90	13.378	0.007	24.000
PG0231+051B	30	30.00	1.126	1292.49	1264.84	14.736	0.071	3.000
PG0231+051C	30	30.00	1.126	1423.46	682.50	14.374	0.004	14.000
PG0231+051D	30	30.00	1.126	714.88	869.00	14.354	0.003	24.000
PG0231+051E	30	30.00	1.126	451.60	806.75	14.443	0.004	24.000
PG0231+051	30	30.00	1.126	1082.24	1026.15	17.342	0.011	12.000
PG0231+051A	40	30.00	1.126	1023.47	1241.14	13.186	0.003	24.000
PG0231+051B	40	30.00	1.126	1300.35	1264.02	13.986	0.003	18.000
PG0231+051C	40	30.00	1.126	1431.22	681.38	14.166	0.004	14.000
PG0231+051D	40	30.00	1.126	722.59	868.02	13.959	0.002	18.000
PG0231+051E	40	30.00	1.126	459.24	805.67	14.266	0.003	18.000
PG0231+051	40	30.00	1.126	1090.06	1025.17	17.732	0.074	3.000
PG0231+051A	00	300.00	1.129	1311.75	1266.90	21.437	0.022	8.000
PG0231+051B	00	300.00	1.129	1311.75	1266.90	21.437	0.022	8.000
PG0231+051C	00	300.00	1.129	1442.31	685.31	18.686	0.034	4.000
PG0231+051D	00	300.00	1.129	734.46	872.00	20.296	0.012	10.000
PG0231+051E	00	300.00	1.129	471.51	809.82	18.899	0.048	3.000
PG0231+051	00	300.00	1.129	1101.48	1028.98	19.056	0.007	20.000

PG0231+051A	10	120.00	1.131	1038.66	1239.86	15.230	0.002	24.000
PG0231+051B	10	120.00	1.131	1315.52	1262.70	17.953	0.006	12.000
PG0231+051C	10	120.00	1.131	1445.93	680.48	16.142	0.003	24.000
PG0231+051D	10	120.00	1.131	737.90	867.21	16.882	0.004	24.000
PG0231+051E	10	120.00	1.131	474.68	805.01	16.266	0.033	4.000
PG0231+051	10	120.00	1.131	1105.09	1024.39	17.511	0.004	14.000
PG0231+051A	20	60.00	1.133	1033.89	1243.20	13.728	0.002	24.000
PG0231+051B	20	60.00	1.133	1310.81	1265.95	15.619	0.003	24.000
PG0231+051C	20	60.00	1.133	1441.44	683.55	14.669	0.026	4.000
PG0231+051D	20	60.00	1.133	733.13	870.46	14.944	0.002	22.000
PG0231+051E	20	60.00	1.133	469.88	808.29	14.787	0.007	24.000
PG0231+051	20	60.00	1.133	1100.49	1027.57	17.123	0.006	12.000
PG0231+051A	20	45.00	1.127	1038.57	1238.47	13.731	0.003	24.000
PG0231+051B	20	45.00	1.127	1315.53	1261.29	15.622	0.003	18.000
PG0231+051C	20	45.00	1.127	1446.05	678.86	14.675	0.002	22.000
PG0231+051D	20	45.00	1.127	737.70	865.63	14.959	0.002	24.000
PG0231+051E	20	45.00	1.127	474.53	803.51	14.807	0.035	3.000
PG0231+051	20	45.00	1.127	1105.12	1022.88	17.122	0.008	12.000
PG0231+051A	30	30.00	1.137	1023.52	1244.18	13.288	0.004	24.000
PG0231+051B	30	30.00	1.137	1300.48	1267.01	14.652	0.004	24.000
PG0231+051C	30	30.00	1.137	1430.93	684.61	14.240	0.003	20.000
PG0231+051D	30	30.00	1.137	722.73	871.49	14.257	0.002	20.000
PG0231+051E	30	30.00	1.137	459.58	809.48	14.353	0.006	16.000
PG0231+051	30	30.00	1.137	1089.89	1028.47	17.227	0.009	10.000
PG0231+051A	30	30.00	1.126	1015.52	1241.90	13.378	0.007	24.000
PG0231+051B	30	30.00	1.126	1292.49	1264.84	14.736	0.071	3.000
PG0231+051C	30	30.00	1.126	1423.46	682.50	14.374	0.004	14.000
PG0231+051D	30	30.00	1.126	714.88	869.00	14.354	0.003	24.000
PG0231+051E	30	30.00	1.126	451.60	806.75	14.443	0.004	24.000
PG0231+051	30	30.00	1.126	1082.24	1026.15	17.342	0.011	12.000
PG0231+051A	40	30.00	1.126	1023.47	1241.14	13.186	0.003	24.000
PG0231+051B	40	30.00	1.126	1300.35	1264.02	13.986	0.003	18.000
PG0231+051C	40	30.00	1.126	1431.22	681.38	14.166	0.004	14.000
PG0231+051D	40	30.00	1.126	722.59	868.02	13.959	0.002	18.000
PG0231+051E	40	30.00	1.126	459.24	805.67	14.266	0.003	18.000
PG0231+051	40	30.00	1.126	1090.06	1025.17	17.732	0.074	3.000
PG0231+051A	00	300.00	1.129	1311.75	1266.90	21.437	0.022	8.000
PG0231+051B	00	300.00	1.129	1311.75	1266.90	21.437	0.022	8.000
PG0231+051C	00	300.00	1.129	1442.31	685.31	18.686	0.034	4.000
PG0231+051D	00	300.00	1.129	734.46	872.00	20.296	0.012	10.000
PG0231+051E	00	300.00	1.129	471.51	809.82	18.899	0.048	3.000
PG0231+051	00	300.00	1.129	1101.48	1028.98	19.056	0.007	20.000
PG0231+051A	10	120.00	1.131	1038.66	1239.86	15.230	0.002	24.000
PG0231+051B	10	120.00	1.131	1315.52	1262.70	17.953	0.006	12.000
PG0231+051C	10	120.00	1.131	1445.93	680.48	16.142	0.003	24.000
PG0231+051D	10	120.00	1.131	737.90	867.21	16.882	0.004	24.000
PG0231+051E	10	120.00	1.131	474.68	805.01	16.266	0.033	4.000
PG0231+051	10	120.00	1.131	1105.09	1024.39	17.511	0.004	14.000
PG0231+051A	20	60.00	1.133	1033.89	1243.20	13.728	0.002	24.000
PG0231+051B	20	60.00	1.133	1310.81	1265.95	15.619	0.003	24.000
PG0231+051C	20	60.00	1.133	1441.44	683.55	14.669	0.026	4.000
PG0231+051D	20	60.00	1.133	733.13	870.46	14.944	0.002	22.000
PG0231+051E	20	60.00	1.133	469.88	808.29	14.787	0.007	24.000
PG0231+051	20	60.00	1.133	1100.49	1027.57	17.123	0.006	12.000

PG0231+051A	20	45.00	1.127	1038.57	1238.47	13.731	0.003	24.000
PG0231+051B	20	45.00	1.127	1315.53	1261.29	15.622	0.003	18.000
PG0231+051C	20	45.00	1.127	1446.05	678.86	14.675	0.002	22.000
PG0231+051D	20	45.00	1.127	737.70	865.63	14.959	0.002	24.000
PG0231+051E	20	45.00	1.127	474.53	803.51	14.807	0.035	3.000
PG0231+051	20	45.00	1.127	1105.12	1022.88	17.122	0.008	12.000
PG0231+051A	30	30.00	1.137	1023.52	1244.18	13.288	0.004	24.000
PG0231+051B	30	30.00	1.137	1300.48	1267.01	14.652	0.004	24.000
PG0231+051C	30	30.00	1.137	1430.93	684.61	14.240	0.003	20.000
PG0231+051D	30	30.00	1.137	722.73	871.49	14.257	0.002	20.000
PG0231+051E	30	30.00	1.137	459.58	809.48	14.353	0.006	16.000
PG0231+051	30	30.00	1.137	1089.89	1028.47	17.227	0.009	10.000

PG0231+051A	30	30.00	1.126	1015.52	1241.90	13.378	0.007	24.000
PG0231+051B	30	30.00	1.126	1292.49	1264.84	14.736	0.071	3.000
PG0231+051C	30	30.00	1.126	1423.46	682.50	14.374	0.004	14.000
PG0231+051D	30	30.00	1.126	714.88	869.00	14.354	0.003	24.000
PG0231+051E	30	30.00	1.126	451.60	806.75	14.443	0.004	24.000
PG0231+051	30	30.00	1.126	1082.24	1026.15	17.342	0.011	12.000
PG0231+051A	40	30.00	1.126	1023.47	1241.14	13.186	0.003	24.000
PG0231+051B	40	30.00	1.126	1300.35	1264.02	13.986	0.003	18.000
PG0231+051C	40	30.00	1.126	1431.22	681.38	14.166	0.004	14.000
PG0231+051D	40	30.00	1.126	722.59	868.02	13.959	0.002	18.000
PG0231+051E	40	30.00	1.126	459.24	805.67	14.266	0.003	18.000
PG0231+051	40	30.00	1.126	1090.06	1025.17	17.732	0.074	3.000
PG0231+051A	00	300.00	1.129	1311.75	1266.90	21.437	0.022	8.000
PG0231+051B	00	300.00	1.129	1311.75	1266.90	21.437	0.022	8.000
PG0231+051C	00	300.00	1.129	1442.31	685.31	18.686	0.034	4.000
PG0231+051D	00	300.00	1.129	734.46	872.00	20.296	0.012	10.000
PG0231+051E	00	300.00	1.129	471.51	809.82	18.899	0.048	3.000
PG0231+051	00	300.00	1.129	1101.48	1028.98	19.056	0.007	20.000
PG0231+051A	10	120.00	1.131	1038.66	1239.86	15.230	0.002	24.000
PG0231+051B	10	120.00	1.131	1315.52	1262.70	17.953	0.006	12.000
PG0231+051C	10	120.00	1.131	1445.93	680.48	16.142	0.003	24.000
PG0231+051D	10	120.00	1.131	737.90	867.21	16.882	0.004	24.000
PG0231+051E	10	120.00	1.131	474.68	805.01	16.266	0.033	4.000
PG0231+051	10	120.00	1.131	1105.09	1024.39	17.511	0.004	14.000
PG0231+051A	20	60.00	1.133	1033.89	1243.20	13.728	0.002	24.000
PG0231+051B	20	60.00	1.133	1310.81	1265.95	15.619	0.003	24.000
PG0231+051C	20	60.00	1.133	1441.44	683.55	14.669	0.026	4.000
PG0231+051D	20	60.00	1.133	733.13	870.46	14.944	0.002	22.000
PG0231+051E	20	60.00	1.133	469.88	808.29	14.787	0.007	24.000
PG0231+051	20	60.00	1.133	1100.49	1027.57	17.123	0.006	12.000
PG0231+051A	20	45.00	1.127	1038.57	1238.47	13.731	0.003	24.000
PG0231+051B	20	45.00	1.127	1315.53	1261.29	15.622	0.003	18.000
PG0231+051C	20	45.00	1.127	1446.05	678.86	14.675	0.002	22.000
PG0231+051D	20	45.00	1.127	737.70	865.63	14.959	0.002	24.000
PG0231+051E	20	45.00	1.127	474.53	803.51	14.807	0.035	3.000
PG0231+051	20	45.00	1.127	1105.12	1022.88	17.122	0.008	12.000
PG0231+051A	30	30.00	1.137	1023.52	1244.18	13.288	0.004	24.000
PG0231+051B	30	30.00	1.137	1300.48	1267.01	14.652	0.004	24.000
PG0231+051C	30	30.00	1.137	1430.93	684.61	14.240	0.003	20.000
PG0231+051D	30	30.00	1.137	722.73	871.49	14.257	0.002	20.000
PG0231+051E	30	30.00	1.137	459.58	809.48	14.353	0.006	16.000
PG0231+051	30	30.00	1.137	1089.89	1028.47	17.227	0.009	10.000

PG0231+051A	40	30.00	1.135	1032.00	1247.00	13.122	0.002	24.000
PG0231+051B	40	30.00	1.135	1309.00	1270.00	13.900	0.002	22.000
PG0231+051C	40	30.00	1.135	1439.53	687.74	14.052	0.033	3.000
PG0231+051D	40	30.00	1.135	731.00	874.36	13.874	0.006	22.000
PG0231+051E	40	30.00	1.135	468.00	812.15	14.195	0.003	24.000
PG0231+051	40	30.00	1.135	1098.53	1031.91	17.575	0.013	8.000
PG2213-006A	00	120.00	1.633	1033.25	1025.78	20.061	0.030	8.000
PG2213-006B	00	120.00	1.633	960.06	1098.50	18.850	0.013	10.000
PG2213-006C	00	120.00	1.633	751.57	1186.02	20.994	0.057	6.000
PG2213-006	00	120.00	1.633	1293.34	979.83	18.143	0.008	12.000
PG2213-006A	10	90.00	1.661	1042.14	1022.52	17.673	0.010	10.000
PG2213-006B	10	90.00	1.661	968.79	1095.41	16.282	0.004	14.000
PG2213-006C	10	90.00	1.661	760.45	1182.59	18.628	0.018	8.000
PG2213-006	10	90.00	1.661	1302.11	976.37	16.723	0.006	12.000
PG2213-006A	20	30.00	1.684	1041.24	1024.20	16.220	0.007	14.000
PG2213-006B	20	30.00	1.684	968.06	1096.91	14.762	0.003	22.000
PG2213-006C	20	30.00	1.684	759.47	1184.47	17.162	0.014	6.000
PG2213-006	20	30.00	1.684	1301.47	977.98	16.240	0.008	10.000
PG2213-006A	30	20.00	1.720	1043.45	1024.20	16.018	0.007	12.000
PG2213-006B	30	20.00	1.720	970.07	1096.98	14.531	0.003	20.000
PG2213-006C	30	20.00	1.720	761.62	1184.53	16.932	0.026	4.000
PG2213-006	30	20.00	1.720	1303.47	978.14	16.536	0.010	8.000
PG2213-006A	40	20.00	1.702	1039.59	1027.71	15.716	0.008	10.000
PG2213-006B	40	20.00	1.702	966.30	1100.44	14.233	0.003	18.000
PG2213-006C	40	20.00	1.702	757.87	1187.83	16.582	0.013	10.000
PG2213-006	40	20.00	1.702	1299.96	981.57	16.742	0.013	10.000
PG1657+078A	00	300.00	1.118	1141.27	1226.19	19.750	0.009	12.000
PG1657+078B	00	300.00	1.118	1079.36	1266.94	19.496	0.007	14.000
PG1657+078C	00	300.00	1.118	1243.84	1201.67	20.445	0.057	4.000
PG1657+078D	00	300.00	1.118	873.84	1091.48	21.584	0.026	8.000
PG1657+078	00	300.00	1.118	1090.77	984.28	18.161	0.004	24.000
PG1657+078A	10	150.00	1.123	1144.03	1222.85	16.729	0.004	18.000
PG1657+078B	10	150.00	1.123	1082.03	1263.42	17.040	0.004	16.000
PG1657+078C	10	150.00	1.123	1246.80	1198.40	17.704	0.008	14.000
PG1657+078D	10	150.00	1.123	876.62	1088.51	18.613	0.014	14.000
PG1657+078	10	150.00	1.123	1093.40	980.57	16.444	0.003	24.000
PG1657+078A	20	60.00	1.126	1138.47	1225.53	14.935	0.003	18.000
PG1657+078B	20	60.00	1.126	1076.52	1266.18	15.624	0.003	24.000
PG1657+078C	20	60.00	1.126	1241.22	1201.32	16.139	0.007	12.000
PG1657+078D	20	60.00	1.126	870.54	1090.33	16.999	0.007	14.000
PG1657+078	20	60.00	1.126	1087.94	983.36	15.956	0.003	16.000
PG1657+078A	30	25.00	1.132	1137.24	1225.21	14.350	0.003	18.000
PG1657+078B	30	25.00	1.132	1075.35	1265.93	15.189	0.004	24.000
PG1657+078C	30	25.00	1.132	1240.04	1200.91	15.702	0.046	4.000
PG1657+078D	30	25.00	1.132	869.30	1089.98	16.456	0.006	12.000
PG1657+078	30	25.00	1.132	1086.74	982.92	16.006	0.005	16.000
PG1657+078A	40	30.00	1.129	1133.47	1228.11	14.032	0.004	20.000
PG1657+078B	40	30.00	1.129	1071.49	1268.65	15.017	0.004	14.000
PG1657+078C	40	30.00	1.129	1236.10	1203.74	15.394	0.013	18.000
PG1657+078D	40	30.00	1.129	871.47	1166.93	18.093	0.018	8.000
PG1657+078	40	30.00	1.129	1082.70	985.79	16.296	0.008	12.000

PG1657+078A	00	300.00	1.171	1118.78	927.07	21.425	0.029	10.000
PG1657+078B	00	300.00	1.171	1056.73	967.83	21.193	0.022	12.000
PG1657+078C	00	300.00	1.171	1220.85	902.93	22.154	0.082	4.000
PG1657+078	00	300.00	1.171	1067.99	685.53	19.860	0.010	12.000
PG1657+078A	10	150.00	1.182	1124.88	926.30	17.043	0.004	16.000
PG1657+078B	10	150.00	1.182	1063.17	966.83	17.343	0.004	22.000
PG1657+078C	10	150.00	1.182	1227.88	901.70	18.001	0.007	16.000
PG1657+078D	10	150.00	1.182	1074.21	683.84	16.745	0.003	24.000
PG1657+078	10	150.00	1.182	856.76	790.85	18.992	0.010	16.000
PG1657+078A	20	50.00	1.189	1121.88	930.23	15.137	0.004	14.000
PG1657+078B	20	50.00	1.189	1059.98	970.89	15.816	0.004	16.000
PG1657+078C	20	50.00	1.189	1224.63	905.86	16.389	0.060	4.000
PG1657+078D	20	50.00	1.189	1071.26	687.79	16.137	0.004	20.000
PG1657+078	20	50.00	1.189	853.84	794.96	17.176	0.008	16.000
PG1657+078A	30	30.00	1.199	1120.35	930.08	14.448	0.004	16.000
PG1657+078B	30	30.00	1.199	1058.51	970.76	15.275	0.004	24.000
PG1657+078C	30	30.00	1.199	1223.20	905.59	15.766	0.036	6.000
PG1657+078D	30	30.00	1.199	1069.91	687.77	16.093	0.006	16.000
PG1657+078	30	30.00	1.199	852.18	794.93	16.530	0.007	18.000
PG1657+078A	40	30.00	1.194	1119.11	931.24	14.167	0.004	14.000
PG1657+078B	40	30.00	1.194	1057.19	971.90	15.113	0.005	14.000
PG1657+078C	40	30.00	1.194	1222.01	906.93	15.492	0.016	14.000
PG1657+078D	40	30.00	1.194	1068.61	689.13	16.421	0.009	12.000
PG1657+078	40	30.00	1.194	851.11	796.03	16.284	0.007	14.000
PG0918+029A	00	300.00	2.358	1482.49	1001.69	19.447	0.008	12.000
PG0918+029B	00	300.00	2.358	1371.10	666.77	19.541	0.009	14.000
PG0918+029C	00	300.00	2.358	1845.19	941.82	18.710	0.006	18.000
PG0918+029D	00	300.00	2.358	815.28	769.41	18.521	0.084	3.000
PG0918+029	00	300.00	2.358	1132.35	1060.66	16.726	0.002	24.000
PG0918+029A	10	150.00	2.254	1484.67	999.45	16.899	0.003	20.000
PG0918+029B	10	150.00	2.254	1373.01	664.32	16.597	0.005	24.000
PG0918+029C	10	150.00	2.254	1847.45	939.55	16.032	0.003	20.000
PG0918+029D	10	150.00	2.254	816.78	766.98	15.200	0.002	24.000
PG0918+029	10	150.00	2.254	1134.50	1058.49	14.923	0.004	24.000
PG0918+029A	20	60.00	2.194	1478.86	1000.10	15.533	0.002	24.000
PG0918+029B	20	60.00	2.194	1367.31	665.01	14.978	0.073	3.000
PG0918+029C	20	60.00	2.194	1841.75	940.31	14.566	0.002	24.000
PG0918+029D	20	60.00	2.194	811.01	767.79	13.285	0.002	24.000
PG0918+029	20	60.00	2.194	1128.36	1059.35	14.419	0.002	24.000
PG0918+029A	30	30.00	2.113	1477.33	997.71	15.133	0.003	16.000
PG0918+029B	30	30.00	2.113	1365.76	662.50	14.507	0.003	24.000
PG0918+029C	30	30.00	2.113	1840.26	937.64	14.124	0.002	22.000
PG0918+029D	30	30.00	2.113	809.56	765.16	12.642	0.002	24.000
PG0918+029	30	30.00	2.113	1126.83	1056.77	14.473	0.003	24.000
PG0918+029A	40	30.00	2.151	1474.81	1003.16	15.012	0.006	12.000
PG0918+029B	40	30.00	2.151	1363.31	668.02	14.331	0.004	22.000
PG0918+029C	40	30.00	2.151	1837.68	943.36	13.973	0.037	4.000
PG0918+029D	40	30.00	2.151	806.97	770.71	12.313	0.005	24.000
PG0918+029A	00	300.00	1.193	1510.02	977.65	18.917	0.006	14.000
PG0918+029B	00	300.00	1.193	1398.94	642.79	19.027	0.007	18.000
PG0918+029C	00	300.00	1.193	1873.01	917.74	18.145	0.049	4.000
PG0918+029D	00	300.00	1.193	842.81	745.43	17.997	0.004	18.000
PG0918+029	00	300.00	1.193	1159.62	1036.86	16.210	0.002	24.000
PG0918+029A	10	150.00	1.186	1519.58	971.91	16.593	0.003	24.000
PG0918+029B	10	150.00	1.186	1408.28	636.87	16.297	0.003	24.000
PG0918+029C	10	150.00	1.186	1882.64	911.99	15.726	0.002	24.000
PG0918+029D	10	150.00	1.186	852.02	739.55	14.904	0.004	24.000
PG0918+029	10	150.00	1.186	1169.08	1031.03	14.598	0.008	22.000
PG0918+029A	20	60.00	1.181	1517.02	968.74	15.353	0.004	24.000
PG0918+029B	20	60.00	1.181	1405.80	633.61	14.806	0.002	24.000
PG0918+029C	20	60.00	1.181	1880.12	908.80	14.383	0.003	24.000
PG0918+029D	20	60.00	1.181	849.26	736.38	13.109	0.002	24.000
PG0918+029	20	60.00	1.181	1166.40	1027.94	14.234	0.005	24.000

PG1047+003A	00	180.00	1.553	1045.74	1073.95	15.726	0.003	14.000
PG1047+003B	00	180.00	1.553	1163.06	1251.51	17.083	0.007	12.000
PG1047+003C	00	180.00	1.553	1451.36	934.47	14.541	0.002	20.000
PG1047+003	00	180.00	1.553	899.16	961.06	13.777	0.002	22.000
PG1047+003A	10	90.00	1.729	1054.65	1072.31	13.327	0.003	24.000
PG1047+003B	10	90.00	1.729	1172.04	1250.07	14.576	0.003	20.000
PG1047+003C	10	90.00	1.729	1460.50	932.68	12.226	0.002	18.000
PG1047+003	10	90.00	1.729	908.16	959.36	12.289	0.003	24.000
PG1047+003A	20	30.00	1.741	1052.49	1074.31	12.168	0.002	16.000
PG1047+003B	20	30.00	1.741	1169.95	1252.19	13.398	0.003	20.000
PG1047+003C	20	30.00	1.741	1458.46	934.80	11.142	0.002	16.000
PG1047+003	20	30.00	1.741	906.00	961.51	12.179	0.008	22.000
PG1047+003A	30	20.00	1.756	1056.50	1073.83	11.875	0.002	14.000
PG1047+003B	30	20.00	1.756	1173.82	1251.67	13.151	0.003	14.000
PG1047+003C	30	20.00	1.756	1462.43	934.16	10.890	0.002	14.000
PG1047+003	30	20.00	1.756	910.13	960.85	12.426	0.004	24.000
PG1047+003A	40	20.00	1.746	1056.00	1079.66	11.578	0.002	14.000
PG1047+003B	40	20.00	1.746	1173.45	1257.57	12.912	0.003	14.000
PG1047+003C	40	20.00	1.746	1461.99	940.08	10.658	0.002	14.000
PG1047+003	40	20.00	1.746	909.51	966.81	12.746	0.003	14.000
RU149A	10	40.00	2.396	1116.58	1261.50	14.043	0.004	24.000
RU149B	10	40.00	2.396	1338.69	1304.27	12.554	0.002	24.000
RU149C	10	40.00	2.396	1324.03	1166.30	13.854	0.004	20.000
RU149D	10	40.00	2.396	1226.31	1242.34	10.678	0.001	24.000
RU149E	10	40.00	2.396	1377.38	937.48	13.470	0.004	24.000
RU149F	10	40.00	2.396	1157.87	1008.53	13.866	0.004	20.000
RU149G	10	40.00	2.396	1048.81	1076.36	12.612	0.003	24.000
RU149	10	40.00	2.396	1175.89	1298.32	12.966	0.003	20.000
RU149A	10	40.00	2.386	1116.48	1261.22	14.042	0.004	24.000
RU149B	10	40.00	2.386	1338.41	1303.83	12.550	0.002	24.000
RU149C	10	40.00	2.386	1323.72	1166.08	13.840	0.004	20.000
RU149D	10	40.00	2.386	1226.17	1241.99	10.671	0.003	24.000
RU149E	10	40.00	2.386	1377.01	937.34	13.463	0.003	24.000
RU149F	10	40.00	2.386	1157.56	1008.48	13.857	0.005	20.000
RU149G	10	40.00	2.386	1048.66	1075.99	12.609	0.002	24.000
RU149	10	40.00	2.386	1175.72	1297.82	12.962	0.003	20.000
RU149A	10	40.00	2.376	1116.01	1261.53	14.032	0.004	24.000
RU149B	10	40.00	2.376	1337.82	1304.34	12.555	0.003	24.000
RU149C	10	40.00	2.376	1323.15	1166.56	13.841	0.004	20.000
RU149D	10	40.00	2.376	1225.47	1242.43	10.678	0.004	24.000
RU149E	10	40.00	2.376	1376.48	937.54	13.464	0.006	24.000
RU149F	10	40.00	2.376	1156.88	1008.81	13.859	0.005	20.000
RU149G	10	40.00	2.376	1047.89	1076.51	12.613	0.003	24.000
RU149	10	40.00	2.376	1175.01	1298.17	12.969	0.004	24.000
RU149A	20	20.00	2.427	1117.35	1258.38	13.303	0.006	20.000
RU149B	20	20.00	2.427	1339.28	1300.96	11.416	0.002	24.000
RU149C	20	20.00	2.427	1324.78	1162.94	13.208	0.007	14.000
RU149D	20	20.00	2.427	1227.14	1239.16	10.283	0.002	24.000
RU149E	20	20.00	2.427	1378.05	934.19	12.483	0.003	24.000
RU149F	20	20.00	2.427	1158.46	1004.95	12.222	0.003	18.000
RU149G	20	20.00	2.427	1049.46	1072.96	11.609	0.003	24.000
RU149	20	20.00	2.427	1176.64	1295.14	12.676	0.003	24.000
RU149A	30	15.00	2.461	1115.83	1254.95	13.282	0.004	16.000
RU149B	30	15.00	2.461	1337.59	1297.34	11.164	0.002	24.000
RU149C	30	15.00	2.461	1323.29	1159.39	13.241	0.009	18.000
RU149D	30	15.00	2.461	1225.63	1235.58	10.398	0.002	24.000
RU149E	30	15.00	2.461	1376.88	930.12	12.297	0.003	20.000
RU149F	30	15.00	2.461	1157.17	1001.53	11.771	0.003	22.000
RU149G	30	15.00	2.461	1048.10	1069.47	11.410	0.004	24.000
RU149	30	15.00	2.461	1175.12	1291.63	12.845	0.004	16.000

RU149A	30	15.00	2.458	1115.91	1255.43	13.264	0.005	18.000
RU149B	30	15.00	2.458	1338.10	1297.91	11.172	0.002	22.000
RU149C	30	15.00	2.458	1323.50	1160.02	13.236	0.008	18.000
RU149D	30	15.00	2.458	1225.77	1236.13	10.395	0.002	24.000
RU149E	30	15.00	2.458	1376.88	930.99	12.295	0.004	24.000
RU149F	30	15.00	2.458	1157.17	1002.07	11.774	0.002	22.000
RU149G	30	15.00	2.458	1048.05	1070.05	11.410	0.003	24.000
RU149	30	15.00	2.458	1175.17	1292.07	12.850	0.004	24.000
RU149A	30	15.00	2.450	1116.88	1255.15	13.276	0.004	18.000
RU149B	30	15.00	2.450	1338.60	1297.99	11.174	0.003	24.000
RU149C	30	15.00	2.450	1323.98	1159.91	13.247	0.007	18.000
RU149D	30	15.00	2.450	1226.41	1236.03	10.397	0.002	24.000
RU149E	30	15.00	2.450	1377.51	930.82	12.285	0.003	24.000
RU149F	30	15.00	2.450	1157.55	1002.05	11.771	0.002	20.000
RU149G	30	15.00	2.450	1048.66	1069.86	11.407	0.003	24.000
RU149	30	15.00	2.450	1176.04	1291.94	12.849	0.005	14.000
RU149A	30	20.00	2.444	1114.62	1256.78	13.342	0.004	18.000
RU149B	30	20.00	2.444	1336.63	1299.46	11.441	0.005	24.000
RU149C	30	20.00	2.444	1322.17	1161.39	13.247	0.004	24.000
RU149D	30	20.00	2.444	1224.48	1237.53	10.302	0.005	24.000
RU149E	30	20.00	2.444	1375.45	932.53	12.508	0.007	24.000
RU149F	30	20.00	2.444	1155.70	1003.44	12.252	0.003	18.000
RU149G	30	20.00	2.444	1046.79	1071.41	11.628	0.003	24.000
RU149	30	20.00	2.444	1173.99	1293.47	12.687	0.006	24.000

Figure 32: The resulting mkconfig.mag file

Using mkconfig.mag create a list fstandobs.dat, which contains all the aperture corrected magnitudes of all stars in the format of the mknobsfile as shown in Massey & Davis 1992, " A user's guide to CCD photometry".

To edit mkconfig.mag into the standobs.dat, we created a separate list for stars in each fields. This appears in order of star, airmass, x and y coordinates, magnitude and magnitude error of the first star in the field, for each filter followed by the second star in the field, third and so on. This is done for each of the fields. The star names are replaced by a '*' from the second line of each of them in the respective field as show in fig: 33. The list for each field is then combined into the single file standobs.dat.

PG0942-029	00	1.331	1096.41	1045.69	17.351	0.005
*	10	1.317	1099.54	1041.95	15.730	0.004
*	20	1.309	1098.50	1043.06	15.291	0.005
*	30	1.298	1103.57	1044.94	15.370	0.045
*	40	1.304	1095.11	1044.99	15.683	0.006
PG0942-029	00	1.471	1082.03	1001.58	17.241	0.003
*	10	1.496	1085.59	995.77	15.613	0.005
*	20	1.511	1083.68	999.08	15.171	0.004
*	30	1.539	1079.57	1004.54	15.245	0.005
*	40	1.524	1085.94	1001.37	15.604	0.006
PG0942-029A	00	1.331	994.52	1222.43	20.775	0.018
*	10	1.317	997.26	1218.98	17.687	0.005
*	20	1.309	996.29	1220.11	15.943	0.004
*	30	1.298	1001.34	1221.96	15.354	0.007
*	40	1.304	993.02	1221.94	15.080	0.004
PG0942-029A	00	1.471	979.99	1179.18	20.699	0.085
*	10	1.496	983.58	1172.97	17.593	0.005
*	20	1.511	981.59	1176.16	15.834	0.004
*	30	1.539	977.52	1181.39	15.237	0.005
*	40	1.524	983.85	1178.39	15.010	0.053
PG0942-029B	00	1.331	1079.81	561.13	19.218	0.008
*	10	1.317	1082.78	557.02	16.720	0.004
*	20	1.309	1081.83	557.98	15.333	0.004
*	30	1.298	1086.93	559.95	14.921	0.003
*	40	1.304	1078.53	560.02	14.771	0.005
PG0942-029B	00	1.471	1065.90	516.78	19.112	0.006
*	10	1.496	1069.30	511.12	16.601	0.003
*	20	1.511	1067.14	513.98	15.213	0.003
*	30	1.539	1063.03	519.79	14.799	0.004
*	40	1.524	1069.75	516.59	14.668	0.004
PG0942-029C	00	1.331	1222.02	500.14	20.687	0.018
*	10	1.317	1225.10	496.13	17.853	0.007
*	20	1.309	1224.05	497.08	16.193	0.006
*	30	1.298	1229.16	499.01	15.653	0.005
*	40	1.304	1220.82	499.03	15.405	0.005
PG0942-029C	00	1.471	1208.09	456.02	20.587	0.021
*	10	1.496	1211.56	450.30	17.752	0.005
*	20	1.511	1209.52	453.12	16.069	0.005
*	30	1.539	1205.49	458.99	15.532	0.009
*	40	1.524	1211.97	455.83	15.298	0.005
PG0942-029D	00	1.331	930.79	344.80	18.817	0.008
*	10	1.317	933.78	340.76	16.295	0.003
*	20	1.309	932.80	341.82	14.898	0.003
*	30	1.298	937.84	343.64	14.481	0.061
*	40	1.304	929.48	343.73	14.367	0.003
PG0942-029D	00	1.471	917.02	300.81	18.709	0.005
*	10	1.496	920.37	294.83	16.174	0.003
*	20	1.511	918.26	297.64	14.787	0.003
*	30	1.539	914.22	303.28	14.363	0.004
*	40	1.524	920.80	300.43	14.226	0.004

PG0918+029	00	1.235	913.19	1351.61	17.527	0.005
*	10	1.223	913.79	1348.99	15.364	0.003
*	20	1.216	909.84	1351.18	14.686	0.003
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0918+029	00	2.358	1132.35	1060.66	16.726	0.002
*	10	2.254	1134.50	1058.49	14.923	0.004
*	20	2.194	1128.36	1059.35	14.419	0.002
*	30	2.113	1126.83	1056.77	14.473	0.003
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0918+029	00	1.193	1159.62	1036.86	16.210	0.002
*	10	1.186	1169.08	1031.03	14.598	0.008
*	20	1.181	1166.40	1027.94	14.234	0.005
*	30	1.176	1167.48	1021.09	14.337	0.003
*	40	1.178	1167.28	1026.44	14.715	0.005
PG0918+029A	00	1.235	1263.71	1292.44	20.240	0.099
*	10	1.223	1264.28	1289.77	17.360	0.004
*	20	1.216	1260.53	1291.84	15.791	0.004
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0918+029A	00	2.358	1482.49	1001.69	19.447	0.008
*	10	2.254	1484.67	999.45	16.899	0.003
*	20	2.194	1478.86	1000.10	15.533	0.002
*	30	2.113	1477.33	997.71	15.133	0.003
*	40	2.151	1474.81	1003.16	15.012	0.006
PG0918+029A	00	1.193	1510.02	977.65	18.917	0.006
*	10	1.186	1519.58	971.91	16.593	0.003
*	20	1.181	1517.02	968.74	15.353	0.004
*	30	1.176	1518.23	961.74	14.995	0.003
*	40	1.178	1517.74	967.21	14.892	0.003
PG0918+029B	00	1.235	1152.25	957.38	20.368	0.099
*	10	1.223	1152.90	954.80	17.067	0.005
*	20	1.216	1149.16	956.84	15.249	0.068
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0918+029B	00	2.358	1371.10	666.77	19.541	0.009
*	10	2.254	1373.01	664.32	16.597	0.005
*	20	2.194	1367.31	665.01	14.978	0.073
*	30	2.113	1365.76	662.50	14.507	0.003
*	40	2.151	1363.31	668.02	14.331	0.004
PG0918+029B	00	1.193	1398.94	642.79	19.027	0.007
*	10	1.186	1408.28	636.87	16.297	0.003
*	20	1.181	1405.80	633.61	14.806	0.002
*	30	1.176	1406.85	626.57	14.368	0.003
*	40	1.178	1406.54	631.98	14.229	0.005
PG0918+029C	00	1.235	1626.47	1232.43	19.538	0.098
*	10	1.223	1627.31	1229.92	16.486	0.003
*	20	1.216	1623.71	1231.93	14.831	0.003
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0918+029C	00	2.358	1845.19	941.82	18.710	0.006
*	10	2.254	1847.45	939.55	16.032	0.003
*	20	2.194	1841.75	940.31	14.566	0.002
*	30	2.113	1840.26	937.64	14.124	0.002
*	40	2.151	1837.68	943.36	13.973	0.037

PG0918+029C	00	1.193	1873.01	917.74	18.145	0.049
*	10	1.186	1882.64	911.99	15.726	0.002
*	20	1.181	1880.12	908.80	14.383	0.003
*	30	1.176	1881.31	901.85	13.993	0.006
*	40	1.178	1880.74	907.34	13.875	0.008
PG0918+029D	00	1.235	596.28	1060.30	19.344	0.017
*	10	1.223	596.50	1057.42	15.660	0.003
*	20	1.216	592.73	1059.56	13.531	0.003
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0918+029D	00	2.358	815.28	769.41	18.521	0.084
*	10	2.254	816.78	766.98	15.200	0.002
*	20	2.194	811.01	767.79	13.285	0.002
*	30	2.113	809.56	765.16	12.642	0.002
*	40	2.151	806.97	770.71	12.313	0.005
PG0918+029D	00	1.193	842.81	745.43	17.997	0.004
*	10	1.186	852.02	739.55	14.904	0.004
*	20	1.181	849.26	736.38	13.109	0.002
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0231+051	00	1.129	1094.89	1021.75	19.220	0.007
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	1.127	1090.88	1018.15	17.246	0.009
*	30	1.126	1082.24	1026.15	17.342	0.011
*	40	1.126	1090.06	1025.17	17.732	0.074
PG0231+051	00	1.129	1101.48	1028.98	19.056	0.007
*	10	1.131	1105.09	1024.39	17.511	0.004
*	20	1.133	1100.49	1027.57	17.123	0.006
*	30	1.137	1089.89	1028.47	17.227	0.009
*	40	1.135	1098.53	1031.91	17.575	0.013
PG0231+051	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	1.127	1105.12	1022.88	17.122	0.008
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0231+051A	00	1.129	1028.46	1237.04	18.103	0.003
*	10	1.127	1029.27	1231.13	15.377	0.001
*	20	1.127	1024.45	1233.76	13.852	0.002
*	30	1.126	1015.52	1241.90	13.378	0.007
*	40	1.126	1023.47	1241.14	13.186	0.003
PG0231+051A	00	1.129	1311.75	1266.90	21.437	0.022
*	10	1.131	1038.66	1239.86	15.230	0.002
*	20	1.133	1033.89	1243.20	13.728	0.002
*	30	1.137	1023.52	1244.18	13.288	0.004
*	40	1.135	1032.00	1247.00	13.122	0.002
PG0231+051A	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	1.127	1038.57	1238.47	13.731	0.003
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF

PG0231+051B	00	1.129	1304.65	1259.69	21.610	0.050
*	10	1.127	1306.16	1254.16	18.110	0.042
*	20	1.127	1301.32	1256.65	15.759	0.004
*	30	1.126	1292.49	1264.84	14.736	0.071
*	40	1.126	1300.35	1264.02	13.986	0.003
PG0231+051B	00	1.129	1311.75	1266.90	21.437	0.022
*	10	1.131	1315.52	1262.70	17.953	0.006
*	20	1.133	1310.81	1265.95	15.619	0.003
*	30	1.137	1300.48	1267.01	14.652	0.004
*	40	1.135	1309.00	1270.00	13.900	0.002
PG0231+051B	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	1.127	1315.53	1261.29	15.622	0.003
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0231+051C	00	1.129	1435.93	678.03	18.848	0.006
*	10	1.127	1436.88	671.75	16.295	0.002
*	20	1.127	1432.20	674.55	14.807	0.003
*	30	1.126	1423.46	682.50	14.374	0.004
*	40	1.126	1431.22	681.38	14.166	0.004
PG0231+051C	00	1.129	1442.31	685.31	18.686	0.034
*	10	1.131	1445.93	680.48	16.142	0.003
*	20	1.133	1441.44	683.55	14.669	0.026
*	30	1.137	1430.93	684.61	14.240	0.003
*	40	1.135	1439.53	687.74	14.052	0.033
PG0231+051C	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	1.127	1446.05	678.86	14.675	0.002
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG0231+051D	00	1.129	727.97	864.54	20.433	0.014
*	10	1.127	728.54	858.20	17.020	0.003
*	20	1.127	723.74	860.94	15.066	0.003
*	30	1.126	714.88	869.00	14.354	0.003
*	40	1.126	722.59	868.02	13.959	0.002
PG0231+051D	00	1.129	734.46	872.00	20.296	0.012
*	10	1.131	737.90	867.21	16.882	0.004
*	20	1.133	733.13	870.46	14.944	0.002
*	30	1.137	722.73	871.49	14.257	0.002
*	40	1.135	731.00	874.36	13.874	0.006
PG0231+051D	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	1.127	737.70	865.63	14.959	0.002
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
PG1657+078	00	1.118	1090.77	984.28	18.161	0.004
*	10	1.123	1093.40	980.57	16.444	0.003
*	20	1.126	1087.94	983.36	15.956	0.003
*	30	1.132	1086.74	982.92	16.006	0.005
*	40	1.129	1082.70	985.79	16.296	0.008
PG1657+078	00	1.171	1067.99	685.53	19.860	0.010
*	10	1.182	856.76	790.85	18.992	0.010
*	20	1.189	853.84	794.96	17.176	0.008
*	30	1.199	852.18	794.93	16.530	0.007
*	40	1.194	851.11	796.03	16.284	0.007

PG1657+078A	00	1.118	1141.27	1226.19	19.750	0.009
*	10	1.123	1144.03	1222.85	16.729	0.004
*	20	1.126	1138.47	1225.53	14.935	0.003
*	30	1.132	1137.24	1225.21	14.350	0.003
*	40	1.129	1133.47	1228.11	14.032	0.004
PG1657+078A	00	1.171	1118.78	927.07	21.425	0.029
*	10	1.182	1124.88	926.30	17.043	0.004
*	20	1.189	1121.88	930.23	15.137	0.004
*	30	1.199	1120.35	930.08	14.448	0.004
*	40	1.194	1119.11	931.24	14.167	0.004
PG1657+078B	00	1.118	1079.36	1266.94	19.496	0.007
*	10	1.123	1082.03	1263.42	17.040	0.004
*	20	1.126	1076.52	1266.18	15.624	0.003
*	30	1.132	1075.35	1265.93	15.189	0.004
*	40	1.129	1071.49	1268.65	15.017	0.004
PG1657+078B	00	1.171	1056.73	967.83	21.193	0.022
*	10	1.182	1063.17	966.83	17.343	0.004
*	20	1.189	1059.98	970.89	15.816	0.004
*	30	1.199	1058.51	970.76	15.275	0.004
*	40	1.194	1057.19	971.90	15.113	0.005
PG1657+078C	00	1.118	1243.84	1201.67	20.445	0.057
*	10	1.123	1246.80	1198.40	17.704	0.008
*	20	1.126	1241.22	1201.32	16.139	0.007
*	30	1.132	1240.04	1200.91	15.702	0.046
*	40	1.129	1236.10	1203.74	15.394	0.013
PG1657+078C	00	1.171	1220.85	902.93	22.154	0.082
*	10	1.182	1227.88	901.70	18.001	0.007
*	20	1.189	1224.63	905.86	16.389	0.060
*	30	1.199	1223.20	905.59	15.766	0.036
*	40	1.194	1222.01	906.93	15.492	0.016
RU_149	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.390	950.16	1023.52	15.638	0.049
*	20	1.401	947.12	1024.73	14.999	0.004
*	30	1.410	942.52	1031.53	14.961	0.006
*	40	1.420	947.99	1026.43	15.186	0.006

RU_149	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.390	950.16	1023.52	15.638	0.049
*	20	1.401	947.12	1024.73	14.999	0.004
*	30	1.410	942.52	1031.53	14.961	0.006
*	40	1.420	947.99	1026.43	15.186	0.006
RU_149	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.373	937.34	734.95	16.512	0.007
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.396	1175.89	1298.32	12.966	0.003
*	20	2.435	1175.00	1292.98	12.680	0.009
*	30	2.461	1175.12	1291.63	12.845	0.004
*	40	INDEF	INDEF	INDEF	INDEF	INDEF

RU_149	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.386	1175.72	1297.82	12.962	0.003
*	20	2.427	1176.64	1295.14	12.676	0.003
*	30	2.458	1175.17	1292.07	12.850	0.004
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.376	1175.01	1298.17	12.969	0.004
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.450	1176.04	1291.94	12.849	0.005
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.444	1173.99	1293.47	12.687	0.006
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149A	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.390	891.53	986.33	16.724	0.005
*	20	1.401	888.59	987.34	15.662	0.057
*	30	1.410	883.90	994.14	15.395	0.005
*	40	1.420	889.48	988.99	15.381	0.009
RU_149A	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.373	893.21	986.06	16.724	0.004
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149A	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.396	1116.58	1261.50	14.043	0.004
*	20	2.435	1115.58	1256.16	13.303	0.007
*	30	2.458	1115.91	1255.43	13.264	0.005
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149A	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.386	1116.48	1261.22	14.042	0.004
*	20	2.427	1117.35	1258.38	13.303	0.006
*	30	2.461	1115.83	1254.95	13.282	0.004
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149A	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.376	1116.01	1261.53	14.032	0.004
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.450	1116.88	1255.15	13.276	0.004
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149A	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.444	1114.62	1256.78	13.342	0.004
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149B	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.390	1111.91	1031.62	15.202	0.002
*	20	1.401	1108.85	1032.71	13.727	0.002
*	30	1.410	1104.18	1039.48	13.292	0.002
*	40	1.420	1109.54	1034.48	13.137	0.002

RU_149B	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.373	1113.48	1031.56	15.204	0.003
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149B	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.396	1338.69	1304.27	12.554	0.002
*	20	2.435	1337.81	1298.97	11.434	0.004
*	30	2.461	1337.59	1297.34	11.164	0.002
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149B	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.386	1338.41	1303.83	12.550	0.002
*	20	2.427	1339.28	1300.96	11.416	0.002
*	30	2.458	1338.10	1297.91	11.172	0.002
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149B	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.376	1337.82	1304.34	12.555	0.003
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.450	1338.60	1297.99	11.174	0.003
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149B	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.444	1336.63	1299.46	11.441	0.005
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149C	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.390	1099.16	894.29	16.508	0.005
*	20	1.401	1096.10	895.32	15.531	0.005
*	30	1.410	1091.49	902.14	15.358	0.006
*	40	1.420	1096.98	897.11	15.394	0.006
RU_149C	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.373	1100.89	894.17	16.501	0.004
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF

RU_149C	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.396	1324.03	1166.30	13.854	0.004
*	20	2.435	1323.22	1160.92	13.239	0.004
*	30	2.461	1323.29	1159.39	13.241	0.009
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149C	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.386	1323.72	1166.08	13.840	0.004
*	20	2.427	1324.78	1162.94	13.208	0.007
*	30	2.458	1323.50	1160.02	13.236	0.008
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149C	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.376	1323.15	1166.56	13.841	0.004
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.450	1323.98	1159.91	13.247	0.007
*	40	INDEF	INDEF	INDEF	INDEF	INDEF

RU_149C	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.444	1322.17	1161.39	13.247	0.004
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149D	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.390	1001.10	968.61	13.323	0.002
*	20	1.401	998.09	969.82	12.598	0.003
*	30	1.410	993.50	976.53	12.508	0.003
*	40	1.420	998.92	971.51	12.670	0.003
RU_149D	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.373	1002.58	968.74	13.853	0.061
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149D	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.396	1226.31	1242.34	10.678	0.001
*	20	2.435	1225.41	1236.96	10.289	0.003
*	30	2.461	1225.63	1235.58	10.398	0.002
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149D	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.386	1226.17	1241.99	10.671	0.003
*	20	2.427	1227.14	1239.16	10.283	0.002
*	30	2.458	1225.77	1236.13	10.395	0.002
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149D	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.376	1225.47	1242.43	10.678	0.004
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.450	1226.41	1236.03	10.397	0.002
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149D	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.444	1224.48	1237.53	10.302	0.005
*	40	INDEF	INDEF	INDEF	INDEF	INDEF

RU_149E	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.390	1155.18	667.37	16.126	0.005
*	20	1.401	1152.12	668.41	14.774	0.042
*	30	1.410	1147.54	675.18	14.406	0.004
*	40	1.420	1152.91	670.26	14.279	0.003
RU_149E	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.373	1156.87	667.31	16.124	0.005
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149E	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.396	1377.38	937.48	13.470	0.004
*	20	2.435	1376.72	931.98	12.501	0.003
*	30	2.461	1376.88	930.12	12.297	0.003
*	40	INDEF	INDEF	INDEF	INDEF	INDEF

RU_149E	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.386	1377.01	937.34	13.463	0.003
*	20	2.427	1378.05	934.19	12.483	0.003
*	30	2.458	1376.88	930.99	12.295	0.004
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149E	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.376	1376.48	937.54	13.464	0.006
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.450	1377.51	930.82	12.285	0.003
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149E	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.444	1375.45	932.53	12.508	0.007
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149F	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.390	935.82	735.03	16.505	0.049
*	20	1.401	932.60	735.97	14.528	0.003
*	30	1.410	928.00	742.70	13.886	0.003
*	40	1.420	933.45	737.62	13.550	0.003
RU_149F	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	1.373	937.34	734.95	16.512	0.007
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	INDEF	INDEF	INDEF	INDEF	INDEF
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149F	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.396	1157.87	1008.53	13.866	0.004
*	20	2.427	1158.46	1004.95	12.222	0.003
*	30	2.461	1157.17	1001.53	11.771	0.003
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149F	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.386	1157.56	1008.48	13.857	0.005
*	20	2.435	1156.64	1003.06	12.246	0.004
*	30	2.458	1157.17	1002.07	11.774	0.002
*	40	INDEF	INDEF	INDEF	INDEF	INDEF

RU_149G	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.386	1048.66	1075.99	12.609	0.002
*	20	2.427	1049.46	1072.96	11.609	0.003
*	30	2.458	1048.05	1070.05	11.410	0.003
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149G	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	2.376	1047.89	1076.51	12.613	0.003
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.450	1048.66	1069.86	11.407	0.003
*	40	INDEF	INDEF	INDEF	INDEF	INDEF
RU_149G	00	INDEF	INDEF	INDEF	INDEF	INDEF
*	10	INDEF	INDEF	INDEF	INDEF	INDEF
*	20	INDEF	INDEF	INDEF	INDEF	INDEF
*	30	2.444	1046.79	1071.41	11.628	0.003
*	40	INDEF	INDEF	INDEF	INDEF	INDEF

PG2213-006	00	1.633	1293.34	979.83	18.143	0.008
*	10	1.661	1302.11	976.37	16.723	0.006
*	20	1.684	1301.47	977.98	16.240	0.008
*	30	1.720	1303.47	978.14	16.536	0.010
*	40	1.702	1299.96	981.57	16.742	0.013
PG2213-006A	00	1.633	1033.25	1025.78	20.061	0.030
*	10	1.661	1042.14	1022.52	17.673	0.010
*	20	1.684	1041.24	1024.20	16.220	0.007
*	30	1.720	1043.45	1024.20	16.018	0.007
*	40	1.702	1039.59	1027.71	15.716	0.008
PG2213-006B	00	1.633	960.06	1098.50	18.850	0.013
*	10	1.661	968.79	1095.41	16.282	0.004
*	20	1.684	968.06	1096.91	14.762	0.003
*	30	1.720	970.07	1096.98	14.531	0.003
*	40	1.702	966.30	1100.44	14.233	0.003
PG2213-006C	00	1.633	751.57	1186.02	20.994	0.057
*	10	1.661	760.45	1182.59	18.628	0.018
*	20	1.684	759.47	1184.47	17.162	0.014
*	30	1.720	761.62	1184.53	16.932	0.026
*	40	1.702	757.87	1187.83	16.582	0.013
PG1047+003	00	1.553	899.16	961.06	13.777	0.002
*	10	1.729	908.16	959.36	12.289	0.003
*	20	1.741	906.00	961.51	12.179	0.008
*	30	1.756	910.13	960.85	12.426	0.004
*	40	1.746	909.51	966.81	12.746	0.003
PG1047+003A	00	1.553	1045.74	1073.95	15.726	0.003
*	10	1.729	1054.65	1072.31	13.327	0.003
*	20	1.741	1052.49	1074.31	12.168	0.002
*	30	1.756	1056.50	1073.83	11.875	0.002
*	40	1.746	1056.00	1079.66	11.578	0.002
PG1047+003B	00	1.553	1163.06	1251.51	17.083	0.007
*	10	1.729	1172.04	1250.07	14.576	0.003
*	20	1.741	1169.95	1252.19	13.398	0.003
*	30	1.756	1173.82	1251.67	13.151	0.003
*	40	1.746	1173.45	1257.57	12.912	0.003
PG1047+003C	00	1.553	1451.36	934.47	14.541	0.002
*	10	1.729	1460.50	932.68	12.226	0.002
*	20	1.741	1458.46	934.80	11.142	0.002
*	30	1.756	1462.43	934.16	10.890	0.002
*	40	1.746	1461.99	940.08	10.658	0.002

Figure 33: The resulting standobs.dat file

Now, create a format file called 'fstandobs.dat' which contains all the aperture corrected magnitude of all the stars and declare the observations file variables in this file as:

Declare the observations file variables
observations

X00	3	# airmass in filter 00
x00	4	# x coordinate in filter 00
y00	5	# y coordinate in filter 00
m00	6	# instrumental magnitude in filter 00
error(m00)	7	# magnitude error in filter 00
X10	9	# airmass in filter 10
x10	10	# x coordinate in filter 10
y10	11	# y coordinate in filter 10
m10	12	# instrumental magnitude in filter 10
error(m10)	13	# magnitude error in filter 10
X20	15	# airmass in filter 20
x20	16	# x coordinate in filter 20
y20	17	# y coordinate in filter 20
m20	18	# instrumental magnitude in filter 20
error(m20)	19	# magnitude error in filter 20
X30	21	# airmass in filter 30
x30	22	# x coordinate in filter 30
y30	23	# y coordinate in filter 30
m30	24	# instrumental magnitude in filter 30
error(m30)	25	# magnitude error in filter 30
X40	27	# airmass in filter 40
x40	28	# x coordinate in filter 40
y40	29	# y coordinate in filter 40
m40	30	# instrumental magnitude in filter 40
error(m40)	31	# magnitude error in filter 40

2.4 EFFECT OF EXTINCTION ON MAGNITUDE

To study the effect of extinction i.e. airmass on magnitude, we take the aperture corrected magnitude of a few stars which have been observed several times over this period. We take the apparent magnitude at r=3 for each filter and plot it is as function of airmass.

We do this using the graphic utility "GNUPLOT". Gnuplot is a data fitting program. Here we open gnuplot from the terminal by typing just "gnuplot" after its installation [11]. Now we have to create a file containing the data to be plotted in the format "plot_file.gnu". In this file how should the graph be represented - lines, dots, grids etc. We display the data using the command "load "plot_file.gnu" ".

From the different set of data we are given, the stars PG0918+029, PG0942-029 and RU_149 are seen repeatedly for more than one night. Hence we use the apparent magnitudes and airmass of these stars for each filters used to study the extinction effect. The corresponding plots are given below:

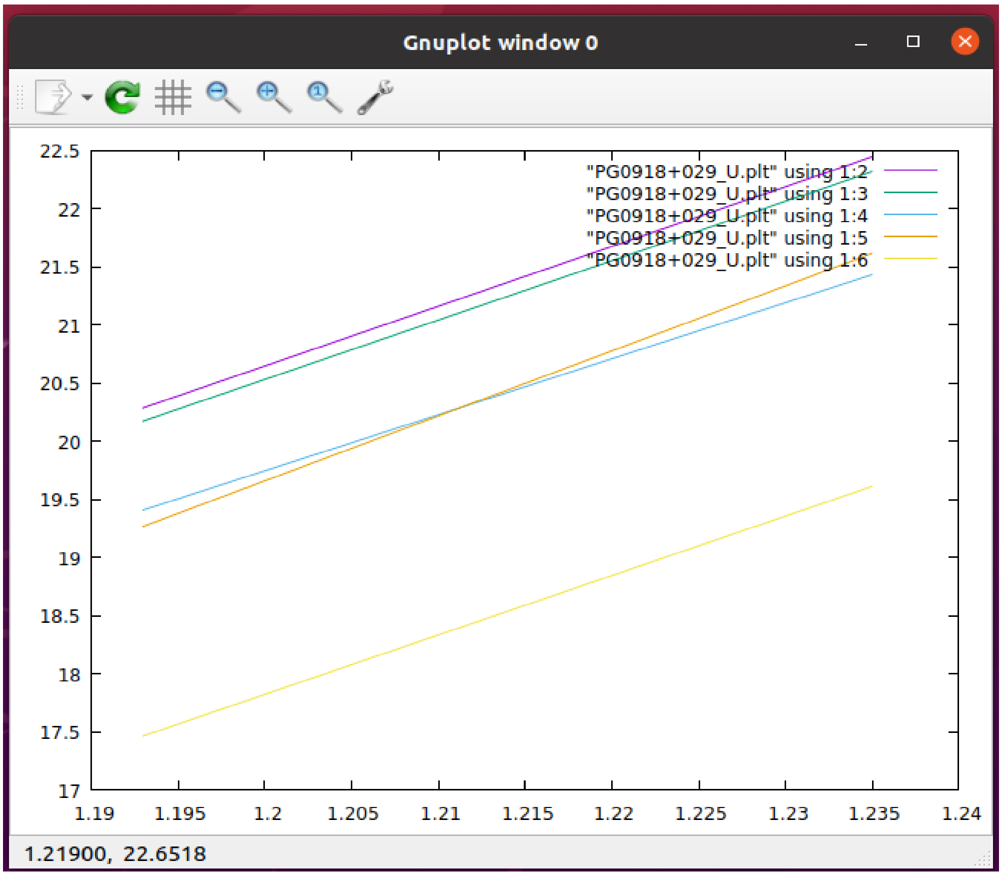

Figure 34: Extinction of PG0918+029 in the U filter from 2021-2022

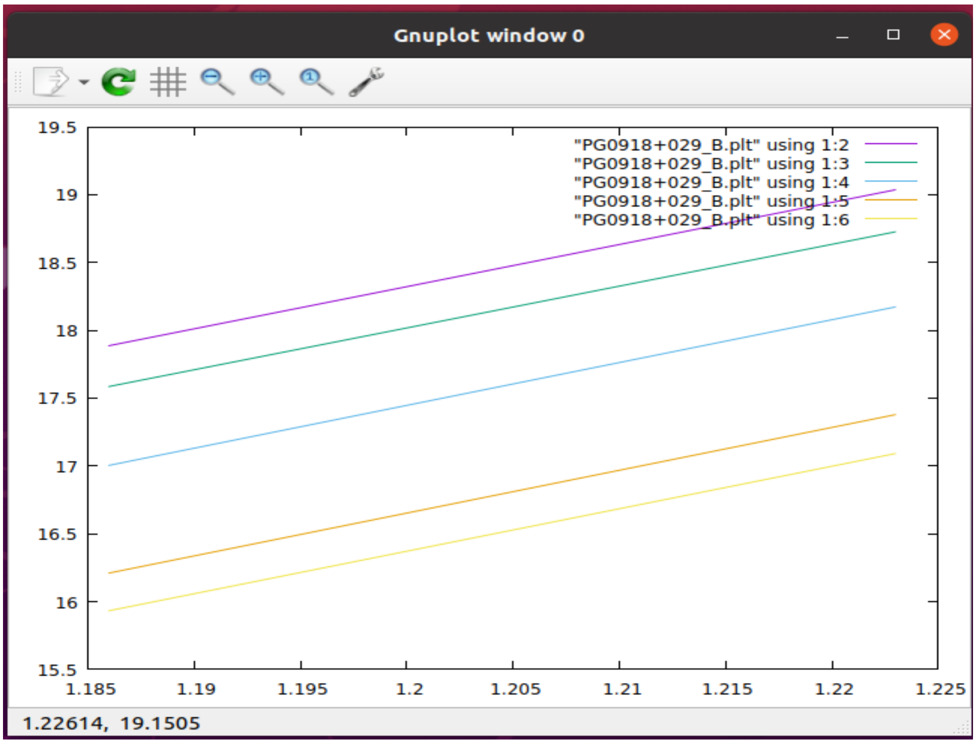

Figure 35: Extinction of PG0918+029 in the B filter from 2021-2022

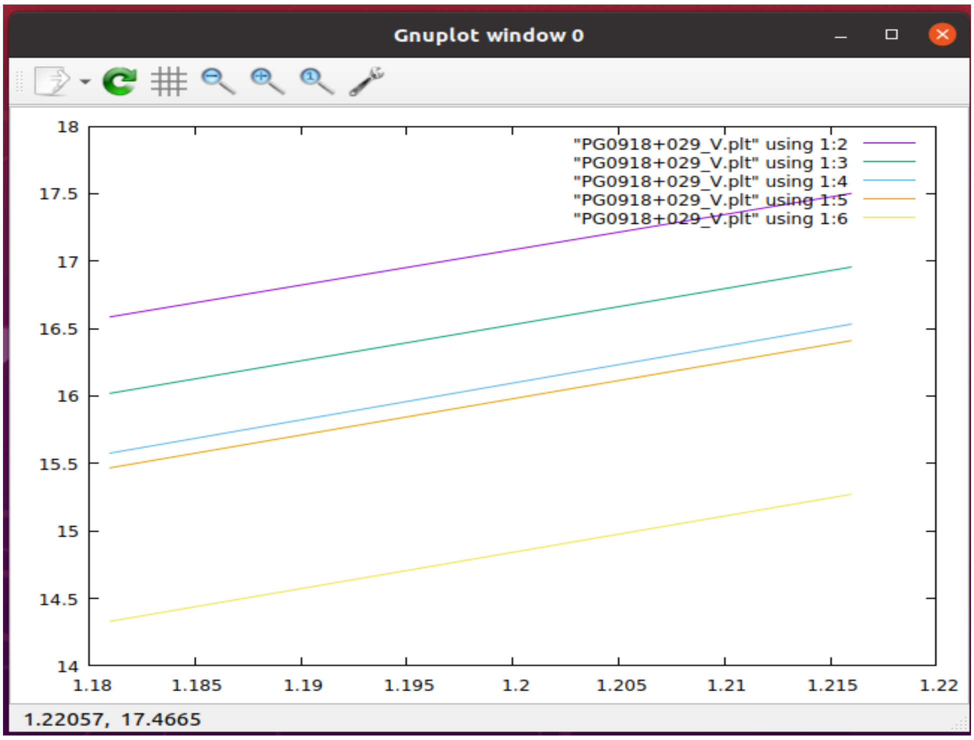

Figure 36: Extinction of PG0918+029 in the V filter from 2021-2022

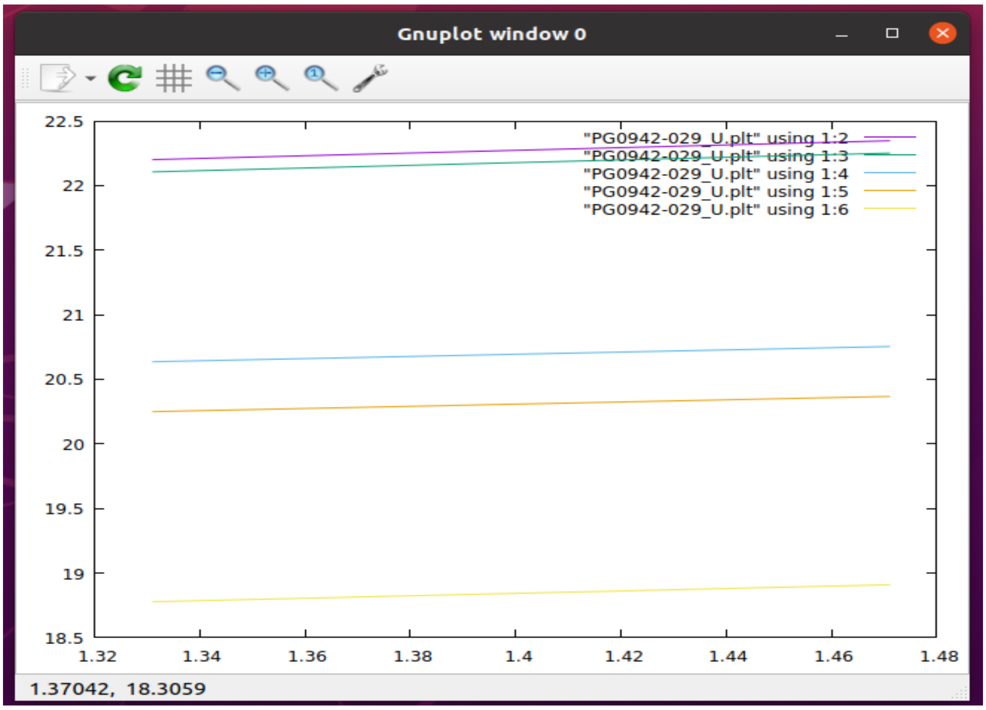

Figure 37: Extinction of PG0942-029 in the U filter from 2021-2022

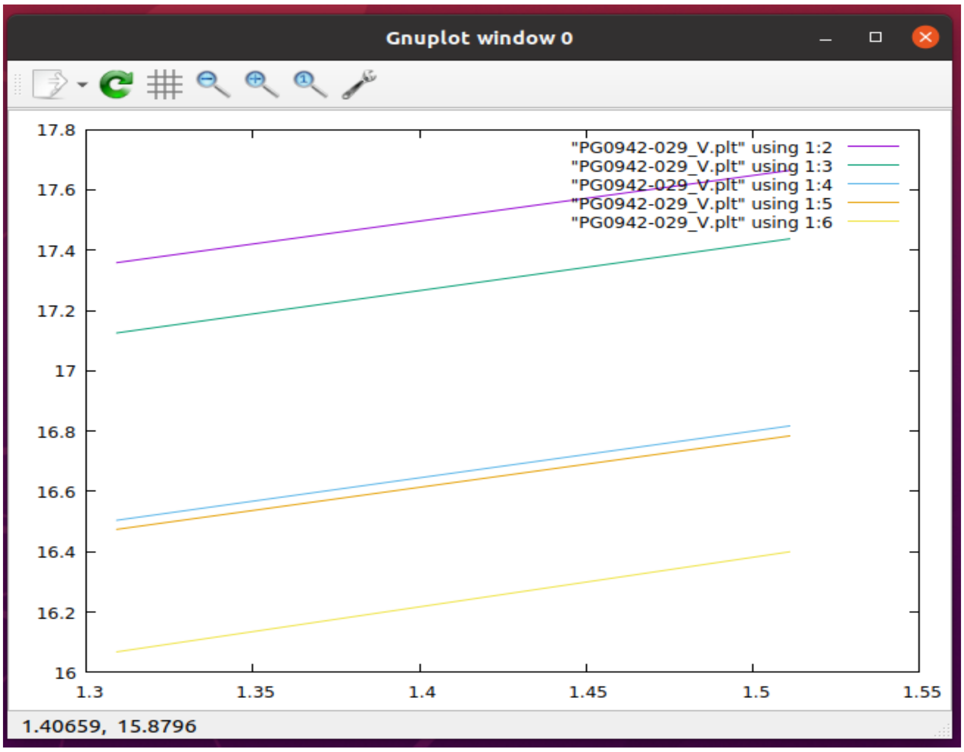

Figure 38: Extinction of PG0942-029 in the B filter from 2021-2022

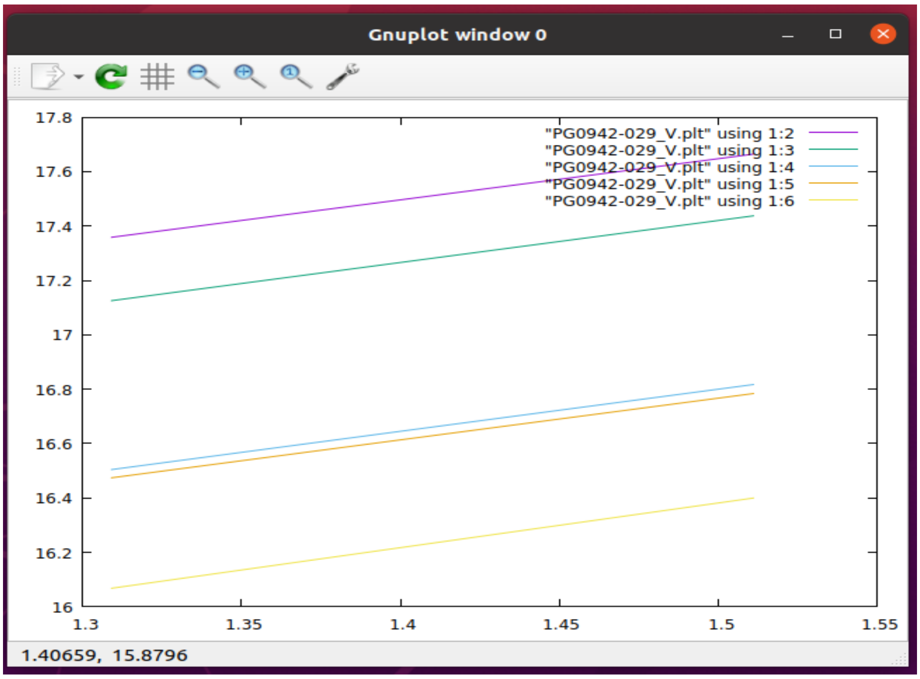

Figure 37: Extinction of PG0942-029 in the V filter from 2021-2022

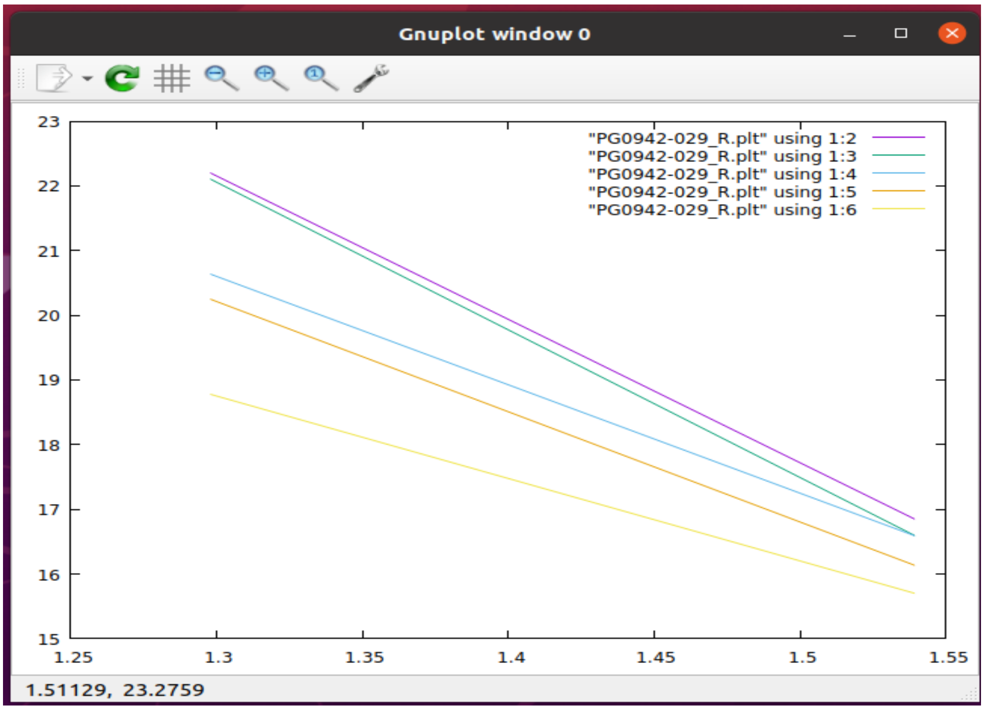

Figure 39: Extinction of PG0942-029 in the R filter from 2021-2022

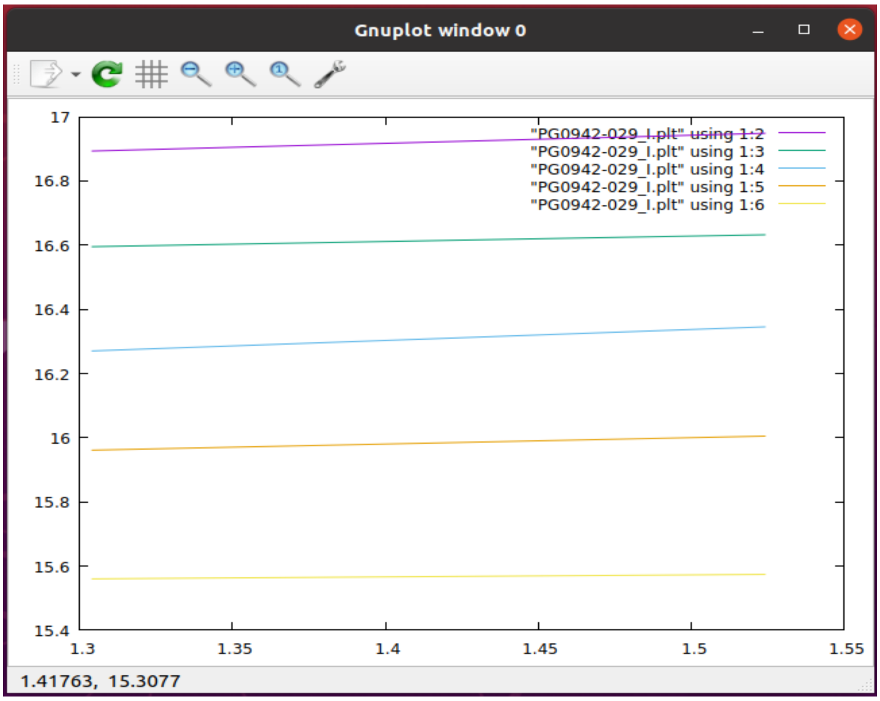

Figure 40: Extinction of PG0942-029 in the I filter from 2021-2022

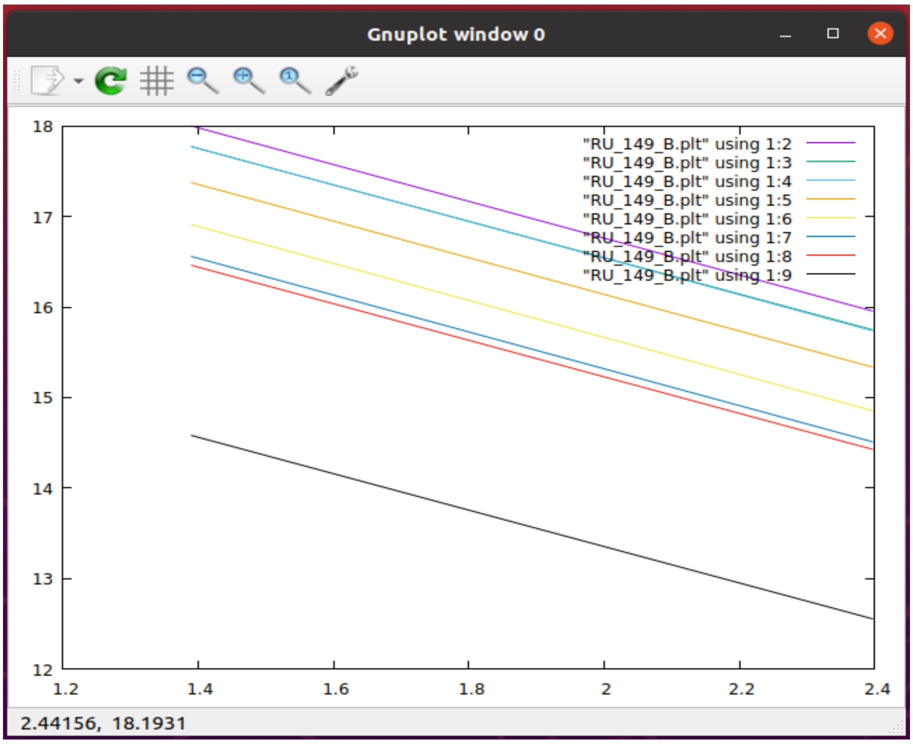

Figure 40: Extinction of RU_149 in the B filter from 2020-2021

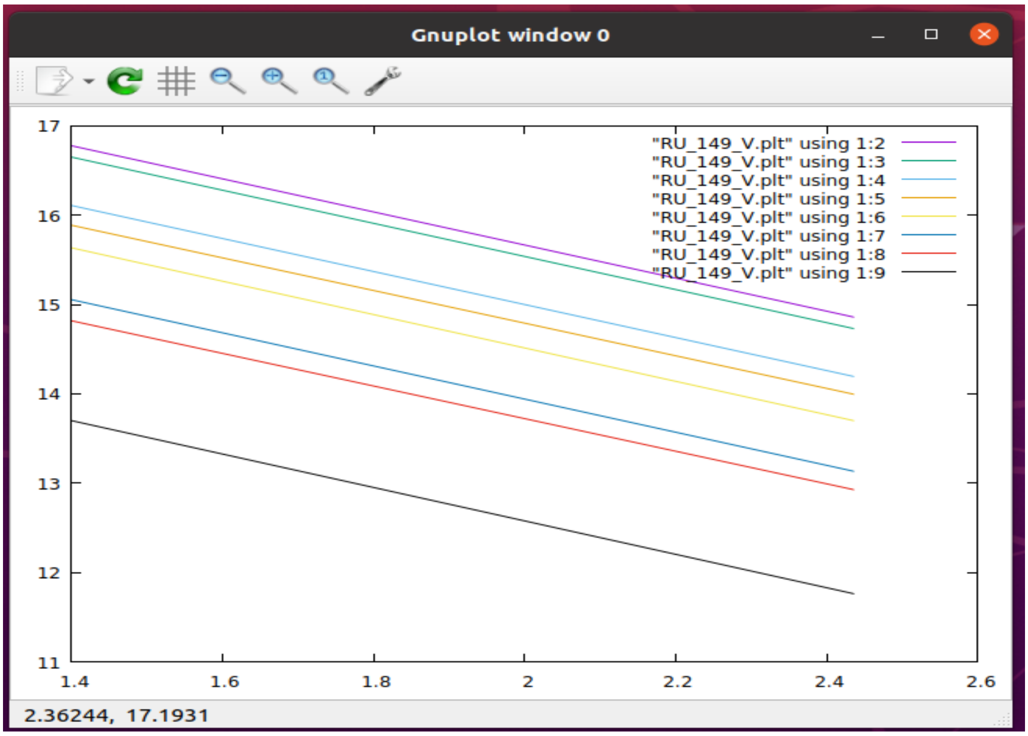

Figure 41: Extinction of RU_149 in the U filter from 2020-2021

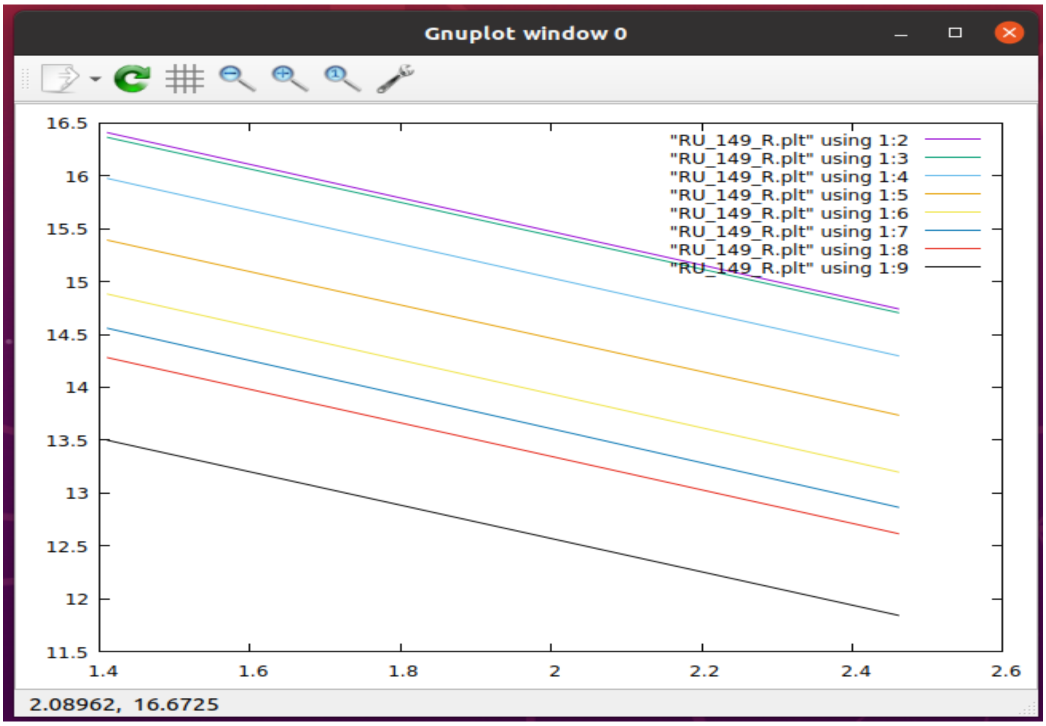

Figure 41: Extinction of RU_149 in the R filter from 2020-2021

From figure 34 to figure 41, the extinction curve of apparent magnitude ate r=3 pixels against airmass shows that magnitude decreases linearly with airmass. For the star PG0918+029, it is shown that the increase of airmass in the atmosphere from the year 2021 to 2022 resulted in a corresponding decrease in its apparent magnitude. Similarly for PG0942-029, the magnitude decreased with an increase in airmass from the same period 2021-2022. Also, for observation made during another period 2020-2021 shows a decrease in the apparent magnitude with the rise in airmass for the star RU_149. Hence, we may conclude as time precedes the magnitude of the stars becomes smaller with the increased concentration of air in the atmosphere making the star dimmer.

CHAPTER 3

CONCLUSION

Aperture Photometry is the study of light coming from a stellar body through a small circular aperture. The sky is observed for several nights during its uniform illumination and an image is captured which shows the field containing the standard stars. The raw images undergo bias subtraction and flat fielding to reduce the randomly occurring errors. The software IRAF and Ds9 are used to aid the project.

In this Project I have performed aperture photometry on standard stars for multiple nights from 2020-2022. I identified the standard stars in the given field for each night by comparison with the standard star catalog available online. The aperture radius, correction in the aperture size and the apparent change in magnitude is calculated. I used the resulting values to study the effect of extinction on magnitude. For this a plot of airmass against magnitude of each stars repeating for more than one or two nights were made. I observed from the plot that as airmass increases in the atmosphere, the magnitude of stars gets smaller making them dimmer.

Aperture Photometry can also be done using Aperture Photometry tool (APT), AstrolImage and MIRI Imaging. The results can be used for future calculations of extinction coefficient of stars.

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