

# A Demonstration Analysis Script for Performing Aperture Photometry

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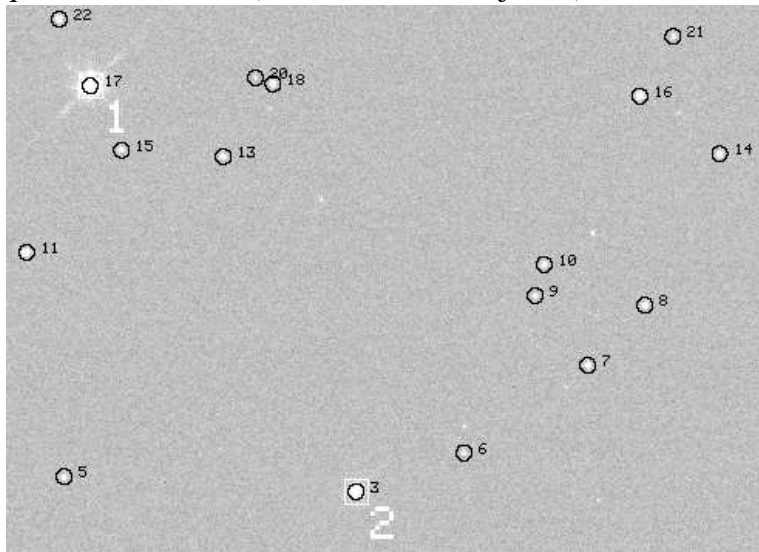
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## ABSTRACT

*A demonstration IRAF/STSDAS script to perform aperture photometry on WFPC2 images of Omega-Cen has been developed and is described in this document. The primary goal is to provide an easy-to-use example that can help introduce observers to the use of scripts, and to demonstrate a few of the commonly used IRAF/STSDAS capabilities.<sup>1</sup> Two sections of auxiliary information are included. One section provides information on how to download the script and notes on running the script. The other section provides a list of other commonly used IRAF and STSDAS tasks for working with WFPC2 data, along with other useful information.*

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**Figure 1:** Portion of the Omega-Cen field showing two of the stars in common with Harris et al. (white squares and numbers) and the fainter objects (black circles and numbers).



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1. This has been developed and tested under IRAF version v2.10.3BETA (08/18/94) for Sun OS 4.1

## 1. A Description of the Script

The script (`wfpc2_script1`) performs its work on HST observations of Omega-Cen (= NGC 5139) taken with WFPC2 on February 15, 1995. Two 16-second images using the F555W filter (`u2g40o05t.c0h` and `u2g40o06t.c0h`) and two 14-second exposures using the F814W filter (`u2g40o09t.c0h` and `u2g40o0at.c0h`) are used in the script. Observers are welcome to modify the script for other datasets and for their own purposes, but they should keep in mind that it is meant primarily as a demonstration tool. A more careful treatment may be required to get the most from your data (e.g., correction for CTE, color terms, geometric distortions, aperture corrections, etc.) This section contains a brief description of each step. See page 10 for instructions on getting the files and notes for running `wfpc2_script1`.

After getting into IRAF and loading the packages required (see page 10), follow the following steps.

### *Step 1: Remove Working Files*

```
del ttt *
```

**WARNING:** The script uses files beginning with “`ttt`” as working files and deletes them at the start, so make sure this won’t cause any problems. Remember to copy any files you want to save after running the script.

### *Step 2: Cosmic Ray Removal*

```
gcombine u2g40o05t.c0h[1],u2g40o06t.c0h[1] ttt1 reject=ccdcrrej  
          combine=average hsigma=3 rdnoise=5 gain=14  
gcombine u2g40o09t.c0h[1],u2g40o0at.c0h[1] ttt1b reject=ccdcrrej  
          combine=average hsigma=3 rdnoise=5 gain=14
```

There are several programs available for removing cosmic rays (e.g., **gcombine**, **crreject**, and a new program developed by Rick White currently being implemented into STSDAS). As is standard, two separate Omega-Cen exposures have been taken to help identify the cosmic rays. `wfpc2_script1` uses **gcombine** for this step. An examination of the resulting images (`ttt1` and `ttt1b`) shows that this task is quite successful at removing cosmic rays for these short exposures which inherently have few cosmic rays, and so have very few cases where cosmic rays fall on the same pixels on the two separate images (using the **display** task described on page 7). This becomes a bigger problem for long exposures. The [1] after each image name means we will work only on group 1 data (i.e., the PC chip) in this script. Note that the calibration data are taken with `gain=14`, while most observations are taken at `gain=7`.

### *Step 3: Hot Pixel Removal*

```
cosmicrays ttt1 ttt2 answer=no threshold=5 fluxrat=3 npasses=5 window=5  
           interactive=no  
cosmicrays ttt1b ttt2b answer=no threshold=5 fluxrat=3 npasses=5  
           window=5 interactive=no
```

Before we can identify the stars, we need to remove a few hot pixels that might be mistaken for stars. This is not critical for these very short exposures since the background is not high enough to allow any but the “hottest” pixels to be evident. The only hot pixels removed during this step are [135,189], [609,623], and [154,107]. However, hot pixels may be the primary difficulty when looking for very faint point sources on long exposures.

For some scientific programs, such as finding relatively bright stars on short exposures, using the IRAF task **cosmicrays** to remove hot pixels may be sufficient. In other cases you may want to retrieve the current hot pixel list from WWW, or recalibrate using updated dark images from the archives. Another technique for removing hot pixels is to dither the images (i.e., observe them with slight offsets; see articles in the January and February 1995 versions of the Space Telescope Analysis Newsletter available via WWW or several articles in the February 1995 ST-ECF Newsletter available via WWW. You might also wish to apply the distortion image available on WWW (f1k1552bu.r9\*) at this point.

A word of warning is in order about using **cosmicrays**. If you set the criteria too low, you may find that you begin removing the centers of real stars. Carefully examine the images before and after using this task (e.g., by “blinking” the images), or use **imarith** to subtract the two images to make a mask that shows where changes have been made. For example, a close look at [609,623] and [154,107] suggests that these are probably real objects, hence a threshold of 5 was probably too low. A value of threshold = 7 would be a better choice.

#### ***Step 4: Trim Off the Region Occulted by the Pyramid***

```
imcopy ttt2[44:799,52:799] ttt3
imcopy ttt2b[44:799,52:799] ttt3b
```

Before identifying the hot pixels we need to trim off the regions occulted by the pyramid, as well as the last column or two, or we will get lots of false identifications. Note that if you modify this script to work on the other chips, you will need to change the region that is trimmed since the occulted region is different for each chip. See Table 2.5 of the *WFPC2 Instrument Handbook* for information on the regions occulted on each chip.

#### ***Step 5: Identify the Object***

```
daofind ttt3 output=ttt3.coo.1 sigma=0.5 nsigma=1.5 fwhmpsf=1.5 thresho=10
        readnoi=7.1 epadu=28 sharplo=.2 verify=no interactive=no
```

The **daofind** task from DAOPHOT (Stetson, 1987, PASP, 99, 111) is used to identify the stars. The current setup searches for objects that are more than 10 sigma above the local background and writes them to the file ttt3.coo.1. Sigma must be set manually. For example, the command “imstat u2g40o05t.c0h[1][200:300,220:320] lower=-2 upper=2” has been used in this case to determine the background in a very blank region.

Some of the other parameters defined here are:

```

nsigma = 1.5          (width of convolution kernel in sigma)
fwhmpsf = 1.5        (full-width-half-maximum of star)
thresho = 10         (threshold in units of sigma)
epadu = 28           (electrons per adu [counts]; used to estimate +/-)
                      (this is often called "gain" by other programs)
readnoise=7.1        (readnoise)

```

The coordinate list written to ttt3.coo.1 will look something like this:

```

#K IRAF          = NOAO/IRAFV2.10.3BETA    version    %-23s
#K USER         = whitmore                name       %-23s
#K DATE          = 03-17-95                mm-dd-yr   %-23s
#K TIME          = 15:00:56                hh:mm:ss   %-23s
#K PACKAGE       = apphot                  name       %-23s
#K TASK          = daofind                  name       %-23s
#
#K SCALE         = 1.                      units      %-23.7g
#K FWHMPSF      = 1.5                      scaleunit  %-23.7g
#
#
#N XCENTER      YCENTER      MAG          SHARPNESS    ROUNDNESS
ID              \
#U pixels       pixels       #          #          #
#F %-13.3f      %-10.3f      %-9.3f     %-12.3f     %-12.3f     %-
6d
#
294.201        78.858        -2.345     0.911       -0.109      1
697.219        104.314       -0.158     0.815       0.118       2
#
#
561.083        668.179       -1.480     0.920       0.060       34
654.141        739.081       -1.659     0.957       -0.066      35

```

See *A User's Guide to Stellar CCD Photometry with IRAF* by P. Massey and L. E. Davis (available from NOAO) for lots more details about DAOPHOT (e.g., running it interactively to tune the parameters for your own use).

### Step 6: Aperture Photometry

```

phot ttt3 skyfile="" output=ttt3.mag.1 coords=ttt3.coo.1 readnoi=7.1
epadu=28 exposure="" aperture=3 salgori=median zmag=24.575
annulus=10 dannulus=5 calgori=none interactive=no verify=no
phot ttt3b skyfile="" output=ttt3b.mag.1 coords=ttt3.coo.1 readnoi=7.1
epadu=28 exposure="" aperture=3 salgori=median zmag=23.428
annulus=10 dannulus=5 calgori=none interactive=no verify=no
txdump ttt3.mag.1 xcenter,ycenter,mag,merr mode=h > ttt4
txdump ttt3b.mag.1 mag,merr mode=h > ttt4b
tcalc ttt4 c1 "c1+43"
tcalc ttt4 c2 "c2+51"

```

Aperture photometry is performed using an aperture with a radius of 3 pixels (“aperture=3”), the background determine by the median (“salgori=median”; the median is less sensitive to contaminating objects in crowded fields), within an annulus from 10 pixels (“annulus=10”) to 15 pixels (“dannulus=5”). The coordinate list from the previous step is used with no recentering (“calgori = no”). The zero point is 24.575 for the F555W

observations and 23.428 for the F814W observations. For example, an object with 100 counts in the F555W filter has a magnitude of  $-2.5 \log(100) + 24.575 = 19.575$  mag.

**WARNING:** These zero points are appropriate only for the particular choice of apertures and exposure times used in this script. See Holtzman et al. (*The Photometric Performance and Calibration of WFPC2*, Jon Holtzman et.al., 1995, in prep., and *Photometry with the WFPC2*, Brad Whitmore, 1995, Proceedings of the 1995 HST Calibration Workshop; both papers available at WWW), for further discussion on this subject.

The results are written to ttt3.mag.1 for the F555W results and to ttt3b.mag.1 for the F814W results, and will look something like this:

```

:
:
#K SALGORITHM = median          algorithm %-23s
#K ANNULUS    = 10.             scaleunit %-23.7g
#K DANNULUS   = 5.             scaleunit %-23.7g
:
#
#K WEIGHTING  = constant        model      %-23s
#K APERTURES  = 3               scaleunit %-23s
#K ZMAG       = 24.575          zeropoint %-23.7g
#
#N IMAGE      XINIT      YINIT      ID      COORDS      LID      \
#U imagename  pixels     pixels     ##      filename    ##      \
#F %-23s      %-10.3f    %-10.3f   %-5d    %-23s      %-5d    \
#
#N XCENTER    YCENTER    XSHIFT    YSHIFT    XERR      YERR      CIER CERROR \
#U pixels     pixels     pixels    pixels    pixels    pixels    ##  cerrors \
#F %-14.3f    %-11.3f    %-8.3f    %-8.3f    %-8.3f    %-8.3f    %-5d %-13s \
#
#N MSKY       STDEV      SSKEW     NSKY      NSREJ     SIER SERROR \
#U counts     counts     counts    npix     npix     ##  serrors \
#F %-18.7g    %-15.7g    %-15.7g    %-7d     %-6d     %-5d %-13s \
#
#N ITIME      XAIRMASS    IFILTER    OTIME     \
#U timeunit   number      name      timeunit \
#F %-18.7g    %-15.7g    %-23s    %-23s    \
#
#N RAPERT     SUM        AREA       MAG      MERR      PIER PERROR \
#U scale      counts     pixels     mag      mag      ##  perrors \
#F %-12.2f    %-15.7f    %-15.7f    %-7.3f  %-6.3f  %-5d %-13s \
#
ttt3          294.201    78.858    1      ttt3.coo.1    1      \
  294.201    78.858    0.000    0.000 INDEF    INDEF    0      NoError \
 -0.0150283  0.3968335  -0.2390791  389    3      0      NoError \
  1.          INDEF    INDEF    INDEF    INDEF    \
  3.00      184.4735    28.5715    184.9029    18.908 0.020 0      NoError \
ttt3          697.219    104.314    2      ttt3.coo.1    2      \
  697.219    104.314    0.000    0.000 INDEF    INDEF    0      NoError \
 -0.0236741  0.3923617  -0.1982743  391    2      0      NoError \
  1.          INDEF    INDEF    INDEF    INDEF    \
  3.00      29.98758    28.52468    30.66288    20.858 0.085 0      NoError \
:
ttt3          654.141    739.081    35     ttt3.coo.1    35     \
  654.141    739.081    0.000    0.000 INDEF    INDEF    0      NoError \
 -0.05124146 0.4315955  -0.1955512  302    2      0      NoError \
  1.          INDEF    INDEF    INDEF    INDEF    \
  3.00      92.23106    28.44914    93.68884    19.646 0.035 0      NoError

```

These can be a little hard to read. To clarify, some of the main parameters from the first object are:

XINIT= 288.201	(X position)
YINIT=70.858	(Y position)
ID = 1	(ID number)
MSKY = -0.0150283	(counts in the background annulus; NOTE: The background has been slightly over-subtracted in this image.)
SUM = 184.4735	(total counts in the object aperture)
AREA = 28.5715	(area in pixels <sup>2</sup> in the object aperture)
MAG = 18.908	(object magnitude)
MERR = 0.025	(magnitude uncertainty)

As seen above, there are 184.47 counts in the main aperture, a background of -0.01503 times 28.5715 = -0.43 needs to be subtracted off, so the corrected flux is  $184.47 + 0.43 = 184.90$ , hence the final result is  $-2.5 \log(184.90) + 24.575 = 18.908$  mag.

The relevant information is then written to ttt4 and ttt4b, and the offset used in step 4 is added back in.

### ***Step 7: Merge the Tables into one Table and Calculate the Mean Value of (F555W - F814W)***

```
tmerge ttt4,ttt4b ttt5 allcols=yes option=merge
tcalc ttt5 new c3-c5
tstat ttt5 c7
```

This step merges the tables obtained for the F555W and F814W filters into a single table (ttt5), determines the value of (F555W - F814W) which it puts into a new column (c7), and then determines the mean value of (F555W - F814W) along with a few other statistics. The statistics are written to the screen, but are not saved in a file.

### ***Step 8: Compare the Results with Harris et al.***

```
copy ttt5 ttt6
tsort ttt6 c3
joinlines ttt6,omegacen_1 > ttt7a
tselect ttt7a ttt7 "c15 == 0"
tcalc ttt7 new c3-c11
tcalc ttt7 new c5-c13
tstat ttt7 c16
tstat ttt7 c17
```

Table 5 is copied and sorted by F555W magnitude, and then joined with the file omegacen\_1 which contains the published ground based photometry from Harris, AJ, 105, 1196. The file omegacen\_1 must be downloaded along with the script (see Appendix A). The differences between the WFPC2 and Harris et al. measurements are then computed

and put into columns c13 and c14, and the statistics on the comparison are written to the screen but are not copied to a file.

The results indicate that the zero points are accurate and the scatter in the measurements is 0.022 mag for F555W and 0.019 for the F814W measurements.

The final results for the stars in common with Harris et al. are in ttt7, as shown below. The full listing for all the detected stars is in ttt5 (sorted in order of Y) and ttt6 (sorted in order of F555W magnitude).

#	X	Y	V	+/-	I	+/-	V-I	X	Y	ID	gr V	+/-	gr I	+/-	f	V - gr V	I - gr I
# 143.036	453.827	14.792	0.002	13.678	0.002	1.114	143	454	1629	14.799	0.004	13.656	0.004	0	-0.007	0.022	
# 315.165	191.122	16.339	0.005	15.346	0.005	0.993	315	191	1461	16.359	0.008	15.348	0.006	0	-0.02	-0.002	
# 313.878	662.084	16.629	0.005	15.601	0.006	1.028	314	663	1714	16.598	0.006	15.598	0.007	0	0.031	0.003	
# 716.766	196.045	17.748	0.01	16.882	0.012	0.866	717	196	1425	17.751	0.008	16.906	0.013	0	-0.003	-0.024	

### Step 9: Display the Image and Mark the Objects

```
display ttt2 1 zrange=no z1=-5 z2=100 ztrans=linear
tvmark 1 coords=ttt4 mark=circle radii=5 color=202 label=no number=yes
      nxoffse=10 nyoffset=0 pointsi=1 txsize=1 interac=no
tvmark 1 coords=ttt7 mark=rectangle lengths=15 color=203
      label=no number=yes nxoffse=10 nyoffset=-30 pointsi=3 txsize=3
      interac=no
```

The image is displayed and the stars are identified (see Figure 1 on page 1). The stars within the black circles are from the full object list, while the stars within the white squares are 2 of the 4 in common with the Harris et al. measurements.

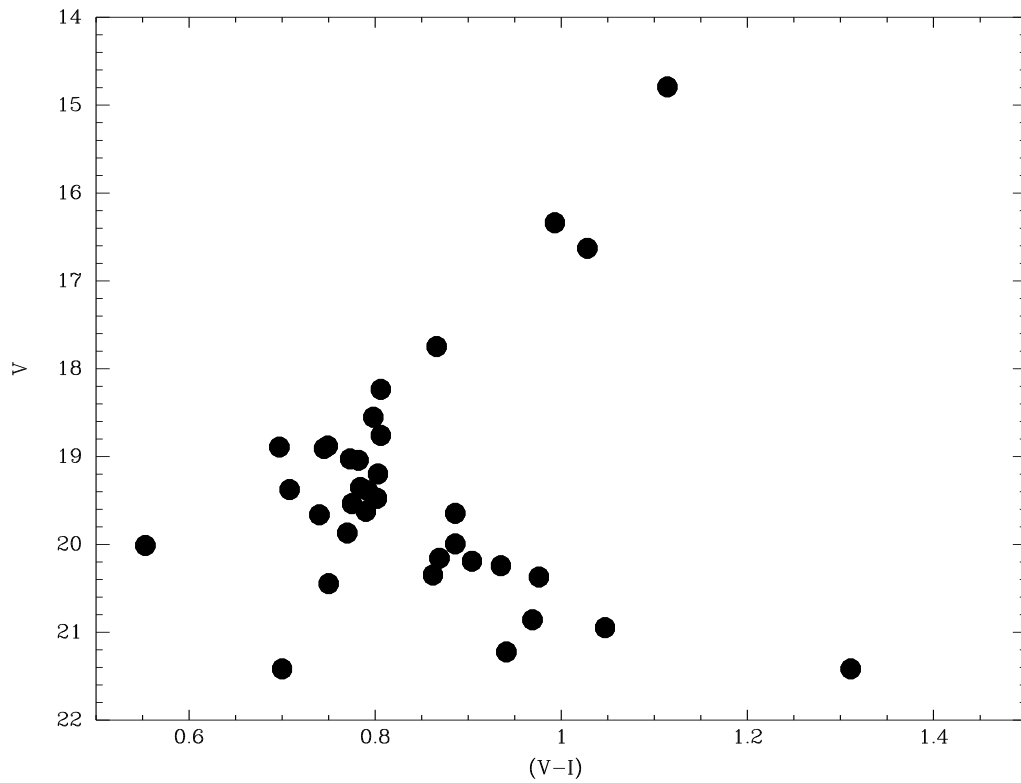
### Step 10: Use IGI to Plot the Color-Magnitude Diagram

Make a plot of the color-magnitude diagram.

*NOTE:* To make a hardcopy rather than plotting on your computer screen just change “stdgraph” to “stdplot” below and remove # in front of “gflush”. To make a PostScript file, change stdgraph to “psi\_land” (landscape) or “psi\_port” (portrait), and remove the # in front of “gflush”.

```
igi device=stdgraph
data ttt5
xcol 7
ycol 3
limits .5 1.5 22 14
box
xlabel (V-I)
ylabel V
ptype 12 3
points
bye
# gflush
```

**Figure 2:** Color magnitude diagram of the stars in a PC image of Omega-Cen as generated by *igi*.



***Step 11: Make a LaTeX File and Preview the Results***

Make a LaTeX file of the results, convert it to PostScript, and preview it.

*NOTE:* table1header.cd is the header file which should be downloaded along with the script and the data files.

```
tcreate ttt5.tab table1header.cd ttt5 hist=no
tprint ttt5.tab pwidth=80 plength=40 showrow=yes columns=* option=latex
> ttt5.tex
!latex ttt5
!dvips ttt5
!ghostview ttt5.ps &
```

**Figure 3:** Positions and magnitudes of the stars in a PC image of Omega-Cen as generated by tcreate.

(row)	x pix	y pix	F555W mag	err1 mag	F814W mag	err2 mag	F555W-F814W mag
1	337.201	129.858	18.908	0.020	18.163	0.025	0.745
2	740.219	155.314	20.858	0.085	19.889	0.106	0.969
3	315.165	191.122	16.339	0.005	15.346	0.005	0.993
4	716.766	196.045	17.748	0.010	16.882	0.012	0.866
5	126.156	200.790	20.012	0.043	19.459	0.068	0.553
6	385.073	216.238	20.371	0.057	19.395	0.056	0.976
7	465.184	272.916	19.352	0.027	18.568	0.034	0.784
8	502.175	311.884	19.389	0.026	18.597	0.035	0.792
9	431.177	318.018	20.157	0.047	19.288	0.054	0.869
10	436.926	338.172	19.536	0.030	18.761	0.038	0.775
11	101.878	345.995	18.552	0.016	17.754	0.019	0.798
12	692.167	404.991	19.663	0.033	18.923	0.045	0.740
13	229.223	408.043	19.623	0.032	18.833	0.036	0.790
14	550.625	409.782	19.475	0.028	18.673	0.035	0.802
15	163.326	412.223	19.994	0.039	19.108	0.050	0.886
16	498.879	447.188	18.235	0.013	17.429	0.016	0.806
17	143.036	453.827	14.792	0.002	13.678	0.002	1.114
18	261.267	455.156	19.042	0.021	18.260	0.027	0.782
19	711.241	455.021	18.880	0.020	18.131	0.027	0.749
20	250.083	459.067	21.417	0.138	20.106	0.113	1.311
21	520.290	485.831	20.348	0.056	19.486	0.063	0.862
22	123.059	496.989	19.198	0.024	18.395	0.027	0.803
23	224.921	516.772	21.224	0.109	20.283	0.129	0.941
24	748.153	530.238	18.759	0.019	17.953	0.021	0.806
25	311.234	530.614	20.243	0.050	19.308	0.058	0.935
26	71.616	538.867	19.376	0.028	18.668	0.039	0.708
27	685.081	561.872	21.417	0.136	20.717	0.199	0.700
28	788.711	566.646	20.191	0.053	19.287	0.063	0.904
29	744.078	637.154	20.447	0.063	19.697	0.088	0.750
30	206.824	656.016	20.948	0.091	19.901	0.090	1.047
31	313.878	662.084	16.629	0.005	15.601	0.006	1.028
32	616.348	699.723	18.892	0.019	18.195	0.025	0.697
33	640.851	709.074	19.027	0.021	18.254	0.028	0.773
34	604.083	719.179	19.870	0.039	19.100	0.046	0.770
35	697.141	790.081	19.646	0.035	18.760	0.043	0.886

## 2. Downloading the Files and Notes for Running the Script

This document and the script can be found at:

[http://www.stsci.edu/ftp/instrument\\_news/WFPC2/Wfpc2\\_phot/](http://www.stsci.edu/ftp/instrument_news/WFPC2/Wfpc2_phot/)

- wfpc2\_script1
- readme.ps (this document)

You can retrieve these files and the relevant data via anonymous FTP ( watch your cases, these commands are case sensitive):

- ftp
- open stsci.edu
- login: anonymous
- password: [your email address here]
- cd instrument\_news/WFPC2/Wfpc2\_phot
- binary
- mget \*
- bye

Here are some notes on running the script taken from the wfpc2\_script1 file:

```
# Notes: 1. If you are not familiar with IRAF/STSDAS, please consult
#          the STSDAS Users' Guide and your site-specific IRAF manual.
#          ( http://ra.stsci.edu/About3.html#Introduction )

#          2. The following tasks need to be loaded in IRAF (Note that you
#             can put these in your login.cl if you wish rather than
#             typing them each time):

#             stsdas.hst_calib.wfpc
#             toolbox.imgtools
#             imred.ccdred
#             images.tv
#             noao.digiphot.apphot
#             ttools
#             proto

#          3. You can run the full script using:  cl < wfpc2_script1
#             or use your mouse to cut and paste part of the script
#             to run only portions of the full script. Portions
#             can be commented out using # in the first column.

#          4. An attempt has been made to include explicitly some of the
#             parameters that are commonly changed, but you should
#             examine the rest of the parameters (e.g., help gcombine, or
#             epar gcombine) to make sure they are appropriate.

#          5. The script is currently set up to work on only the PC
#             (i.e., group number 1, denoted by [1]). You probably want
#             to change the apertures and zeropoints for the WF chips.

#          5. These particular observations used the gain=14 channel.
#             The zeropoints will be about +0.75 mag for the more
#             commonly used gain=7 channel. See the Holtzmann article
#             or the Whitmore Calibration Workshop paper for details.
```

### 3. IRAF/STSDAS Tasks Used in This Script

**Table 1.** IRAF and STSDAS Tasks Used in this Script

<b>Task</b>	<b>Package</b>	<b>Function</b>
gcombine	stdas.toolbox.imgtools	Combine multi-group images while rejecting outliers
igi	stdas.graphics.stplot	Interactive Graphics Interpreter (see IGI manual)
cosmicrays	noao.imred.ccdred	Detect and replace cosmic rays and hot pixels
daofind	noao.digiphot.apphot	Automatically detect objects in an image
phot	noao.digiphot.apphot	Perform aperture photometry on a list of stars
txdump	noao.digiphot.ptools	Print fields from selected records in APPHOT text database
imcopy	images	Copy image into another image
display	images.tv	Load and display images in an image display
tvmark	images.tv	Mark the objects specified on the image display
joinlines	proto	Join input text files line by line, keeping only common rows
tcalc	tables	Perform arithmetic operations on table columns
tmerge	tables	Merge two tables, or append on to the other
tstat	tables	Get statistics for a table column
tcreate	tables	Create a table from ASCII files describing a table format
tprint	tables	Convert STSDAS tables to STSDAS, ASCII, LATEX files
tselect	tables	Create a new table from selected rows of an old table
tsort	tables	Sort a table on one or more columns

**Table 2.** Other Commonly Used IRAF and STSDAS Tasks for Working with WFPC2 Data

Task	Description
help <i>task</i>	Show help file for a given task whose name is known
imexamine	Examine images and make quick measurements
imarith	Do simple arithmetic on images
listpix	List pixel values
imstat	Compute and print image pixel statistics
crrej	Remove cosmic rays
wmosaic	Patch 4 chips into a single image. Correct for distortion
metric	Determine coordinates and correct for distortion
compass	Determine orientation, draws on the image (make copy!)
epix	Edit pixel values
wfixup	Fix bad pixels

**Table 3.** Other Useful Stuff

Command	Purpose
set stdimage = imt1600	Sets SAOIMAGE to display the entire chip (set up in login.cl)
set imtype = "hhh"	Sets the image type to "hhh" (set up in login.cl)
flprc	On occasion, processes hang. This flushes them.
apropos <i>string</i>	Obtain information on a task whose exact name is not known
ehist <i>string</i>	Show last command containing <i>string</i>

***Some general information:***

- readnoise = 5 (for single exposure)
- gain = 7 (or 14 in rare cases)
- 1 count ~ 7 electrons (if gain=7)  
~  $3.6 \times 10^{-18}$  ergs-cm<sup>2</sup>s<sup>-1</sup> in V.  
~ 22.5 V magnitude in a 1-second F555W exposure
- 1 pixel = 0.04554 arcsecs (platescale at the center of the PC chip)
- 1 pixel = 0.09961 arcsecs (platescale at the center of the WF chips)

### ***Relevant WWW Addresses***

- This demo package:  
[http://ftp.stsci.edu/ftp/instrument\\_news/WFPC2/Wfpc2\\_phot/](http://ftp.stsci.edu/ftp/instrument_news/WFPC2/Wfpc2_phot/)
- Holtzman paper:  
[http://ftp.stsci.edu/ftp/instrument\\_news/WFPC2/Wfpc2\\_isr/wfpc2\\_phot.ps](http://ftp.stsci.edu/ftp/instrument_news/WFPC2/Wfpc2_isr/wfpc2_phot.ps)
- Hot pixel list:  
[http://ftp.stsci.edu/ftp/instrument\\_news/WFPC2/hotpix.html](http://ftp.stsci.edu/ftp/instrument_news/WFPC2/hotpix.html)
- WFPC2 newsletter:  
[http://ftp.stsci.edu/ftp/instrument\\_news/WFPC2/Wfpc2\\_stan/](http://ftp.stsci.edu/ftp/instrument_news/WFPC2/Wfpc2_stan/)
- Whitmore Photometry Paper (Calibration Workshop):  
[http://www.stsci.edu/ftp/instrument\\_news/WFPC2/Wfpc2\\_phot/photom2.ps](http://www.stsci.edu/ftp/instrument_news/WFPC2/Wfpc2_phot/photom2.ps)